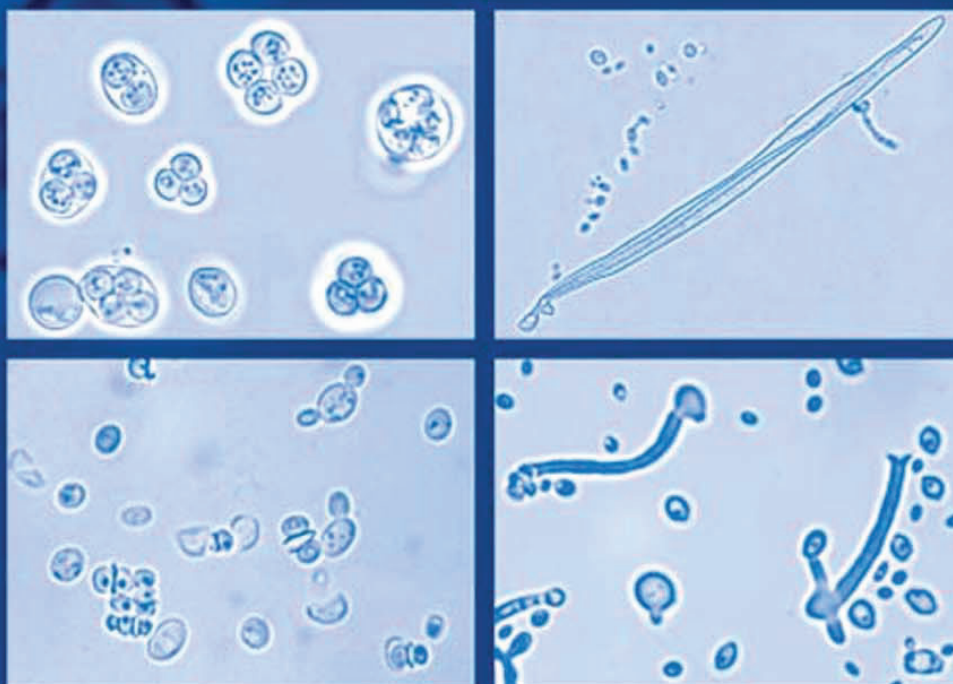




THE YEASTS

A TAXONOMIC STUDY

FIFTH EDITION



VOLUME 2

EDITED BY
C.P. KURTZMAN • J.W. FELL • T. BOEKHOUT

The Yeasts, a Taxonomic Study

Volume 2

Fifth Edition

Edited by

Cletus P. Kurtzman

Bacterial Foodborne Pathogens and Mycology Research Unit
National Center for Agricultural Utilization Research
Agricultural Research Service, US Department of Agriculture
Peoria, Illinois, USA

Jack W. Fell

Rosenstiel School of Marine and Atmospheric Science
University of Miami
Key Biscayne, Florida, USA

and

Teun Boekhout

CBS-KNAW Fungal Biodiversity Centre
Utrecht, The Netherlands



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Elsevier
32 Jamestown Road, London NW1 7BY, UK
30 Corporate Drive, Suite 400, Burlington, MA 01803, USA
525 B Street, Suite 1800, San Diego, CA 92101-4495, USA

First edition 1952
Second edition 1970
Third edition 1984
Fourth edition 1998
Fifth edition 2011

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Except chapters 13, 17, 18, 20, 33, 37, 38, 42, 44, 47, 48, 51, 53, 54, 55, 56, 57, 59, 60, 64, 65, 70, 72, 75, 78, 80, 81, 82, 85 and 99 which are in the Public Domain.

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British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data

A catalog record for this book is available from the Library of Congress

ISBN: 978-0-444-52149-1 (Set)
ISBN: 978-0-123-84708-9 (Volume 1)
ISBN: 978-0-123-84707-2 (Volume 2)
ISBN: 978-0-123-84868-0 (Volume 3)

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Typeset by MPS Limited, a Macmillan Company, Chennai, India
www.macmillansolutions.com

Printed and bound in United States of America

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Candida Berkhout (1923)

Marc-André Lachance, Teun Boekhout, Gloria Scorzetti, Jack W. Fell and Cletus P. Kurtzman

DIAGNOSIS OF THE GENUS

Asexual reproduction: Cells are globose, ellipsoidal, cylindroidal or elongate, occasionally ogival, triangular or lunate. Reproduction is by holoblastic budding. Pseudohyphae and septate hyphae may be formed. The cell wall is ascomycetous and two-layered. Ballistoconidia are not formed. Arthroconidia may be formed, but not extensively.

Sexual reproduction: Absent.

Physiology/biochemistry: Glucose may be fermented. Nitrate may be assimilated. Starch-like compounds are not produced. The diazonium blue B reaction is negative. Xylose, rhamnose and fucose are not present in cell hydrolysates.

Phylogenetic placement: Saccharomycetales. The genus is highly polyphyletic as it comprises mitosporic species that are devoid of special distinguishing features. Most species have relatives in various teleomorphic genera assigned to the Saccharomycetales (Figs 90.1–90.5).

TYPE SPECIES

Candida vulgaris Berkhout [synonym of *Candida tropicalis* (Castellani) Berkhout (1923)]

SPECIES ACCEPTED

1. *Candida aaseri* Dietrichson ex van Uden & H.R. Buckley (1970)
2. *Candida aglyptinia* S.-O. Suh, N.H. Nguyen & M. Blackwell (2006)
3. *Candida akabanensis* Nakase, M. Suzuki, Takashima, Rosadi, Hermosillo & Komagata (1994)
4. *Candida alai* S.-O. Suh, N.H. Nguyen & M. Blackwell (2008)
5. *Candida albicans* (Robin) Berkhout (1923)
6. *Candida alimentaria* Knutsen, V. Robert & M.Th. Smith (2007)
7. *Candida allociferii* Ueda-Nishimura & Mikata (2002)
8. *Candida amapae* Morais, Rosa, S.A. Meyer, Mendonça-Hagler & Hagler (1995)
9. *Candida ambrosiae* Kurtzman (2001)
10. *Candida amphixiae* S.-O. Suh, N.H. Nguyen & M. Blackwell (2005)
11. *Candida anatomiae* (Zwillenberg) S.A. Meyer & Yarrow (1978)
12. *Candida anglica* Kurtzman, Robnett & Yarrow (2001)
13. *Candida anneliseae* S.-O. Suh & M. Blackwell (2004)
14. *Candida anutae* Bab'eva, Lisichkina, Maksimova, Reshetova, Terenina & Chernov (2000)
15. *Candida apicola* (Hajsig) S.A. Meyer & Yarrow (1978)
16. *Candida apis* (Lavie ex van Uden & Vidal-Leiria) S.A. Meyer & Yarrow (1978)
17. *Candida arabinofermentans* Kurtzman & Dien (1998)
18. *Candida arcana* S.-O. Suh & M. Blackwell (2005)
19. *Candida asparagi* Bai & Lu (2004)
20. *Candida atakaporum* S.-O. Suh & M. Blackwell (2004)
21. *Candida atbi* S.-O. Suh, N.H. Nguyen & M. Blackwell (2006)

22. *Candida athensis* S.-O. Suh & M. Blackwell (2004)
23. *Candida atlantica* (Siepmann) S.A. Meyer & Simone ex S.A. Meyer & Yarrow (1998)
24. *Candida atmosphaerica* Santa María (1959)
25. *Candida auringiensis* Santa María (1978)
26. *Candida aurita* Polyakova & Chernov (2002)
27. *Candida azyma* (van der Walt, E. Johannsen & Yarrow) S.A. Meyer & Yarrow (1978)
28. *Candida azymoides* Rosa, Morais, Lachance & Trindade (2006)
29. *Candida barrocoloradensis* S.-O. Suh, N.H. Nguyen & M. Blackwell (2006)
30. *Candida batistae* Rosa, Viana, Martins, Antonini & Lachance (1999)
31. *Candida bentonensis* Kurtzman (2005)
32. *Candida berthetii* Boidin, Pignal, Mermier & Arpin (1963)
33. *Candida bituminiphila* Robert, Bonjean, Karutz, Paschold, Peeters & Wubboldts (2001)
34. *Candida blankii* H.R. Buckley & van Uden (1968)
35. *Candida blattariae* S.-O. Suh, N.H. Nguyen & M. Blackwell (2005)
36. *Candida bohiensis* S.-O. Suh, N.H. Nguyen & M. Blackwell (2008)
37. *Candida boidinii* C. Ramírez (1953)
38. *Candida bokatorum* S.-O. Suh & M. Blackwell (2004)
39. *Candida boleticola* Nakase (1971)
40. *Candida bolitotheri* S.-O. Suh & M. Blackwell (2004)
41. *Candida bombi* Montrocher (1967)
42. *Candida bombiphila* Brysch-Herzberg & Lachance (2004)
43. *Candida boreocarlinsensis* Kurtzman (2007)
44. *Candida bracarenensis* Correia, P. Sampaio, James & Pais (2006)
45. *Candida bibrorum* S.-O. Suh & M. Blackwell (2004)
46. *Candida bromeliacearum* Ruivo, Pagnocca, Lachance & Rosa (2005)
47. *Candida buenavistaensis* S.-O. Suh, N.H. Nguyen & M. Blackwell (2008)
48. *Candida buinensis* Soneda & S. Uchida (1971)
49. *Candida californica* (Anderson & Skinner) Bai, Wu & Robert (2006)
50. *Candida canberrae* Kurtzman (2001)
51. *Candida carpophila* Phaff & M.W. Miller Vaughan-Martini, Kurtzman, S.A. Meyer & O'Neill (2005)
52. *Candida caryicola* Kurtzman (2001)
53. *Candida caseinolytica* Phaff, Starmer, Lachance & Ganter (1994)
54. *Candida castellii* (Capriotti) S.A. Meyer & Yarrow (1978)
55. *Candida castrensis* C. Ramírez & A. González (1984)
56. *Candida catenulata* Diddens & Lodder (1942)
57. *Candida cellae* Pimentel, Lachance & Rosa (2005)
58. *Candida cerambycidarum* S.-O. Suh, N.H. Nguyen & M. Blackwell (2005)
59. *Candida chickasaworum* S.-O. Suh & M. Blackwell (2004)
60. *Candida chilensis* Grinbergs & Yarrow (1970)
61. *Candida choctaworum* S.-O. Suh & M. Blackwell (2004)
62. *Candida chrysomelidarum* N.H. Nguyen, S.-O. Suh, Erbil & M. Blackwell (2006)
63. *Candida cidri* Kurtzman, Robnett & Yarrow (2001)
64. *Candida coipomoensis* C. Ramírez & A. González (1984)
65. *Candida conglobata* (Redaelli) van Uden & H.R. Buckley ex S.A. Meyer & Ahearn (1983)
66. *Candida cretensis* Middelhoven & Kurtzman (2007)
67. *Candida cylindracea* K. Yamada & Machida ex S.A. Meyer & Yarrow (1998)
68. *Candida dajiensis* Lee & Liu (2008)
69. *Candida davenportii* Stratford, Bond, James, Roberts & Steels (2002)
70. *Candida deformans* Langeron & Guerra (1938)
71. *Candida dendrica* (van der Walt, van der Klift & D.B. Scott) S.A. Meyer & Yarrow (1978)
72. *Candida dendronema* van der Walt, van der Klift & D.B. Scott (1971)
73. *Candida derodonti* S.-O. Suh & M. Blackwell (2005)
74. *Candida diddensiae* (Phaff, Mrak & Williams) Fell & S.A. Meyer ex S.A. Meyer & Ahearn (1983)
75. *Candida digboiensis* G.S. Prasad, Mayilraj, Sood & Lal (2005)
76. *Candida diospyri* Bai & Lu (2004)
77. *Candida diversa* Y. Ohara, Nonomura & Yunome ex van Uden & H.R. Buckley (1970)
78. *Candida drosophilae* Lachance, Rosa, Starmer, Schlag-Edler, Barker & Bowles (1998)
79. *Candida dubliniensis* Sullivan, Westerneng, Haynes, Bennett & Coleman (1995)
80. *Candida easanensis* Jindamorakot, Thuy & Nakase (2004)
81. *Candida elateridarum* S.-O. Suh & M. Blackwell (2004)
82. *Candida emberorum* S.-O. Suh & M. Blackwell (2004)

83. *Candida endomycidarum* S.-O. Suh, N.H. Nguyen & M. Blackwell (2005)
84. *Candida entomophila* D.B. Scott, van der Walt & van der Klift (1971)
85. *Candida ergatensis* Santa María (1971)
86. *Candida etchellsii* (Lodder & Kreger-van Rij) S.A. Meyer & Yarrow (1978)
87. *Candida ethanolica* Rybářová, Štros & Kocková-Kratochvílová (1980)
88. *Candida fennica* (Sonck & Yarrow) S.A. Meyer & Ahearn (1983)
89. *Candida fermenticarens* van der Walt & P.B. Baker (1978)
90. *Candida floccosa* Péter, Dlauchy & Tornai-Lehoczki (2006)
91. *Candida floricola* Tokuoka, Ishitani, S. Goto & Komagata (1987)
92. *Candida floridensis* Kurtzman (2007)
93. *Candida floris* Rosa, Pagnocca & Lachance (2007)
94. *Candida flosculorum* Rosa, Pagnocca, Lachance, Ruivo & Medeiros (2007)
95. *Candida fluviatilis* Hedrick (1976)
96. *Candida fragi* M. Suzuki, Nakase & Fukazawa (1991)
97. *Candida freyschussii* H.R. Buckley & van Uden (1968)
98. *Candida friedrichii* van Uden & Windisch (1968)
99. *Candida frijolesensis* S.-O. Suh, N.H. Nguyen & M. Blackwell (2008)
100. *Candida fructus* (Nakase) S.A. Meyer & Yarrow (1978)
101. *Candida fukazawae* Nakase, M. Suzuki, Sugita, S.-O. Suh & Komagata (1999)
102. *Candida fungicola* Nakase, M. Suzuki, Sugita, S.-O. Suh & Komagata (1999)
103. *Candida galacta* (Golubev & Bab'eva) F.-L. Lee, C.-F. Lee, Okada, Komagata & Kozak (1993)
104. *Candida galis* Lachance (2001)
105. *Candida galli* Péter, Dlauchy, Vasdinyei, Tornai-Lehoczki & Deák (2004)
106. *Candida gatunensis* S.-O. Suh, N.H. Nguyen & M. Blackwell (2006)
107. *Candida gelsemii* Lachance (2007)
108. *Candida geochares* (van der Walt, E. Johannsen & Yarrow) S.A. Meyer & Yarrow (1978)
109. *Candida germanica* Kurtzman, Robnett & Yarrow (2001)
110. *Candida ghanaensis* Kurtzman (2001)
111. *Candida gigantensis* S.-O. Suh, N.H. Nguyen & M. Blackwell (2008)
112. *Candida glabrata* (Anderson) S.A. Meyer & Yarrow (1978)
113. *Candida glabrosa* Komagata & Nakase (1965)
114. *Candida glucosophila* Tokuoka, Ishitani, S. Goto & Komagata (1987)
115. *Candida gorgasii* S.-O. Suh, N.H. Nguyen & M. Blackwell (2005)
116. *Candida gotoi* Nakase & Suzuki (1997)
117. *Candida grinbergsii* Kurtzman (2007)
118. *Candida gropengiesseri* (Harrison) S.A. Meyer & Yarrow (1978)
119. *Candida guaymorum* S.-O. Suh & M. Blackwell (2004)
120. *Candida haemulonii* (van Uden & Kolipinski) S.A. Meyer & Yarrow (1978)
121. *Candida hawaiiiana* Lachance, Bowles & Starmer (2003)
122. *Candida heliconiae* Ruivo, Pagnocca, Lachance & Rosa (2006)
123. *Candida hispaniensis* Kurtzman (2005)
124. *Candida hollandica* Knutsen, V. Robert & M.Th. Smith (2007)
125. *Candida homilientoma* van der Walt & Nakase (1973)
126. *Candida humilis* (E.E. Nel & van der Walt) S.A. Meyer & Yarrow (1978)
127. *Candida hungarica* Péter, Tornai-Lehoczki, Fülöp & Dlauchy (2003)
128. *Candida hyderabadensis* Rao, Bhadra, Kumar & Shivaji (2007)
129. *Candida incommunis* Y. Ohara, Nonomura & T. Yamazaki (1965)
130. *Candida inconspicua* (Lodder & Kreger-van Rij) S.A. Meyer & Yarrow (1978)
131. *Candida infanticola* Kurtzman (2007)
132. *Candida insectalens* (D.B. Scott, van der Walt & van der Klift) S.A. Meyer & Yarrow (1978)
133. *Candida insectamans* D.B. Scott, van der Walt & van der Klift (1972)
134. *Candida insectorum* D.B. Scott, van der Walt & van der Klift (1972)
135. *Candida insectosa* (Kurtzman) Kurtzman (2010)
136. *Candida intermedia* (Ciferri & Ashford) Langeron & Guerra (1938)
137. *Candida ipomoeae* Lachance, Rosa, Starmer & Bowles (1998)
138. *Candida ishiwadae* Sugiyama & S. Goto (1969)
139. *Candida jeffriesii* N.H. Nguyen, S.-O. Suh & M. Blackwell (2006)
140. *Candida jianshihensis* C.F. Lee & Liu (2008)
141. *Candida kipukae* Lachance, Bowles & Starmer (2003)
142. *Candida kofuensis* Mikata, Ueda-Nishimura, Goto, Kurtzman, M. Suzuki, Yarrow & Nakase (1999)
143. *Candida krabiensis* Limtong, Srisuk, Yongmanitchai, Kawasaki, Yurimoto, Nakase & Kato (2004)

144. *Candida kruisii* (Kocková-Kratochvílová & Ondrušová) S.A. Meyer & Yarrow (1978)
145. *Candida kunorum* S.-O. Suh & M. Blackwell (2004)
146. *Candida labiduridarum* S.-O. Suh, N.H. Nguyen & M. Blackwell (2008)
147. *Candida lactis-condensi* (B.W. Hammer) S.A. Meyer & Yarrow (1978)
148. *Candida lassenensis* Kurtzman (1999)
149. *Candida leandrae* Ruivo, Pagnocca, Lachance & Rosa (2004)
150. *Candida lessepsii* S.-O. Suh, N.H. Nguyen & M. Blackwell (2005)
151. *Candida lignohabitans* Kurtzman (2007)
152. *Candida lignosa* (Kurtzman) Kurtzman (2010)
153. *Candida linzhiensis* Bai & Wu (2006)
154. *Candida litsaeae* Kurtzman (2001)
155. *Candida llanquihuensis* C. Ramírez & A. González (1984)
156. *Candida lycoperdinae* S.-O. Suh, N.H. Nguyen & M. Blackwell (2006)
157. *Candida lyxosophila* van der Walt, N.P. Ferreira & Steyn (1987)
158. *Candida magnoliae* (Lodder & Kreger-van Rij) S.A. Meyer & Yarrow (1978)
159. *Candida maltosa* Komagata, Nakase & Katsuya (1964)
160. *Candida marilandica* Kurtzman (2007)
161. *Candida marionensis* Kurtzman (2007)
162. *Candida maris* (van Uden & Zobell) S.A. Meyer & Yarrow (1978)
163. *Candida maritima* (Siepmann) van Uden & H.R. Buckley ex S.A. Meyer & Ahearn (1983)
164. *Candida maxii* S.-O. Suh & M. Blackwell (2004)
165. *Candida melibiosica* H.R. Buckley & van Uden (1968)
166. *Candida membranifaciens* (Lodder & Kreger-van Rij) Wickerham & K.A. Burton (1954)
167. *Candida mesenterica* (Geiger) Diddens & Lodder (1942)
168. *Candida metapsilosis* Tavanti, Davidson, Gow, Maiden & Odds (2005)
169. *Candida methanosorbosa* (Abe & Yokote) J.A. Barnett, R.W. Payne & Yarrow (1983)
170. *Candida michaelii* S.-O. Suh, N.H. Nguyen & M. Blackwell (2005)
171. *Candida milleri* Yarrow (1978)
172. *Candida mogii* Vidal-Leiria (1967)
173. *Candida montana* S. Goto & Oguri (1983)
174. *Candida mucifera* Ueda-Nishimura & Mikata (2002)
175. *Candida multigemmis* (Buhagiar) S.A. Meyer & Yarrow (1978)
176. *Candida musae* (Nakase) S.A. Meyer & Yarrow (1978)
177. *Candida mycetangii* Kurtzman (2000)
178. *Candida naeodendra* van der Walt, E. Johannsen & Nakase (1973)
179. *Candida nakhonratchasimensis* Jindamorakot & Nakase (2004)
180. *Candida nanaspora* Saëz & Rodrigues de Miranda (1988)
181. *Candida natalensis* van der Walt & Tscheuschner (1957)
182. *Candida neerlandica* Kurtzman, Robnett & Yarrow (2001)
183. *Candida nemodendra* (van der Walt, van der Klift & D.B. Scott) S.A. Meyer & Yarrow (1978)
184. *Candida neomexicana* Kurtzman (2007)
185. *Candida nitratoiphila* (Shifrine & Phaff) S.A. Meyer & Yarrow (1978)
186. *Candida nivariensis* Alcoba-Flórez, Méndez-Álvarez, Cano, Guarro, Pérez-Roth & Arévalo (2005)
187. *Candida norvegica* (Reiersøl) S.A. Meyer & Yarrow (1978)
188. *Candida novakii* Péter, Tornai-Lehocski & Deák (1997)
189. *Candida odintsovae* Bab'eva, Reshetova, Blagodatskaya & Galimova (1989)
190. *Candida oleophila* Montrocher (1967)
191. *Candida ontarioensis* Kurtzman & Robnett (1998)
192. *Candida orba* Starmer, Phaff, Ganter & Lachance (2001)
193. *Candida oregonensis* Phaff & do Carmo-Sousa (1962)
194. *Candida orthopsilosis* Tavanti, Davidson, Gow, Maiden & Odds (2005)
195. *Candida ortonii* Lachance (2001)
196. *Candida oslonensis* Knutsen, V. Robert & M.Th. Smith (2007)
197. *Candida ovalis* Kumamoto & Yamamoto (1986)
198. *Candida pallodes* S.-O. Suh, N.H. Nguyen & M. Blackwell (2006)
199. *Candida palmioleophila* Nakase & M. Itoh (1988)
200. *Candida paludigena* Golubev & Blagodatskaya (1981)
201. *Candida panamensis* S.-O. Suh, N.H. Nguyen & M. Blackwell (2006)
202. *Candida panamericana* S.-O. Suh & M. Blackwell (2004)
203. *Candida parapsilosis* (Ashford) Langeron & Talice (1932)
204. *Candida pararugosa* Nakase, Komagata & Fukazawa (1978)

205. *Candida pattaniensis* Jindamorakot, Duy & Nakase (2004)
206. *Candida peltata* (Yarrow) S.A. Meyer & Ahearn (1983)
207. *Candida peoriensis* Kurtzman (2001)
208. *Candida petrohuensis* C. Ramírez & A. González (1984)
209. *Candida picachoensis* S.-O. Suh, Gibson & M. Blackwell (2004)
210. *Candida piceae* Kurtzman (2000)
211. *Candida pinguabensis* Ruivo, Pagnocca, Lachance & Rosa (2006)
212. *Candida pignaliae* (F.H. Jacob) S.A. Meyer & Yarrow (1978)
213. *Candida pimensis* S.-O. Suh, Gibson & M. Blackwell (2004)
214. *Candida pini* (Lodder & Kreger-van Rij) S.A. Meyer & Yarrow (1978)
215. *Candida pinicola* Kurtzman (2007)
216. *Candida plutei* S.-O. Suh & M. Blackwell (2005)
217. *Candida polysorbophila* Kurtzman (2007)
218. *Candida pomicola* Kurtzman, Robnett & Yarrow (2001)
219. *Candida ponderosae* Kurtzman (2001)
220. *Candida populi* Hagler, Mendonça-Hagler & Phaff (1989)
221. *Candida powellii* Lachance (2001)
222. *Candida prunicola* Kurtzman (2001)
223. *Candida pseudoglaebosa* M. Suzuki & Nakase (1993)
224. *Candida pseudointermedia* Nakase, Komagata & Fukazawa (1976)
225. *Candida pseudolambica* M.Th. Smith, Poot & Kull (1989)
226. *Candida pseudorhagii* Kurtzman (2005)
227. *Candida psychrophila* (S. Goto, Sugiyama & Iizuka) S.A. Meyer & Yarrow (1978)
228. *Candida pyralidae* Kurtzman (2001)
229. *Candida qinlingensis* Bai & Lu (2004)
230. *Candida quercitrusa* (van Uden & do Carmo-Sousa) S.A. Meyer & Phaff ex S.A. Meyer & Yarrow (1998)
231. *Candida quercuum* Nakase (1971)
232. *Candida railenensis* C. Ramírez & A. González (1984)
233. *Candida rancensis* C. Ramírez & A. González (1984)
234. *Candida restingae* Rosa, Lachance, Starmer, Barker, Bowles & Schlag-Edler (1999)
235. *Candida rhagii* Jurzitza, Kuhlwein & Kreger-van Rij (1960)
236. *Candida riodocensis* Pimentel, Lachance & Rosa (2005)
237. *Candida rugopelliculosa* Nakase (1971)
238. *Candida rugosa* (Anderson) Diddens & Lodder (1942)
239. *Candida sagamina* Nakase, M. Suzuki, Sugita, S.-O. Suh & Komagata (1999)
240. *Candida saitoana* Nakase & M. Suzuki (1985)
241. *Candida sake* (Saito & Oda) van Uden & H.R. Buckley ex S.A. Meyer & Ahearn (1983)
242. *Candida salmanticensis* (Santa María) van Uden & H.R. Buckley ex S.A. Meyer & Ahearn (1983)
243. *Candida santamariae* Montrocher (1967)
244. *Candida santjacobensis* C. Ramírez & A. González (1984)
245. *Candida sanyiensis* Lee & Liu (2008)
246. *Candida saopaulonensis* Ruivo, Pagnocca, Lachance & Rosa (2006)
247. *Candida savonica* Sonck (1974)
248. *Candida schatavii* (Kocková-Kratochvílová & Ondrušová) S.A. Meyer & Yarrow (1978)
249. *Candida scorzettiae* Middelhoven & Kurtzman (2007)
250. *Candida sequanensis* Saëz & Rodrigues de Miranda (1984)
251. *Candida sergipensis* Trindade, Resende, Lachance & Rosa (2004)
252. *Candida shehatae* H.R. Buckley & van Uden (1967)
253. *Candida silvae* Vidal-Leiria & van Uden (1963)
254. *Candida silvanorum* van der Walt, van der Klift & D.B. Scott (1971)
255. *Candida silvatica* (van der Walt, van der Klift & D.B. Scott) S.A. Meyer & Yarrow (1978)
256. *Candida silvicultrix* van der Walt, D.B. Scott & van der Klift (1972)
257. *Candida sinolaborantium* S.-O. Suh, N.H. Nguyen & M. Blackwell (2005)
258. *Candida sithepensis* Limtong, Srisuk, Yongmanitchai, Kawasaki, Yurimoto, Nakase & Kato (2004)
259. *Candida smithsonii* S.-O. Suh & M. Blackwell (2004)
260. *Candida sojae* Nakase, M. Suzuki, Takashima, Miyakawa, Kagaya, Fukazawa & Komagata (1994)
261. *Candida solani* Lodder & Kreger-van Rij (1952)
262. *Candida sonorensis* (M.W. Miller, Phaff, Miranda, Heed & Starmer) S.A. Meyer & Yarrow (1978)
263. *Candida sophiae-reginae* C. Ramírez & A. González (1984)
264. *Candida sorbophila* (Nakase) S.A. Meyer & Yarrow (1978)
265. *Candida sorbosivorans* James, Bond & Roberts (2001)

266. *Candida sorboxylosa* Nakase (1971)
267. *Candida spandovensis* (Henninger & Windisch) S.A. Meyer & Yarrow (1978)
268. *Candida spencermartinsiae* Statzell-Tallman, Scorzetti & Fell (2010)
269. *Candida stellata* (Kroemer & Krumbholz) S.A. Meyer & Yarrow (1978)
270. *Candida stellimalicola* M. Suzuki, Nakase & Komagata (1994)
271. *Candida stri* S.-O. Suh, N.H. Nguyen & M. Blackwell (2006)
272. *Candida subhashii* M. Groenewald, Sigler, Richardson & Sugiyama (2009)
273. *Candida succiphila* J.-D. Lee & Komagata (1980)
274. *Candida suecica* Rodrigues de Miranda & Norkrans (1968)
275. *Candida suzukii* Péter, Tornai-Lehoczki, Fülöp & Dlačny (2003)
276. *Candida takamatsuzukensis* Nagatsuka, Kiyuna, Kigawa & Sugiyama (2009)
277. *Candida taliae* S.-O. Suh & M. Blackwell (2004)
278. *Candida tammaniensis* Kurtzman & Robnett (1998)
279. *Candida tanzawaensis* Nakase & M. Itoh (1988)
280. *Candida tartarivorans* Fonseca, Fell, Kurtzman & Spencer-Martins (2000)
281. *Candida taylori* Statzell-Tallman, Scorzetti & Fell (2010)
282. *Candida temnochilae* S.-O. Suh, N.H. Nguyen & M. Blackwell (2005)
283. *Candida tenuis* Diddens & Lodder (1942)
284. *Candida tepae* Grinbergs (1967)
285. *Candida terraborum* S.-O. Suh & M. Blackwell (2004)
286. *Candida tetrigidarum* S.-O. Suh, N.H. Nguyen & M. Blackwell (2008)
287. *Candida thaimueangensis* Limtong, Yongmanitchai, Kawasaki & Seki (2007)
288. *Candida tibetensis* Bai & Wu (2006)
289. *Candida tilneyi* Lachance (2001)
290. *Candida tolerans* Lachance, Bowles, Starmer & Barker (1999)
291. *Candida torresii* (van Uden & Zobell) S.A. Meyer & Yarrow (1978)
292. *Candida transvaalensis* Kurtzman (2007)
293. *Candida tritomae* S.-O. Suh, N.H. Nguyen & M. Blackwell (2006)
294. *Candida tropicalis* (Castellani) Berkhout (1923)
295. *Candida trypodendroni* Kurtzman and Robnett (1998)
296. *Candida tsuchiyae* Nakase & M. Suzuki (1985)
297. *Candida tumulicola* Nagatsuka, Kiyuna, Kigawa & Sugiyama (2009)
298. *Candida ubatubensis* Ruivo, Pagnocca, Lachance & Rosa (2005)
299. *Candida ulmi* Kurtzman (2000)
300. *Candida vaccinii* Tokuoka, Ishitani, S. Goto & Komagata (1987)
301. *Candida vadensis* Middelhoven & Kurtzman (2007)
302. *Candida valdiviana* Grinbergs & Yarrow (1970)
303. *Candida vanderwaltii* (Vidal-Leiria) S.A. Meyer & Yarrow (1978)
304. *Candida vartiovaarae* (Capriotti) van Uden & H.R. Buckley ex S.A. Meyer & Ahearn (1983)
305. *Candida versatilis* (Etchells & T.A. Bell) S.A. Meyer & Yarrow (1978)
306. *Candida viswanathii* Viswanathan & H.S. Randhawa ex R.S. Sandhu & H.S. Randhawa (1962)
307. *Candida wickerhamii* (Capriotti) S.A. Meyer & Yarrow (1978)
308. *Candida wounanorum* S.-O. Suh & M. Blackwell (2004)
309. *Candida wyomingensis* Kurtzman (2000)
310. *Candida xylopsoci* Kurtzman (2001)
311. *Candida yuanshanicus* Lee & Liu (2008)
312. *Candida yuchorum* S.-O. Suh & M. Blackwell (2004)
313. *Candida zemplinina* Sipiczki (2003)
314. *Candida zeylanoides* (Castellani) Langeron & Guerra (1938)

KEY TO SPECIES

A key to species of the genus *Candida* has not been provided because many of the species are phenotypically similar to species assigned to certain teleomorphic genera. Instead, species should be identified using the all-species key placed in Volume 1 of this book.

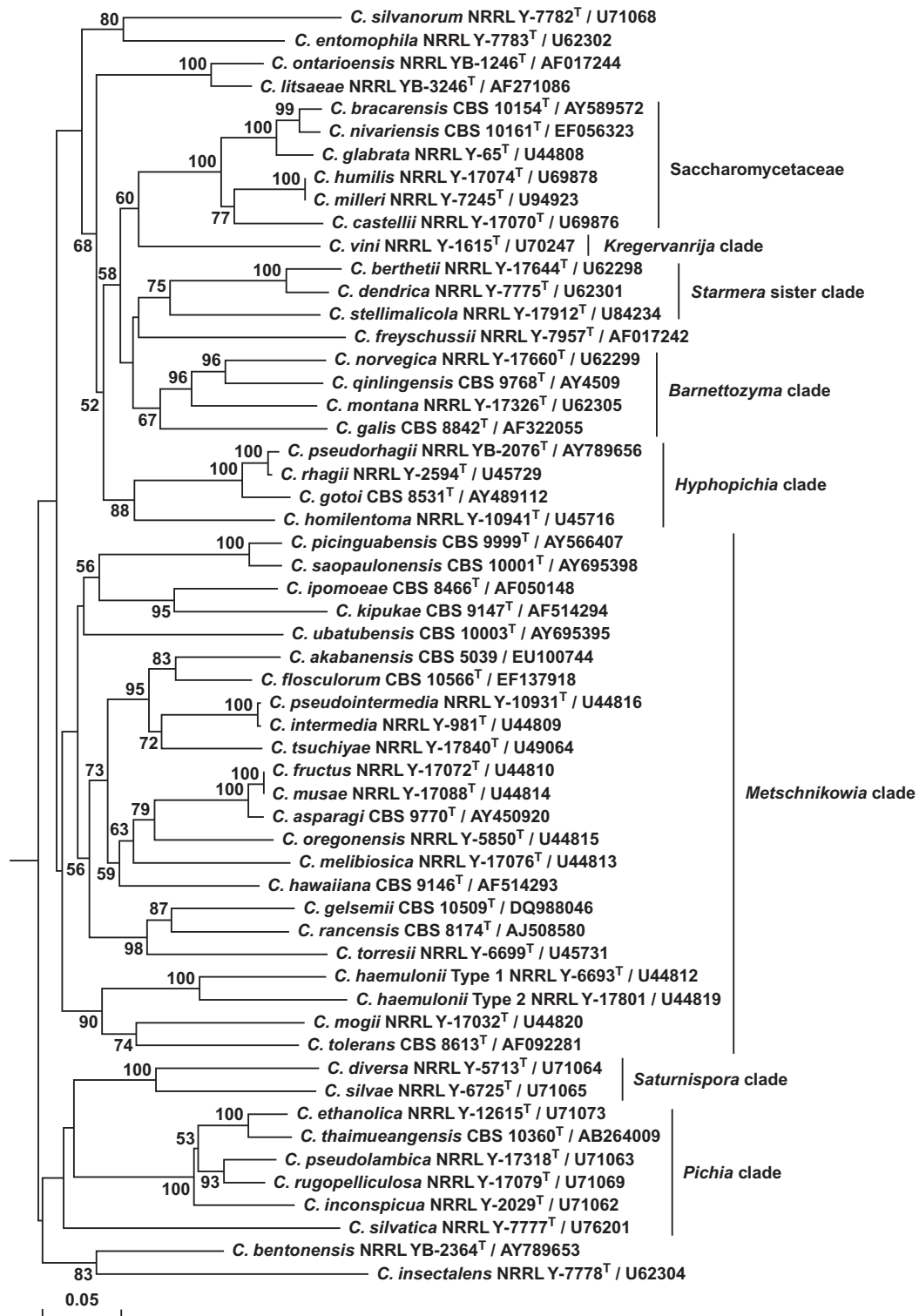


FIGURE 90.1 Phylogram of selected *Candida* species based on neighbor-joining analysis of D1/D2 LSU rRNA gene sequences. Bootstrap support is based on 1000 replicates. Species assigned to the Saccharomycetaceae have teleomorphs in the genera *Nakaseomyces*, *Naumovozyma* and *Kazachstania*. Species assigned to the "Starmera sister clade" were found to be related to *Starmera* species in a multigene analysis (Kurtzman et al. 2008). Relationships with other teleomorphic species are shown in Figs 13.2 and 13.4.

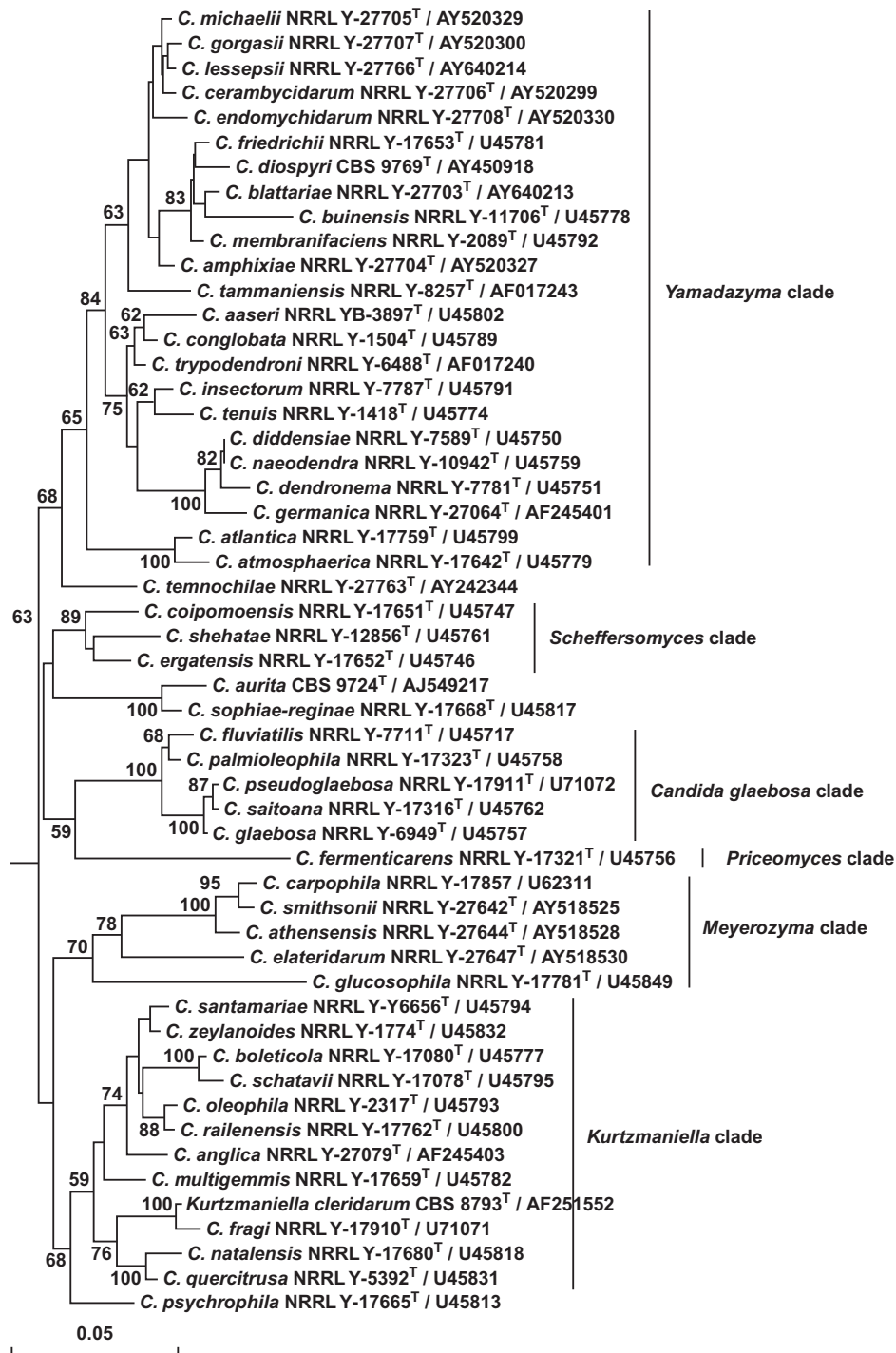


FIGURE 90.2 Phylogram of selected *Candida* species based on neighbor-joining analysis of D1/D2 LSU rRNA gene sequences. Bootstrap support is based on 1000 replicates. Teleomorphic members of the clades shown are given in Fig. 13.5.

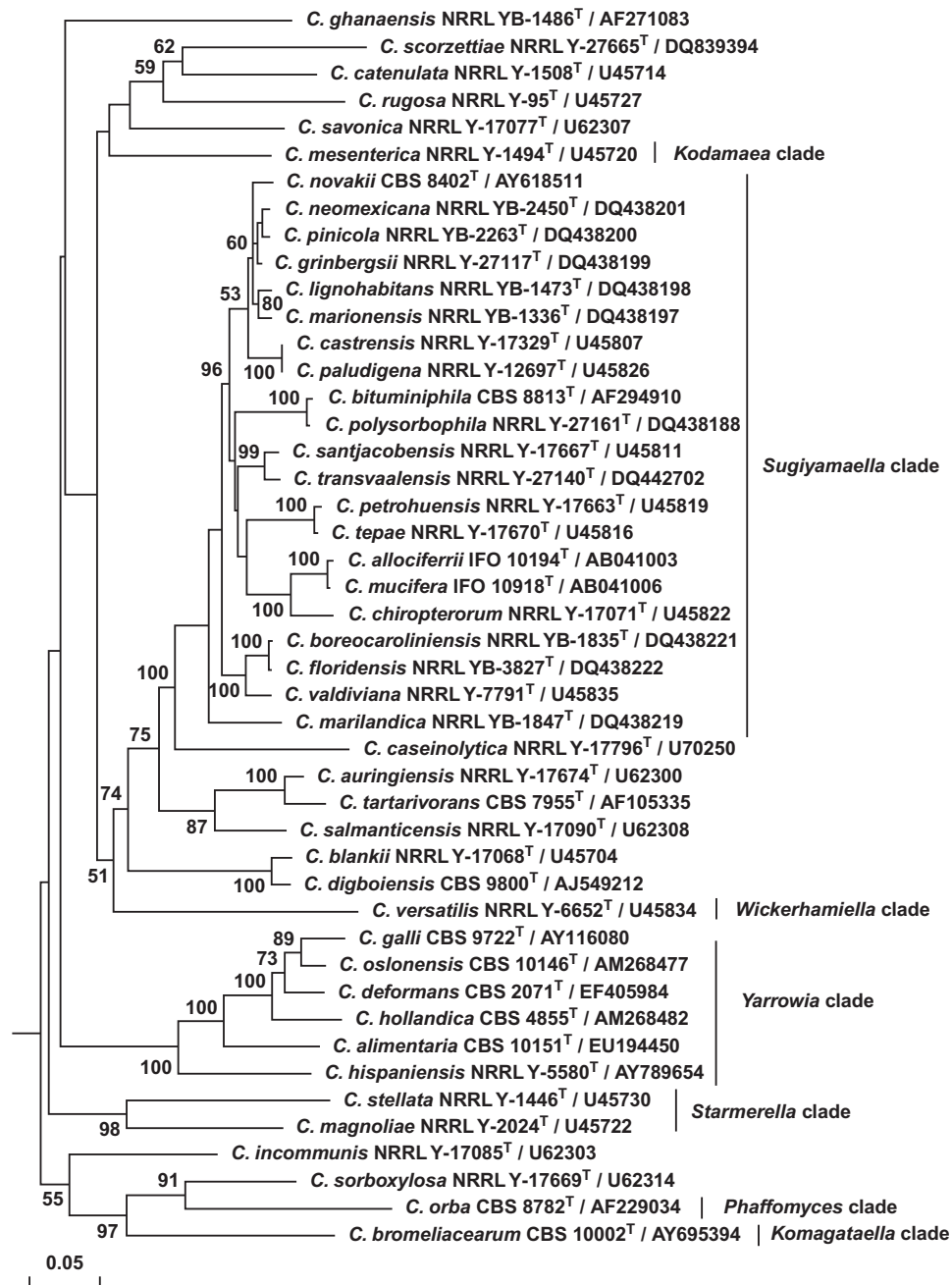


FIGURE 90.3 Phylogram of selected *Candida* species based on neighbor-joining analysis of D1/D2 LSU rRNA gene sequences. Bootstrap support is based on 1000 replicates. Each of the *Kodamaea*, *Starmerella* and *Wickerhamiella* clades is represented by a single *Candida* species. For a full listing, see Figs 13.6, 36.1, 71.1 and 79.1.

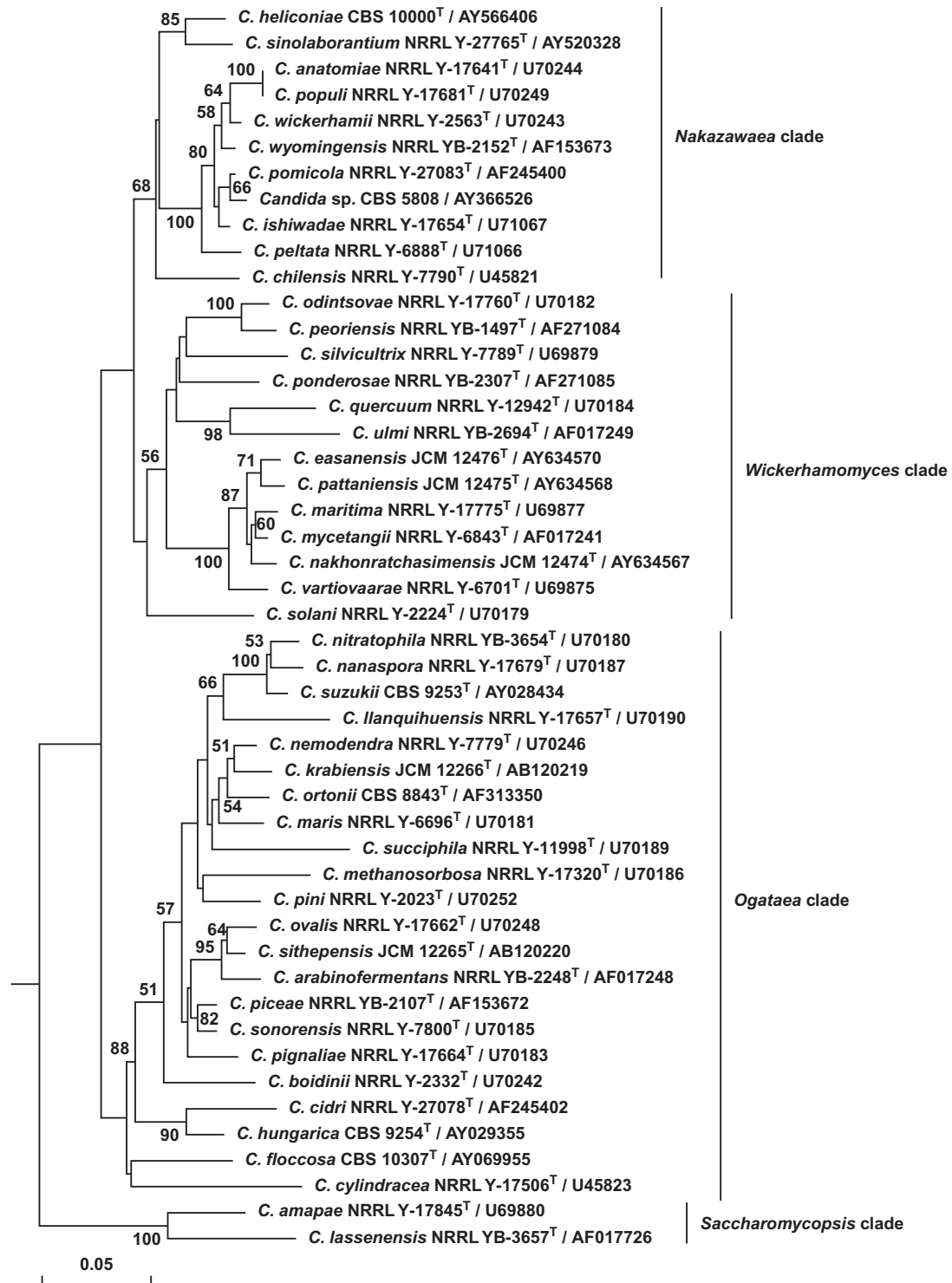


FIGURE 90.4 Phylogram of selected *Candida* species based on neighbor-joining analysis of D1/D2 LSU rRNA gene sequences. Bootstrap support is based on 1000 replicates. Teleomorphic species of the four clades shown are given in Figs 13.2, 13.4, 13.7 and 63.1.

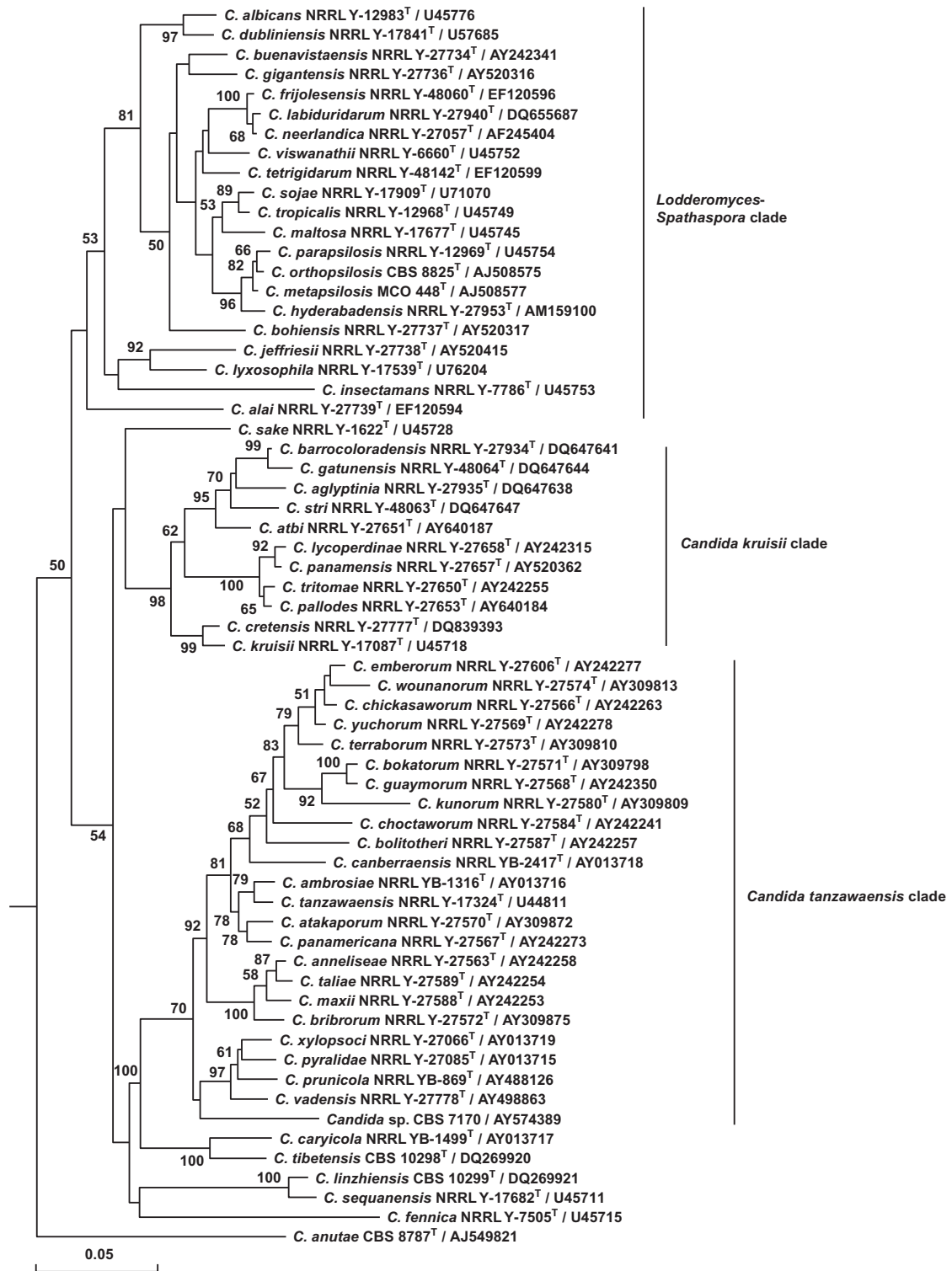


FIGURE 90.5 Phylogram of selected *Candida* species based on neighbor-joining analysis of D1/D2 LSU rRNA gene sequences. Bootstrap support is based on 1000 replicates. Neighboring teleomorphic species for the *Lodderomyces*–*Spathaspora* clade are shown in Fig. 13.5.

SYSTEMATIC DISCUSSION OF THE SPECIES

90.1. *Candida aaseri* Dietrichson ex van Uden & H.R. Buckley (1970)**Phylogenetic placement:** *Yamadazyma* clade (Figs 81.1, 90.2).**Synonyms:**¹*Azymocandida aaseri* (Dietrichson) Novák & Zsolt (1961)*Candida butyri* Nakase (1971b)¹ Synonymy is based on D1/D2 LSU rRNA gene sequences (Kurtzman and Robnett 1998a).**Growth on YM agar:** After 3 days at 25°C, the cells are subglobose, ovoid to elongate, 4–6 × 4–7 µm, and occur singly, in pairs, clusters and chains (Fig. 90.6 left). Pseudohyphae may be present.**Growth in glucose–yeast extract broth:** After 3 days at 25°C, the cells are elongate, 2.5–3 × 7–15 µm, and occur in chains and clusters. A thin powdery pellicle may be present.**Dalmau plate culture on corn meal agar:** After 2 weeks at 18°C, abundant pseudohyphae are formed (Fig. 90.6 right).**Fermentation**

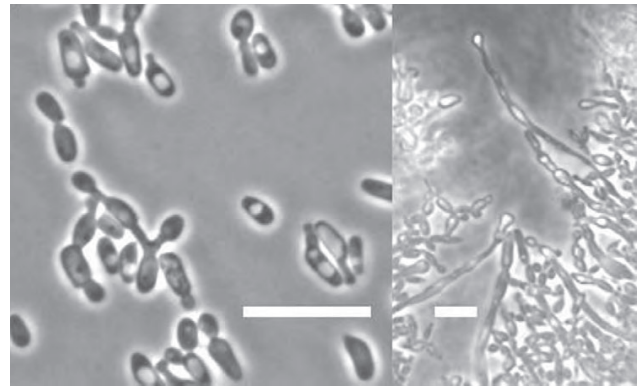
Glucose	v	Lactose	–
Galactose	v	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	v	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	s	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	s
L-Sorbose	s	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	v
L-Arabinose	+	Nitrate	–
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	v
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

**FIGURE 90.6** *Candida aaseri* CBS 1913. Budding cells, 3 days, 25°C, YM agar (left) and pseudohyphae, 2 weeks, 18°C, YCBAS agar (right). Bars = 10 µm.**CoQ:** 9 (Shin et al. 1996).**Mol% G + C:** 37.1, CBS 1913 (T_m : Meyer and Phaff 1972); 34.4, 34.9, 2 strains (T_m : Nakase 1971b); 36.1, CBS 2226 (T_m : von Arx 1979a).**Gene sequence accession number, type strain:** D1/D2 LSU rRNA = U45802.**Cell carbohydrates:** Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).**Origin of the strains studied:** CBS 1913, isolated from sputum, Norway; CBS 2226, from abscess at site of penicillin injection, The Netherlands; CBS 6421, type strain of *Candida butyri*, isolated from butter, Japan.**Type strain:** CBS 1913.**Systematics:** The description of *C. aaseri* by Dietrichson (1954) was validated by van Uden and Buckley (1970), who noted differences between their assimilation results and those in the original description, namely in the utilization of lactose and ethanol. Kurtzman and Robnett (1997) found *C. aaseri* and *C. butyri* to have identical D1/D2 LSU rRNA gene sequences, and Sugita and Nakase (1999) reported identical SSU rRNA gene sequences. The physiological profiles of the two taxa are similar except for the assimilation of D-arabinose and hexadecane, and the fermentation of glucose, which is never vigorous. On that basis, they are treated as members of a single species. Analysis of rRNA gene sequences indicates a close relationship between *C. aaseri* and a number of *Candida* species such as *C. insectorum*, *C. globata* and others, and suggests an affinity with *Yamadazyma mexicana* and relatives.**Ecology:** Unknown.**Biotechnology:** Unknown.**Agriculture and food:** Unknown.**Clinical importance:** Unknown.**90.2. *Candida aglyptinia* S.-O. Suh, N.H. Nguyen & M. Blackwell (Suh et al. 2006a)****Phylogenetic placement:** *Candida kruisii* clade (Fig. 90.5).

(The description is based on Suh et al. 2006a.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, butyrous and smooth.**Growth in YM broth:** After 7 days at 25°C, cells are ellipsoidal to fusiform, 2–4 × 2–6 µm, and occur singly or rarely in pairs and clusters. Pseudohyphae are not present but true hyphae are formed.**Dalmau plate culture on corn meal agar:** After 10 days at 25°C, pseudohyphae and septate hyphae are present. Aerobic growth is off-white and smooth with a filamentous margin.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	d	Trehalose	+
Maltose	d	D-Xylose	—

Growth (in Liquid Media)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	—
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	d	myo-Inositol	—
Methyl- α -D-glucoside	+	D-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	—	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	d	Growth at 30°C	+
2-Keto-D-gluconate	+	Growth at 35°C	—
5-Keto-D-gluconate	n	D-Glucono-1,5-lactone	+
D-Glucuronate	—	Tryptophan	—
L-Arabinitol	—	Quinic acid	—
Arbutin	+	D-Glucarate	—
Propane 1,2 diol	—	Creatine	—
Butane 2,3 diol	—	D-Glucosamine (as N compound)	—
Nitrite	—	Imidazole	—
Cadaverine	+	Growth w/o myo-inositol	+
Creatinine	—	Growth w/o panthotenate	+
L-Lysine	+	Growth w/o biotin	—
Ethylamine	w	Growth w/o thiamine	+
50% Glucose	+	Growth w/o biotin & thiamine	—
10% NaCl/5% glucose	—	Growth w/o pyridoxine	+
16% NaCl	—	Growth w/o pyridoxine & thiamine	+
Starch formation	—	Growth w/o niacin	+
Urease	—	Growth w/o PABA	+
Cycloheximide 0.01%	+	Growth on 1% acetic acid	—
Cycloheximide 0.1%	+	DBB reaction	—

CoQ: Not determined.**Mol% G + C:** Not determined.**Gene sequence accession numbers, type strain:** D1/D2 LSU rRNA = DQ647637, SSU rRNA = DQ647636, ITS and 5.8S rRNA = DQ647638.**Cell carbohydrates:** Not determined.**Origin of the strain studied:** The type strain CBS 10311 (NRRL Y-27935), which is the only known strain of this species, was collected from the guts of small scavenger beetle *Aglyptinus* sp. (Leiodidae: Coleoptera) on a puffball (*Lycoperdon* sp.), Barro Colorado Island, Panama (Suh et al. 2006a).**Type strain:** CBS 10311.

Systematics: *Candida aglyptinia* clusters with eight other *Candida* species in a sister group of *C. kruisii* and CBS 9453 (Suh et al. 2006a). The sister clade is well supported by bootstrap and Bayesian analyses and can be divided in two subclusters comprising respectively *C. aglyptinia*, *C. barrocoloradensis*, *C. gatunensis*, *C. atbi* and *C. stri*, and *C. tritomonae*, *C. pallodes*, *C. lycoperdinae* and *C. panamensis*. The above-mentioned clusters can be distinguished by their reaction to 0.01% and 0.1% cycloheximide. The only exception is *C. kruisii*, which is negative for growth in 0.1% cycloheximide, as the rest of its cluster, but will grow in 0.01% cycloheximide.

Ecology: The type strain, which is the only representative for this species, was isolated from the guts of a beetle.

Biotechnology: Unknown.**Agriculture and food:** Unknown.**Clinical importance:** Unknown, but the species does not grow at 37°C.**Additional comments:** No ascospores were produced after 6 weeks at 17°C on YM agar or on half-strength corn meal agar.

90.3. *Candida akabanensis* Nakase, M. Suzuki, Takashima, Rosadi, Hermosillo & Komagata (1994d)

Phylogenetic placement: *Metschnikowia* clade (Fig. 90.1).

(Some of the morphological characteristics are based on Nakase et al. 1994d.)

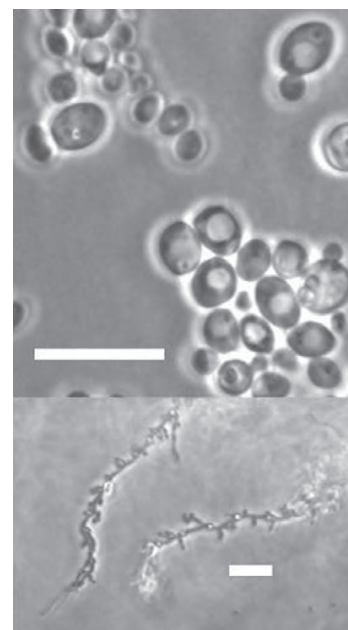
Growth on YM agar: After 1 month at 17°C, the streak culture is white, yellowish-white to yellowish-gray, smooth or slightly wrinkled, dull-shining, soft, with an entire or partly ciliated margin.**Growth in YM broth:** After 3 days at 25°C, cells are spherical to ovoid, 2–5 × 1–6 µm, and occur singly or in pairs (Fig. 90.7 top). A ring and often a thin pellicle are formed.**Dalmeu plate culture on corn meal agar:** After 2 weeks at 18°C, pseudohyphae are formed (Fig. 90.7 bottom).

FIGURE 90.7 *Candida akabanensis* CBS 7878. Budding cells, 3 days, 25°C, YM agar (top) and pseudohyphae, 2 weeks, 18°C, YCBAS agar (bottom). Bars = 10 µm.

Fermentation

Glucose	+/s	Lactose	—
Galactose	+/s	Raffinose	+/w
Sucrose	+/s	Trehalose	n
Maltose	+/s		

Growth (on Agar)

Glucose	+	D-Ribose	w
Inulin	+	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	—
Melibiose	—	Erythritol	—
Galactose	s	Ribitol	s
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	s	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	s
L-Sorbose	—	D-Glucosamine	s
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	—	Nitrate	—
D-Arabinose	w	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	s	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	s	Casein	—
Amino acid-free	+	Lipase	w
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	w	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 9 (Nakase et al. 1994d).

Mol% G + C: 47.0–48.2, 10 strains (HPLC: Nakase et al. 1994d).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = EU100744.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Nakase et al. 1994d).

Origin of the strains studied: CBS 5039 (NRRL Y-27089), isolated from an exudate of dogwood (*Cornus* sp.,) Japan; CBS 7878 (JCM 9115), from frass of insects in bark of grape vine (*Vitis vinifera*, Vitaceae), Japan. UWOPS 06-530.1, from flux of *Acacia* sp. (Fabaceae), Echan Lake, Australia.

Type strain: CBS 7878.

Systematics: Nakase et al. (1994d) isolated several strains of *C. akabanensis* from insect frass in a grape vine. DNA reassociation showed the strains to be identical to one another and genetically distinct from *C. intermedia* and *C. pseudointermedia*, which were thought to be related due to their phenotypic similarity. Sugita and Nakase (1999) substantiated these relationships by SSU sequencing, which further demonstrated that the species is part of a group of *Candida* species with affinities in the Metschnikowiaceae.

Some of the growth characteristics determined by replica plating differed from those in the original description. The utilization of starch, which was reported as weak, and glycerol, as well as growth at 37°C were not observed. The physiological profile is similar to that of related species. *C. akabanensis* can be separated on the utilization of inulin (positive), and the absence of growth on L-arabinose and lactose or in the presence of 50% glucose (negative). Separation from *C. pseudointermedia* is difficult.

Ecology: The species is probably associated with tree-boring insects.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.4. *Candida alai* S.-O. Suh, N.H. Nguyen & M. Blackwell (Suh et al. 2008)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Fig. 90.5). (The description is based on Suh et al. 2008.)

Growth on YM agar: After 7 days at 25°C, colonies are cream colored, smooth, shiny and butyrous.

Growth in YM broth: After 7 days in YM broth at 25°C, cells are globose to subglobose, 3–8 $\times$ 4–8 μ m, and occur singly, in pairs, in short chains or in clusters. Pseudohyphae and true hyphae are not present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae are not present. Aerobic growth is off-white and smooth, with some fuzzy areas on the surface.

Fermentation

Glucose	d	Lactose	—
Galactose	d	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—	D-Xylose	—

Growth (in Liquid Media)

Glucose	+	D-Ribose	d
Inulin	—	Methanol	—
Sucrose	+	Ethanol	w
Raffinose	—	Glycerol	w
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	—
L-Sorbose	—	D-Glucosamine	w
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Cycloheximide 0.1%	—
2-Keto-D-gluconate	+	Growth at 25°C	+
5-Keto-D-gluconate	n	Growth at 37°C	+
D-Glucuronate	—	Growth at 40°C	—
Saccharate	n	D-Glucono-1,5-lactone	—
L-Arabinitol	—	Quinic acid	—

Arbutin	+	D-Glucarate	—
Propane 1,2 diol	d	Creatine	—
Butane 2,3 diol	—	D-Glucosamine (as N compound)	—
Nitrite	—	Imidazole	—
Cadaverine	+	Growth w/o myo-inositol	+
Creatinine	—	Growth w/o panthotenate	+
L-Lysine	+	Growth w/o biotin	—
Ethylamine	+	Growth w/o biotin & thiamine	—
50% Glucose	—	Growth w/o pyridoxine	+
10% NaCl/5% glucose	—	Growth w/o niacin	+
16% NaCl	—	Growth w/o PABA	+
Starch formation	—	Growth on 1% acetic acid	—
Urease	—	DBB reaction	—
Cycloheximide 0.01%	—		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = EF120594, SSU rRNA = EF120579.

Cell carbohydrates: Not determined.

Origin of the strain studied: The type strain CBS 9899 (NRRL Y-27739), which is the only known strain for this species, was collected from the gut of the blind click beetle (*Alaus myops*, Coleoptera: Elateridae) caught under light in Livingston Parish, Louisiana, USA (Suh et al. 2008).

Type strain: CBS 9899.

Systematics: The phylogenetic position of *C. alai* is not yet fully resolved. Although the species was placed near the *C. albicans*/*Lodderomyces elongispora* clade in all analyses using different taxon samplings and analysis methods, no well-supported sister taxa were found (Suh et al. 2008). The species often formed a clade with *C. lyxophila*, *C. jeffriesii* and *Spathaspora passalidarum*, but the placement was not supported by robust bootstrap values or Bayesian analysis.

Ecology: The type strain, which is the only representative for this species, was isolated from the guts of a beetle.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: No ascospores were produced after 6 weeks on half-strength corn meal agar.

90.5. *Candida albicans* (Robin) Berkhout (1923)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Fig. 90.5).
Synonyms:¹

Oidium albicans Robin (1853)
Saccharomyces albicans (Robin) Reess (1877)
Monilia albicans Plaut (1887)
Dermatium albicans (Robin) Laurent (1889)
Monilia albicans (Robin) Zopf (1890)
Endomyces albicans (Robin) Vuillemin (1898)
Parasaccharomyces albicans (Robin) Froilano de Mello (Froilano de Mello and Gonzaga Fernandes 1918)
Monilia albicans (Robin) Zopf var. *non-liquefaciens* Sasakawa (1922)
Myceloblastanion albicans Ota (1928)
Endomyces albicans Okabe (1929)
Endomycopsis albicans (Vuillemin) Dekker (Stelling-Dekker 1931)
Mycotorula albicans (Robin) Langeron & Talice (1932)
Syringospora albicans (Robin) Dodge (1935)
Zymonema albicans (Okabe) Dodge (1935)
Mycotorula albicans (Robin) Langeron & Talice var. *vuillemini* (Landrieu ex Castellani & Chalmers) Redaelli, Ciferri & Cavallero (1938)
Procandida albicans (Robin) Novák & Zsolt (1961)

Syringospora robinii Quinquaud (1868)
Monilia candida Plaut (1885) non Bonorden (1851)
Saccharomyces buccalis Guidi (1896)
Monilia buccalis Niño & Puglisi (1927)
Zymonema buccalis (Niño & Puglisi) Dodge (1935)
Saccharomyces tumefaciens-albus Foulerton (1900)
Myceloblastanion tumefaciens-album Ota (1928)
Cryptococcus harteri Geddoelst (1911)
Parasaccharomyces harteri Verdun (1913)
Monilia harteri (Verdun) Castellani & Chalmers (1913)
Torulopsis harteri (Verdun) Redaelli (1931)
Zymonema harteri (Verdun) Dodge (1935)
Endomyces pinoyi Castellani (1912a)
Monilia pinoyi (Castellani) Castellani & Chalmers (1913)
Blastodendron pinoyi (Castellani) Langeron & Talice (1932)
Myceloblastanion pinoyi (Castellani) Ota (1928)
Candida pinoyi (Castellani) Basgal (1931)
Mycotorula pinoyi (Castellani) Saggese (1934)
Endomyces faecalis Castellani (1912b)
Parendomyces albus Queyrat & Laroche (1909)
Monilia alba (Queyrat & Laroche) Brumpt (1913)
Monilia decolorans Castellani & Low (1913)
Myceloblastanion decolorans (Castellani & Low) Ota (1928)
Castellania decolorans (Castellani & Low) Dodge (1935)
Endomyces vuillemini Landrieu (1912)
Guilliermondella vuillemini (Lindau) Dodge (1935)
Endomyces pulmonalis Castellani (1913)
Endomyces pulmonalis Senez (1918) non Castellani (1913)
Monilia pulmonalis (Castellani) Castellani & Chalmers (1913)
Candida pulmonalis (Castellani) Basgal (1931)
Castellania pulmonalis (Castellani) Dodge (1935)
Saccharomyces unguium Bourgeois (1915)
Oidiomyces unguium Frei (1921)
Onychomyces unguium Ota (1924a) nom. nud.
Monilia metchnikoffi Castellani (1916)
Castellania metchnikoffi (Castellani) Dodge (1935)
Monilia balcanica Castellani (1916)
Monilia psilosis Ashford (1917)
Myceloblastanion psilose (Ashford) Ota (1928)
Candida psilosis (Ashford) de Almeida (1933)
Syringospora psilosis (Ashford) Dodge (1935)
Parasaccharomyces ashfordi Anderson (1917)
Myceloblastanion ashfordi (Anderson) Ota (1928)
Monilia ashfordi (Anderson) Langeron & Talice (1932)
Monilia alba Castellani & Chalmers (1919)
Castellania alba (Castellani & Chalmers) Dodge (1935)
Monilia metalondinensis Castellani & Chalmers var. *alba* (Castellani & Chalmers) Castellani (1937a)
Monilia metalondinensis Castellani & Chalmers (1919)
Candida metalondinensis (Castellani & Chalmers) Berkhout (1923)
Myceloblastanion metalondinense (Castellani & Chalmers) Ota (1928)
Castellania metalondinensis (Castellani & Chalmers) Dodge (1935)
Candida albicans (Robin) Berkhout var. *metalondinensis* (Castellani & Chalmers) Ciferri (1960)
Monilia bethaliensis Pijper ex Castellani & Chalmers (1919)
Myceloblastanion bethaliensis Ota (1928)
Candida bethaliensis (Pijper) Dodge (1935)
Endomyces tropicalis Acton (1919) non Castellani (1911)
Actonia tropicalis (Acton) Dodge (1935)
Monilia nabarroii Castellani & Chalmers (1919)
Myceloblastanion nabarroii (Castellani & Chalmers) Ota (1928)
Castellania nabarroii (Castellani & Chalmers) Dodge (1935)
Monilia pinoyi (Castellani) Castellani & Chalmers (1913) var. *nabarroii* Castellani & Chalmers Castellani (1937a)
Monilia pseudolondinensis Castellani & Chalmers (1919)

- Castellania pseudolondinensis* (Castellani & Chalmers) Dodge (1935)
Monilia metalondinensis Castellani & Chalmers var. *pseudolondinensis* (Castellani & Chalmers) Castellani (1937a)
Monilia pseudolondinoides Castellani & Chalmers (1919)
Castellania pseudolondinoides (Castellani & Chalmers) Dodge (1935)
Monilia pseudometalondinensis Castellani & Chalmers (1919)
Castellania pseudometalondinensis (Castellani & Chalmers) Dodge (1935)
Endomyces actoni Vuillemin (Nannizzi 1934)
Monilia actoni (Vuillemin) Vuillemin (1931)
Monilia pseudoalbicans Neveu-Lemaire (1921)
Myceloblastanion pseudoalbicans (Neveu-Lemaire) Ota (1928)
Mycoderma pseudoalbicans (Neveu-Lemaire) Dodge (1935)
Cryptococcus copellii Froilano de Mello (Froilano de Mello and Gonzaga Fernandes 1918)
Cryptococcus copellii Neveu-Lemaire (1921)
Myceloblastanion copellii (Neveu-Lemaire) Ota (1928)
Torulopsis copellii (Neveu-Lemaire) de Almeida (1933)
Castellania copellii (Neveu-Lemaire) Dodge (1935)
Endomyces molardi Salvat & Fontoynt (1922)
Zymonema molardi (Salvat & Fontoynt) Dodge (1935)
Cryptococcus laryngitidis Sartory, Petges & Claque (1923)
Atelosaccharomyces laryngitidis (Sartory, Petges & Claque) Dodge (1935)
Monilia butantanensis Gomes (1924)
Candida butantanensis (Gomes) Langeron & Talice (1932)
Parendomyces butantanensis (Gomes) Dodge (1935)
Myceloblastanion cutaneum Ota (1924a)
Mycelorrhizodes cutaneum Ota (1924a)
Monilia cutanea (Ota) Nannizzi (1934) non Castellani & Chalmers (1913)
Blastodendron cutaneum (Ota) Dodge (1935)
Syringospora cutanea Dodge (1935)
Myceloblastanion gruetzii Ota (1924a)
Mycelorrhizodes gruetzii Ota (1924a)
Myceloblastanion favrei Ota (1925)
Cryptococcus favrei (Ota) Pollacci & Nannizzi (1929)
Blastodendron favrei (Ota) Langeron & Talice (1932)
Candida favrei (Ota) de Almeida (1933)
Myceloblastanion gifuense Taniguchi (1926)
Blastodendron gifuense (Taniguchi) Dodge (1935)
Blastodendron intestinale Mattlet (1926)
Parasaccharomyces intestinalis (Mattlet) Dodge (1935)
Monilia richmondi Shaw (1926)
Castellania richmondi (Shaw) Dodge (1935)
Mycotorula tonsillae Carnevale-Ricci & Redaelli (Carnevale-Ricci 1926)
?Cryptococcus tonsillarum Nannizzi (1934)
Monilia aldoi Pereira Filho (1927)
Mycotoruloides aldoi (Pereira) Langeron & Talice (1932)
Candida aldoi (Pereira) Castellani & Jacono (1933)
Monilia fiocci Pollacci & Nannizzi (1928)
Myceloblastanion skutetzkii Ota (1928)
Mycocandida skutetzkii (Ota) Dodge (1935)
Monilia mannitofermentans Castellani (1929)
Castellania mannitofermentans (Castellani) Dodge (1935)
Monilia periunguealis Niño (1930)
Parendomyces periunguealis (Niño) Dodge (1935)
Mycotorula periunguealis Niño (1938)
Monilia alvarezsotoi Mazza & Niño (Mazza, Niño, Quintana and Bernasconi 1931)
Zymonema alvarezsotoi (Mazza & Niño) Dodge (1935)
Mycotorula alvarezsotoi (Mazza & Niño) Niño (1938)
Monilia vaginalis Mazza & de los Rios (1931)
Blastodendron erectum Langeron & Talice (1932)
Mycotoruloides ovalis Langeron & Talice (1932)
Mycotoruloides triadis Langeron & Talice (1932)
Monilia triadis (Langeron & Talice) Castellani (1937a)
Candida triadis (Langeron & Talice) Langeron & Guerra (1938)
Monilia inexorabilis Mazza & Palamedi (1932)
Syringospora inexorabilis (Mazza & Palamedi) Dodge (1935)
Blastodendron oosporoides Zach (Wolfram and Zach 1934a)
Parasaccharomyces oosporoides (Zach) Dodge (1935)
Cryptococcus pinosimilis Castellani (1933)
Blastodendron pinosimilis (Castellani) Castellani & Jacono (1933)
Candida pinosimilis (Castellani) Castellani & Jacono (1933)
Monilia pinosimilis (Castellani) Castellani & Jacono (1933)
Mycocandida pinosimilis (Castellani) Redaelli & Ciferri (Ciferri and Redaelli 1935)
Candida desidiosa Ciferri & Redaelli (1935)
Mycoderma desidiosum (Ciferri & Redaelli) Dodge & Moore (1936)
Candida mycotoruloidea Redaelli & Ciferri (Ciferri and Redaelli 1935)
Mycotorula sinensis Reiss (1935)
Mycotorula verticillata Redaelli & Ciferri (Ciferri and Redaelli 1935)
Parasaccharomyces colardi Dodge (1935)
Syringospora hasegawae Dodge (1935)
Syringospora negroni Dodge (1935)
Zymonema album Dodge (1935)
Monilia stellatoidea Jones & Martin (1938)
Candida stellatoidea (Jones & Martin) Langeron & Guerra (1939)
Candida albicans (Robin) Berkhout var. *stellatoidea* (Jones & Martin) Diddens & Lodder (1942)
Procandida stellatoidea (Jones & Martin) Novák & Zsolt (1961)
Syringospora stellatoidea van der Walt (1970b)
Candida truncata Vanbreuseghem (1948)
Candida clausenii Lodder & Kreger-van Rij (1952)
Syringospora clausenii van der Walt (1970a)
Candida intestinalis Batista & Silveira (1959c)
Candida biliaria Batista & Silveira (1959c)
Procandida langeroni (Dietrichson) Novák & Zsolt (1961)
Candida langeroni Dietrichson ex van Uden & H.R. Buckley (1970)
Candida genitalis Batista & Silveira (1962)
Procandida grubyii Novák & Vitéz (1964)
Candida nouvelii Saëz (1973a)
Candida berolinensis Tietz, Hopp, Sterry & Czaika (2001) nom. nud.
Candida africana Tietz, Hopp, Sterry & Czaika (2001)

¹ Synonymy based on phenotypic similarity. The proposed synonymy for several of these taxa was confirmed by multi-locus sequence typing (Jacobsen et al. 2008).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, 3.5–6 × 4–8 µm, and occur singly, in pairs, chains and clusters.

Growth in glucose–yeast extract broth: Rings or pellicles are not formed.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, well-differentiated, branched pseudohyphae with chains or clusters of blastoconidia and septate hyphae are present. Pseudohyphae of the “*Mycotorula*” type are often observed, i.e., grape-like clusters of blastoconidia occurring along the pseudohyphal chains. Chlamydospores are usually present. A few strains fail to form pseudohyphae when first isolated, although most of them demonstrate this ability after being maintained in culture. Aerobic growth is white to cream colored, glistening, usually butyrous, soft and smooth; sometimes growth is membranous.

Fermentation

Glucose	+	Lactose	–
Galactose	v	Raffinose	–
Sucrose	v	Trehalose	v
Maltose	+		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	v	Ethanol	+
Raffinose	—	Glycerol	v
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	v
Lactose	—	Galactitol	—
Trehalose	v	D-Mannitol	+
Maltose	+	D-Glucitol	v
Melezitose	v	myo-Inositol	—
Methyl- α -D-glucoside	v	DL-Lactate	+
Soluble starch	+	Succinate	+
Cellobiose	—	Citrate	+
Salicin	—	D-Gluconate	v
L-Sorbose	v	D-Glucosamine	v
L-Rhamnose	—	N-Acetyl-D-glucosamine	v
D-Xylose	+	Hexadecane	v
L-Arabinose	v	Nitrate	—
D-Arabinose	v	Vitamin-free	v

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	v	Casein	—
Amino acid-free	+	Lipase	s
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	v	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	+

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 34.9, CSAV 29-31-1; 35.1, CBS 2712; 35.7, CBS 1905; 36.9, CBS 1899 (T_m : Stenderup and Bak 1968); 34.4–35.4, seven strains (Nakase and Komagata 1971f); 35.9–37.3, four strains (T_m : Meyer and Phaff 1972); 34.3–35.6, 15 strains (T_m : Meyer et al. 1984); 32.6–34.2, 34 strains (T_m : Kamiyama et al. 1989); 35.6, 35.9, two strains (T_m : Su and Meyer 1991).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45776.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 8781, type of *C. africana*, was isolated from a patient with balanitis, Germany; UWOPS 83-936.1 and several others, from fruit of *Stenocereus hystrix* (Cactaceae), Jamaica; UWOPS 99.1, from sputum, Ontario, Canada; UWOPS 99-711.1, from flower of African tulip tree (*Spathodea campanulata*, Bignoniaceae), Rarontonga, Cook Islands.

Other strains: CBS 562, from skin infection (Mackinnon 1936); CBS 1894, from soil, New Zealand; CBS 1899, from skin, received as *C. truncata* (Vanbreuseghem 1948); CBS 1905, type strain of *Monilia stellatoidea*; CBS 1912, type strain of *C. langeroni*, from sputum; CBS 1918, probably from human, N.F. Conant; CBS 1949, type strain of *C. clausenii* and *Syringospora clausenii*; CBS 2689, type strain of *Myceloblastanion gruetzii* from interdigital mycosis; CBS 2691, from pharyngitis, received as *Saccharomyces tumefaciens-albus*; CBS 2693, from nail; CBS 2694, origin unknown.; CBS 2695, authentic strain of *Monilia psilosis*, from sprue; CBS 2697, type strain of *Mycotoruloides triadis*, from sputum; CBS 2703, type strain of *C. mycotoruloides*, from tonsillo-pharyngitis; CBS 2707, type strain of *Monilia alvarezsotoi*,

from blastomycosis; CBS 2711, type strain of *Monilia richmondii*, from sputum; CBS 2721, origin unknown; CBS 2738, from child's mouth; CBS 2740, from leaf; CBS 2770, origin unknown; CBS 2990, from sputum; CBS 5137, type strain of *Syringospora stellatoidea*, from sputum; CBS 5982, serotype A; CBS 5983, serotype B; CBS 5990, from vagina; CBS 6073, from sputum; CBS 6431, from bronchomycosis; CBS 6552, from pharynx of a bay duiker (*Cephalophus dorsalis*), type strain of *C. novellii*; CBS 6589, from vagina; CBS 6910, from urine.

Type strain: CBS 562.

Systematics: *Candida albicans* is the most studied of all *Candida* species. Much of the research is directed toward opportunistic or pathogenic aspects of this species, treatment of infections and epidemiology. A large number of *C. albicans* strains are isolated routinely from clinical sources. The degree of variability has been reported repeatedly using various techniques. The terms "typical" and "atypical" are frequently used. Besides the usual morphological and physiological characterization, *C. albicans* has been studied with numerous molecular techniques to determine strain identity and strain variability. The methods include restriction fragment length polymorphisms (RFLPs), karyotypes, DNA probes, randomly amplified polymorphic DNA (RAPD) analysis, nuclear DNA reassociation, mitochondrial DNA RFLP and base composition, protein electrophoretic profiles, as well as gene sequence analyses of all sorts, including multilocus sequence typing (MLST) and genomic studies.

The conspecificity of *C. albicans* and *C. stellatoidea* was established by DNA reassociation (Kamiyama et al. 1989, Meyer 1979) and corroborated by other studies (Jacobsen et al. 2008, Montrocher 1980). However, Kwon-Chung et al. (1988) showed two distinct karyotype profiles for strains of *C. stellatoidea*. They were designated as type I and type II. Mahrous et al. (1990) demonstrated that phenotypically diverse, but authentic strains of *C. albicans* were polymorphic in their karyotypes. Sullivan et al. (1995) showed that the nucleotide sequences of the D1/D2 (V3) LSU rRNA genes of *C. stellatoidea* type I and type II are identical and differ from five other strains of *C. albicans* at only one or two nucleotide positions. Jacobsen et al. (2008) provided further confirmation of the conspecificity of *C. stellatoidea*, but did identify a significant genetic divergence for *C. stellatoidea* type I strains on the basis of multilocus sequence typing, suggesting that a variety status might be warranted for those strains.

Tietz et al. (2001) described *C. africana* (syn. *C. berolinensis*) to accommodate variant strains isolated from patients in Angola, Madagascar and Germany. The main justification was the lack of pseudohyphae and chlamydospores, generally poor growth, and absence of growth on trehalose, methyl- α -D-glucoside, lactic acid, glucosamine and N-acetyl-D-glucosamine. In addition, cluster analysis of infrared spectroscopic data separated the strains not only from *C. albicans*, but also from strains of *C. dubliniensis* and *C. sake*. Interestingly, the pattern observed for *C. dubliniensis* and typical strains of *C. albicans* clustered together at the exclusion of strains assigned by the authors to *C. africana*. In the present study, examination of the type strain by replica plating showed that it is able to grow on lactic acid and trehalose, but confirmed the other differences, most of which had been reported as variable in *C. albicans* by Meyer et al. (1998). The sequences of the ITS/5.8S and D1/D2 LSU rRNA gene regions were determined (AY342214) and found to be typical of the various *C. albicans* sequences found in GenBank. The types of *C. africana* and *C. albicans* differed by two substitutions and two gaps in the ITS regions and a single substitution in the D2 domain. Forche et al. (1999) conducted a detailed study of gene polymorphisms in typical and atypical (Angola and Madagascar) populations of *C. albicans* and concluded that they are genetically distinct, but closely related. They stated that it is not possible to decide whether these populations represent one, two or even three species based on the currently available data. Jacobsen et al. (2008) reached similar conclusions from their multilocus sequence typing studies. In view of the above, we retain *C. africana* in *C. albicans*.

Analysis of rRNA gene sequences (Kurtzman and Robnett 1998a, Sugita and Nakase 1999) showed that *C. albicans* belongs to a clade that includes *Lodderomyces elongisporus* and several *Candida* species.

The physiological profile of *C. albicans* is variable but characteristic. Discrimination from related species (Fig. 90.5) is difficult. The utilization of starch reduces the number of possible misidentifications to *C. tropicalis*, *C. dubliniensis* and *C. sojae*. In view of the existence of species-specific probes and their ease of application by PCR amplification or related methods, reliance on physiology is not advisable if alternatives are available.

Ecology: Although *C. albicans* is known mostly in association with human ailments, the species is occasionally recovered from decaying plant material (Lachance et al. 2001e), although anthropogenic contamination of these materials cannot be ruled out.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: *Candida albicans* is broadly known as a frequent agent of human mycoses, resulting in a condition called thrush. However, a fair discussion of clinical aspects is beyond the scope of this monograph. The reader is referred to Calderone's (2002) multi-authored treatise on pathogenic *Candida* species. It is worth noting that the key factors that cause some yeast species to be potential pathogens are still elusive.

Additional comments: Perhaps the most spectacular recent development in the molecular genetics of *C. albicans* has been the discovery of mating genes. Hull and Johnson (1999) first identified a set of genes that corresponded to sexual cycle regulators of the mating-type locus in *Saccharomyces cerevisiae*. This opened the door to an exploration of the mating system at the gene level, which ultimately led to the cytological characterization of the mating process itself (Lockhart et al. 2003). The species occurs in the diploid state and strains are usually heterozygous for the mating type alleles *MTL_a* and *MTL_α*, but a small fraction of clinical isolates are homozygous for one or the other. When compatible strains were mixed, conjugation tubes were formed abundantly after approximately 2 hours and could grow to several cell lengths. In Lee's synthetic medium supplemented with zinc and arginine, the cells agglutinated and fusion took place over an additional 1.5 hours. Lockhart et al. (2003) further demonstrated that conjugations take place only between cells of opposite mating types. The resulting zygotes produced an elongate daughter cell close to the point of fusion. This cell then gave rise to normally shaped buds. Nuclei were seen to meet, return to the parent cells and divide asynchronously. As a result, most nascent buds received one progeny nucleus, but some buds could receive two. Clear evidence for karyogamy or meiosis was not seen. The absence of recombination was also demonstrated with genetic markers.

Studies of the distribution of genetic markers in *C. albicans* (Forche et al. 1999) suggested that the genetic structure of natural populations is mostly clonal, but with some evidence for recombination. The mode by which meiosis takes place in the species is still obscure. Van der Walt (1970b) had proposed that the chlamydospores formed by the species act in a manner analogous to the teliospores of basidiomycetous yeasts, forming meiotic buds directly on the surface and not through production of a basidium. Whereas the idea of a possible affinity with the Basidiomycetes is no longer tenable, the possibility of an externally delimited haplophase remains.

90.6. *Candida alimentaria* Knutsen, V. Robert & M.Th. Smith (Knutsen et al. 2007)

Phylogenetic placement: *Yarrowia* clade (Fig. 90.3).

(The description is based on Knutsen et al. 2007.)

Growth in YM broth: After 3 days at 25°C, cells are ovoid to globose, 3–6 × 4–7 μm, occur singly, in pairs and in small clusters, and

reproduce by multilateral budding. Pseudohyphae and true hyphae are not produced.

Dalmau plate culture on YM agar: Pseudohyphae and true hyphae are produced after 3 days at 25°C.

Fermentation: Absent.

Growth

Glucose	+	D-Ribose	+
Inulin	–	Methanol	n
Sucrose	–	Ethanol	n
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	w	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	v
Salicin	–	D-Gluconate	+
L-Sorbose	v	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	–	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	D-Galacturonate	–
2-Keto-D-gluconate	n	Quinic acid	–
5-Keto-D-gluconate	–	D-Glucarate	–
D-Glucuronate	–	D-Galactonate	–
L-Arabinitol	–	Laevulinate	–
Propane 1,2 diol	–	L-Tartaric acid	–
Butane 2,3 diol	–	D-Tartaric acid	–
Nitrite	–	meso-Tartaric acid	–
Cadaverine	+	Ethylene glycol	–
Creatinine	–	Tween 40	–
L-Lysine	+	Tween 60	–
Ethylamine	+	Tween 80	–
10% NaCl/5% glucose	–	Creatine	–
Urease	v	D-Glucosamine (as N compound)	–
Cycloheximide 0.1%	+	Putrescine	–
Growth at 27°C	+	Imidazole	w
Growth at 30°C	–	D-Tryptophan	–
Galactaric acid	+	D-Proline	+
D-Glucono-1,5-lactone	+	Growth at pH 3	v
Palatinose	v	Starch formation	–
L-Malic acid	–	Growth on 1% acetic acid	–
Gentiobiose	–		

CoQ: Not determined.

Mol% G + C: 45.2, CBS 10151; 43.5, CBS 10149 (Knutsen et al. 2007).

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = AM268481, ITS and 5.8S rRNA = AM279279.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 10151 (NRRL Y-48253), isolated from cured ham, Norway; CBS 10149, from yogurt, Norway (Knutsen et al. 2007).

Type strain: CBS 10151.

Systematics: Prior to D1/D2 and ITS sequence analysis, *C. alimentaria* was identified as *Yarrowia lipolytica* (Knutsen et al. 2007).

Phylogenetically, the species is related to the *Yarrowia* clade, but with low bootstrap support. Besides *C. alimentaria*, the *Yarrowia* clade includes *Y. lipolytica*, *C. yakushimensis*, *C. oslonensis*, *C. galli*, *C. deformans* and *C. hollandica*.

Ecology: As indicated by the species name “*alimentaria*”, both strains were isolated from food products.

Biotechnology: Unknown

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.7. *Candida allociferii* Ueda-Nishimura & Mikata (2002)

Phylogenetic placement: *Sugiyamaella* clade (Fig. 90.3).

(The description is based on Ueda-Nishimura and Mikata 2002.)

Growth on YM broth: After 2 days at 24°C, the cells are ovoid or elongate, 2–5 × 3–9 μm and occur singly or in pairs and reproduce by multilateral budding (Fig. 90.8A). Rings or pellicles are not formed.

Growth in YM agar: After 1 month at 24°C, colonies are white to slightly cream with a mycelial surface, raised and wrinkled. Pseudohyphae grow from the reverse of the colony into the agar and from the margin of the colony to outside on the surface of agar (Fig. 90.8B).

Formation of ascospores: The type strain produces asci and occasionally immature ascospores when mated with mating type *a* strains of *Stephanoascus ciferrii* and *Candida mucifera*, demonstrating the close relationship between these species.

Fermentation: Absent.

Growth

Glucose	+	D-Ribose	+
Inulin	w	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	+	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	+
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	+
Methyl-α-D-glucoside	+	D,L-Lactate	+
Soluble starch	+	Succinate	+
Cellulobiose	+	Citrate	–
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	+	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	+	Gelatin	n
Glucono-δ-lactone	–	Casein	n
Amino acid-free	+	Lipase	n
Nitrite	v	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	n	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	+

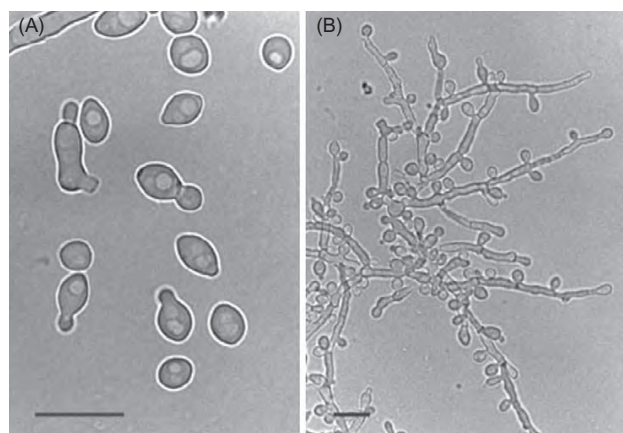


FIGURE 90.8 *Candida allociferii* IFO 10194. Cells in YM broth after 2 days at 24°C (A) and pseudohyphae after 1 month on YM agar at 24°C (B). Bars = 10 μm. Reproduced from Ueda-Nishimura and Mikata (2002) with permission.

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AB041003.

Cell carbohydrates: Not determined.

Origin of the strains studied: IFO 10193 (CBS 5165) and IFO 10194 (CBS 5166), isolated from a wooden pole in a cowshed; IFO 10913 (JCM 2984), from pickled emblic myrobalan (*Emblica officinalis*, Euphorbiaceae), Thailand.

Type strain: CBS 5166.

Systematics: Ueda-Nishimura and Mikata (2002) examined nine strains identified as *Stephanoascus ciferrii* and found that some strains contained large group I introns in their SSU rDNAs. Of these, three strains differed from the others by the absence of introns and exhibited 52% or less DNA reassociation with the others. Two did not mate when mixed with other strains, and one produced sterile asci when crossed with strains of mating type *a*. On that basis, *C. allociferii* was described as a separate biological species. Of the remaining strains, five were retained as authentic members of *S. ciferrii*. Their SSU rDNA contained a single intron (404 bp). The type strain of *C. mucifera* had two introns (355 and 403 bp), was genetically distinct, and was regarded as representative of yet another species. The D1/D2 LSU rRNA gene of *C. allociferii* differs by four and five substitutions, respectively, from those of *C. mucifera* and *S. ciferrii*, and the divergence in the SSU rRNA gene is 9 and 15 substitutions, respectively, also supporting the description of the new species. *C. allociferii* is nearly indistinguishable physiologically from *S. ciferrii* except for a weak utilization of inulin.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.8. *Candida amapae* Morais, Rosa, S.A. Meyer, Mendonça-Hagler & Hagler (1995c)

Phylogenetic placement: *Saccharomycopsis* clade (Fig. 90.4).

Growth on malt extract agar: After 3 days, cells are pleiomorphic and cylindrical to elongate. Well-developed, moderately branched pseudohyphae are also present. The streak culture is dry, white, cottony, rough with a smooth center and an irregularly fringed margin.

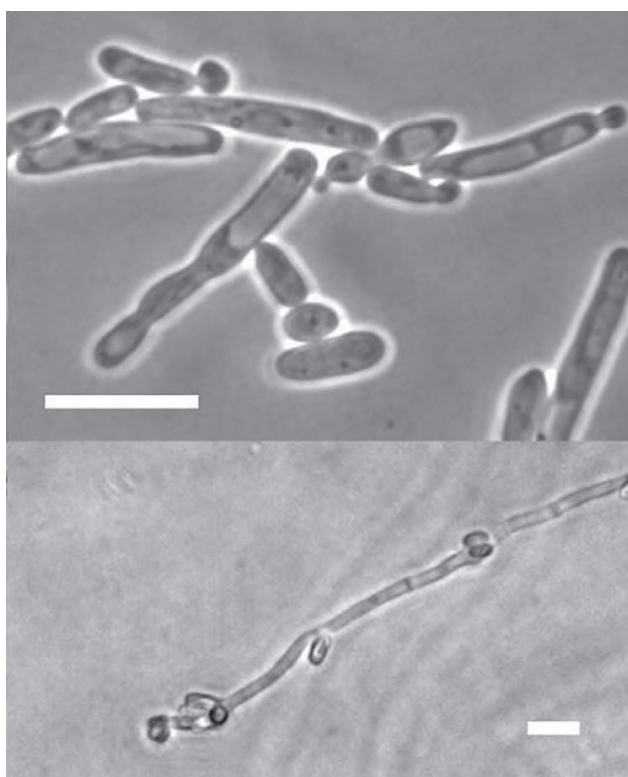


FIGURE 90.9 *Candida amapae* CBS 7872. Budding cells, 3 days, 25°C, YM agar (top) and pseudohyphae, 2 weeks, 18°C, YCBAS agar (bottom). Bars = 10 µm.

After 10 days, the growth is off-white, smooth and with a rugose lobate margin that is fringed with pseudohyphae.

Growth in malt extract: After 3 days at 25°C, the cells are large and globose to elongate, 2–3 × 4–15 µm (Fig. 90.9 top). After 4 weeks, a thick ring is formed.

Dalmau plate culture on corn meal agar: After 5 days at 25°C, abundant, differentiated pseudohyphae are present (Fig. 90.9 bottom). After 10–20 days, rare true hyphae occur.

Fermentation

Glucose	w	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	+

Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	s
L-Sorbose	s	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	s	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	n	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	w	Lipase	–
Nitrite	–	Acid production	s
Ethylamine	–	Cycloheximide 0.01%	+
L-Lysine	w	Cycloheximide 0.1%	n
Cadaverine	–	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: 38.8, CBS 7872 (T_m : Morais et al. 1995c).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U69880.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 7872, isolated from fallen fruit of amapa (*Parahancornia amapa*, Apocynaceae), Mocambo forest, Belem, Para, Brazil.

Type strain: CBS 7872.

Systematics: Morais et al. (1995c) described *C. amapae* from 14 strains isolated in decaying amapa, a tropical fruit endemic to the Amazonian forest. The authors noted similarities with *C. sorboxylosa* and various *Pichia* (*Issatchenkia*) species, but a requirement for sulfur in the form of amino acids was regarded as an important distinguishing feature. This feature is shared with species in the *Saccharomycopsis* clade (Lachance et al. 2000b), to which *C. amapae* belongs (Kurtzman and Robnett 1998a). The species is closely related to *Saccharomycopsis crataegensis*.

The original description reported absence of growth on ethanol, glycerol and 2-keto-D-gluconic acid, growth on lactic acid, and vitamin independence, which was at variance with the results obtained in this study. The overall assimilation profile of *C. amapae* is typical of that seen in the genus *Saccharomycopsis*, although separation from the closer species can be effected on the basis of 2-keto-D-gluconate utilization and the absence of growth on D-glucitol.

Ecology: *Candida amapae* is part of an interesting community of yeasts vectored by *Drosophila* spp. in amapa fruits (Morais et al. 1995c). Like most species in the *Saccharomycopsis* clade *C. amapae* is capable of necrotrophic mycoparasitism by means of infection pegs (Lachance et al. 2000b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.9. *Candida ambrosiae* Kurtzman (2001b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5).

(Some of the morphological characteristics are based on Kurtzman 2001b.)

Growth on 5% malt agar: After 3 days at 25°C, yeast cells are spherical, 2–6 µm, ellipsoidal, to elongate, 2–4.5 × 3–25 µm, and occur

singly or in pairs (Fig. 90.10A). Elongated cells are straight or curved and may produce small denticles that bear blastoconidia. Some elongated cells form an inflated spherical tip cell that may also form denticles that give rise to blastoconidia. Budding is multilateral, but often occurs near the poles of the parent cell. There are usually 1–3 buds per cell. Colonies are white in color, dull, to almost powdery, and have a butyrous texture.

Growth in liquid media: Pellicles may be formed on liquid growth media.

Dalmau plate culture on yeast morphology agar: After 7 days at 25°C, growth under the coverglass shows abundant pseudohyphae that often bear clusters of blastoconidia (Fig. 90.10B,C). True hyphae are not seen, but some of the pseudohyphae show well-developed septations between cells. Aerobic growth is dull, white and almost powdery in appearance. Colonies are low with a central plateau and margins may be smooth to finely lobed.

Fermentation

Glucose	s	Lactose	—
Galactose	—	Raffinose	—
Sucrose	w	Trehalose	s
Maltose	w		

Growth (on Agar)

Glucose	+	D-Ribose	w
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	D,L-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	+
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	w	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	w	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Gluconate	—	Gelatin	—
Glucono- δ -lactone	w	Casein	s
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	w	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY013716.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 8844 (NRRL YB-1316), isolated from insect frass of a dead elm tree (*Ulmus* sp., Ulmaceae), Illinois, USA.

Other strains: NRRL YB-1928 (CBS 8845), from rotted log of unidentified tree, NRRL YB-1949, unidentified pink coral fungus, both from McCormicks State Park, Spencer, Indiana; NRRL YB-2289, from unidentified mushroom on a rotted log, Peoria, Illinois; NRRL YB-2317, from frass in insect tunnel of sugar maple tree (*Acer saccharum*), Laconia, New Hampshire; NRRL YB-2725, from frass in insect tunnel of oak tree (*Quercus* sp.), Matthiessen State Park, Illinois, all from USA.

Type strain: CBS 8844.

Systematics: Kurtzman (2001b) described *C. ambrosiae* from several isolates recovered in insect frass of various trees in the USA. The species is closely related to *C. tanzawaensis* and is part of a rapidly expanding clade (see comments on *C. tanzawaensis*). According to the data given in the original description, *C. ambrosiae* is indistinguishable from *C. atmospherica* except for growth at 37°C, even though the two are unrelated. In this study, the two were found also to differ in resistance to 0.01% cycloheximide.

Ecology: *Candida ambrosiae* is evidently associated with insects involved in the fungal decay of trees. This is further corroborated by the isolation of the species in tenebrionid beetles collected in a tree canker of *Inonotus ludovicianus* and in erolyid beetles of a bracket fungus (*Ganoderma* sp., M. Blackwell, personal communication).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.



FIGURE 90.10 *Candida ambrosiae* NRRL YB-1316. Budding cells, 3 days, 25°C, 5% malt extract agar (A) and pseudohyphae, 7 days, 25°C, yeast morphology agar (B, C). Bar = 5 μ m.

90.10. *Candida amphixiae* S.-O. Suh, N.H. Nguyen & M. Blackwell (Suh et al. 2005b)

Phylogenetic placement: *Yamadazyma* clade (Fig. 90.2).
(The description is based on Suh et al. 2005b.)

Growth on YM agar: After 7 days at 25°C, colonies are white, smooth and butyrous.

Growth in YM broth: After 7 days at 25°C, cells are globose to ellipsoidal, $3-5 \times 3-5 \mu\text{m}$, and occur singly, in pairs, and in short chains and clusters. Pseudohyphae are not present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae or septate hyphae are not present. Aerobic growth is white and smooth.

Fermentation

Glucose	+	Lactose	—
Galactose	+	Raffinose	—
Sucrose	d	Trehalose	+
Maltose	—	D-Xylose	—

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	d
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	w	D-Glucosamine	+
L-Rhamnose	+	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	—
D-Arabinose	+	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Growth at 35°C	—
2-Keto-D-gluconate	—	L-Arabinitol	+
5-Keto-D-gluconate	n	D-Glucono-1,5-lactone	+
D-Glucuronate	—	Quinic acid	—
Arbutin	+	D-Glucarate	—
Propane 1,2 diol	d	D-Glucosamine (as N compound)	—
Butane 2,3 diol	—	D-Tryptophan	—
Nitrite	—	Creatine	—
Cadaverine	+	Imidazole	—
Creatinine	—	Growth w/o myo-inositol	+
L-Lysine	+	Growth w/o panthotenate	+
Ethylamine	+	Growth w/o biotin	—
50% Glucose	+	Growth w/o thiamine	+
60% Glucose	—	Growth w/o biotin & thiamine	—
10% NaCl/5% glucose	+	Growth w/o pyridoxine	+
16% NaCl	+	Growth w/o pyridoxine & thiamine	+
Starch formation	—	Growth w/o niacin	+
Urease	—	Growth w/o PABA	+
Cycloheximide 0.01%	w	Growth on 1% acetic acid	—
Cycloheximide 0.1%	—	DBB	—
Growth at 30°C	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY520327, SSU rRNA = AY520197.

Cell carbohydrates: Not determined.

Origin of the strain studied: The type strain, CBS 9877 (NRRL Y-27704), which is the only known strain of *C. amphixiae*, was isolated from the gut of a handsome fungus beetle (*Amphix laevigatus*, Coleoptera: Endomychidae), Barro Colorado Island, Panama (Suh et al. 2005b).

Type strain: CBS 9877.

Systematics: *Candida amphixiae* clusters within the *C. membranifaciens* subclade (Fig. 90.4). According to Suh et al. (2005b), the species is closely related to *C. cerambycidarum*, *C. gorgasii*, *C. michaelii*, *C. endomychidarum* and *C. lessepsii*, which are all associated with beetles.

Ecology: The type strain, which is the only representative of *C. amphixiae*, was isolated from the gut of a beetle, *Amphix laevigatus*, as were the related species *C. michaelii* and *C. sinolaborantium* (Suh et al. 2005b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown, but this species does not grow at 37°C.

Additional comments: No ascospores were produced after 6 weeks at 17°C on YM agar or on half-strength corn meal agar.

90.11. *Candida anatomiae* (Zwillenberg) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Nakazawaea* clade (Figs 51.1, 90.4).

Synonym:

Torulopsis anatomiae Zwillenberg (1966)

Growth in glucose-yeast extract broth: After 3 days at 25°C, the cells are globose to short-ovoid, $3-5 \times 3-7 \mu\text{m}$, single, in pairs and short chains (Fig. 90.11). Pellicles or rings are not formed.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, poorly developed pseudohyphae composed of short chains of cells are sometimes present. Aerobic growth is white to cream colored, soft, glistening, smooth and entire.

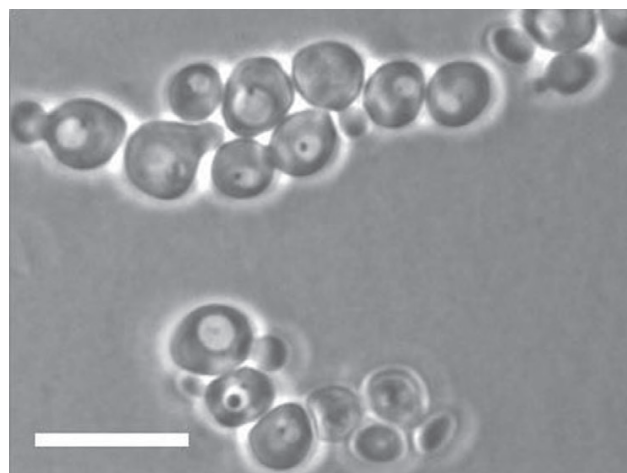


FIGURE 90.11 *Candida anatomiae* CBS 5547. Budding cells, 3 days, 25°C, YM agar. Bar = 10 μm .

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	—
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	—
Maltose	—	D-Glucitol	—
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	D-Lactate	—
Soluble starch	—	Succinate	—
Cellobiose	v	Citrate	—
Salicin	+	D-Gluconate	w
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	+	N-Acetyl-D-glucosamine	—
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	s	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	s	Acid production	w
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	s
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	—
50% Glucose	—	Growth at 37°C	—

CoQ: 8 (Suzuki and Nakase 1998).

Mol% G + C: 39.0, CBS 5547 (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70244.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 5547, isolated from a corpse embalmed in formalin.

Other strain: CBS 1786 (NRRL Y-27070), from a corpse, Zürich, Switzerland.

Type strain: CBS 5547.

Systematics: The strain originally assigned to *C. anatomiae* was isolated from turbid formalin in tanks in an anatomy department (Zwillenberg 1966). When tested for growth in the presence of various concentrations of formaldehyde, growth occurred at 1.5% but not 2.0%. Unfortunately, the significance of this interesting finding is not known as no comparisons were drawn with other species. *C. anatomiae* differs from *C. populi* by only two substitutions in the D1/D2 LSU rRNA gene (Kurtzman and Robnett 1998a) and eight substitutions and three gaps in the SSU rRNA gene (Suzuki and Nakase 1999), providing evidence that the two are closely related. However, the two are quite different in

physiology and are retained as separate species. The species belongs to a growing clade with an affinity for the genus *Nakazawaea*. At variance with the original description, the type strain assimilated L-rhamnose and ethanol, as reported by Meyer et al. (1998). However, no growth was observed on D-mannitol. As tested by replica plating, slow growth was observed in the presence of 0.1% cycloheximide. The growth profile has a certain resemblance to those of *Hanseniaspora valbyensis* and some *Dekkera* (or *Brettanomyces*) species, but separation is possible based on the utilization of L-rhamnose and nitrite.

Ecology: In view of the isolation of the species, twice, from corpses, the question of a special adaptation to formaldehyde is relevant, but has not been satisfactorily examined. Examination of the type strain by replica plating did not reveal anything striking with respect to stress resistance, although the strain grew on Yeast Nitrogen Base-glucose agar in the presence of 200 ppm cinnamic acid, a test that gives negative results for most species. *Candida populi* shares this attribute.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.12. *Candida anglica* Kurtzman, Robnett & Yarrow (2001)

Phylogenetic placement: *Kurtzmaniella* clade (Figs 40.1, 90.2).

(Some of the morphological characteristics are based on Kurtzman et al. 2001a.)

Growth on 5% malt agar: After 7 days at 25°C, the cells are spherical, 4–7.5 μ m, to ellipsoidal 2–5.5 $\times$ 3.5–18 μ m, occur singly and in pairs, and reproduce by multilateral budding (Fig. 90.12A). Growth is tannish-white, dull, butyrous and with a thin border of pseudohyphae.

Dalmau plate culture on morphology agar: After 7 days at 25°C, moderately branched pseudohyphae with blastoconidia are formed under the coverglass (Fig. 90.12B). True hyphae are not observed. Aerobic growth is tannish-white, semi-glistening, coarsely striated and butyrous. The colony margin is finely lobed.

Fermentation

Glucose	+	Lactose	—
Galactose	v	Raffinose	—
Sucrose	—	Trehalose	+
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	s
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	s
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	D-Lactate	+
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	+
Salicin	—	D-Gluconate	+
L-Sorbose	s	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

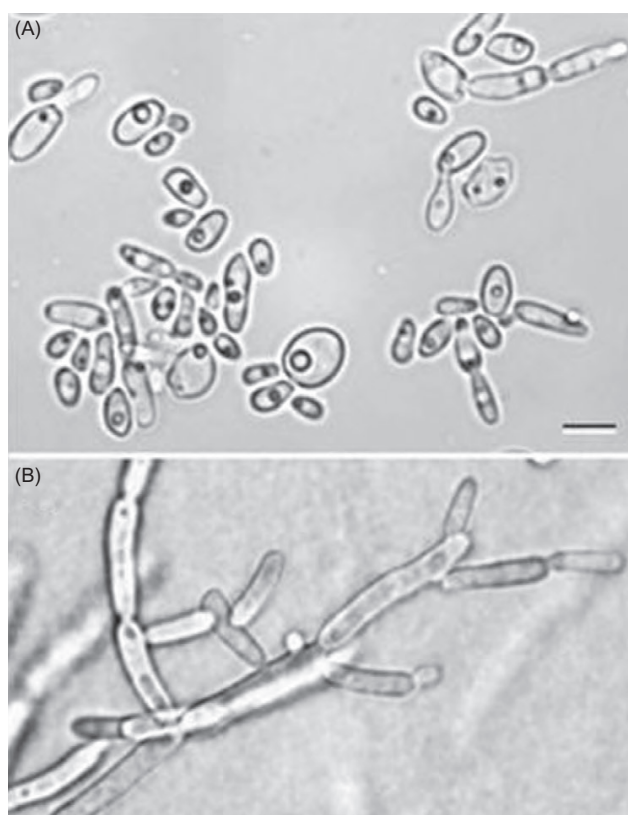


FIGURE 90.12 *Candida anglica* NRRL Y-27079. Budding cells, 2 days, 25°C, YM agar (A) and pseudohyphae, 7 days, 25°C, yeast morphology agar (B). Bar = 5 μm.

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	s	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF245403.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL-Y-27079 (CBS 4262), isolated by F.W. Beech from apple cider, UK.

Type strain: CBS 4262.

Systematics: Kurtzman et al. (2001a) described *C. anglica* to accommodate a strain isolated by F.W. Beech from apple cider. The strain could not be identified by conventional methods, but the D1/D2 LSU rRNA gene sequence differed from that of any other known species. *C. anglica* belongs to a small clade that includes *C. oleophila* and other species with a moderate relationship to the genus *Debaryomyces*. The original description reports a negative reaction for the assimilation

of lactic acid. Good growth occurred on this compound when assessed by replica plating.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.13. *Candida anneliseae* S.-O. Suh & M. Blackwell (Suh et al. 2004b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5).

(The description is based on Suh et al. 2004b.)

Growth on YM agar: After 7 days at 25°C, colonies are white to cream colored, pale-pinkish from center to edge, smooth and with a slightly wrinkled mycelial margin.

Growth in YM broth: After 7 days at 25°C, cells are globose to ellipsoid, 1.25–7 × 1.25–7 μm, and occur singly, in pairs or in chains. Pseudohyphae may be present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae are present and septate hyphae also may be present. Aerobic growth is white, glistening, smooth and the aerobic growth with a mycelial periphery.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	d
Maltose	–	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	v	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	v	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Growth at 35°C	v
2-Keto-D-gluconate	+	Growth at 40°C	–
5-Keto-D-gluconate	n	D-Arabinitol	v
D-Glucuronate	–	D-Glucono-1,5-lactone	+/-d
Arbutin	+	Quinic acid	–
Propane 1,2 diol	w/–	D-Glucarate	–
Butane 2,3 diol	–	D-Galactonate	–
Nitrite	–	D-Glucosamine (as N compound)	v
Cadaverine	+	D-Tryptophan	–

Creatinine	—	Creatine	—
L-Lysine	+	Imidazole	—
Ethylamine	+	Growth w/o myo-inositol	+
50% Glucose	+	Growth w/o panthotenate	+
60% Glucose	+	Growth w/o biotin	—
10% NaCl/5% glucose	v	Growth w/o thiamine	v
16% NaCl	w/—	Growth w/o biotin & thiamine	—
Starch formation	—	Growth w/o pyridoxine	+
Urease	—	Growth w/o pyridoxine & thiamine	+
Cycloheximide 0.01%	v	Growth w/o niacin	+
Cycloheximide 0.1%	—	Growth w/o PABA	+
Growth at 25°C	+	Growth on 1% acetic acid	—
Growth at 30°C	+	DBB	—

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA = AY242258, SSU rRNA = AY242149.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9837 (NRRL Y-27563), type strain, isolated from a red-banded fungus beetle (*Megalodacne fasciata*, Coleoptera: Erotylidae), Athens, Georgia, USA; BG 02-7-21-Nhu-1-1-C, from a pleasing fungus beetle (*Triplax festiva*, Coleoptera: Erotylidae) in basidiocarp of a polypore (*Ganoderma applanatus*) Athens, Georgia, USA; NRRL Y-27585, from a tenebrionoid beetle, *Platyedema ruficorne* (Coleoptera: Tenebrionidae), Baton Rouge, Louisiana, USA; BG 99-8-18-1-1 and BG 00-6-14-1-1, from tenebrionoid beetles (Coleoptera: Tenebrionidae), respectively, *Diaperis nigronata* on basidiocarps of *Inonotus ludovicianus* and *Neomida ferruginea*, Baton Rouge, Louisiana, USA; BG 02-5-30-011B-6, Athens, Georgia, USA; BG 01-7-21-010A-1-1, BG 01-7-21-010B-1-1, all three from unidentified tenebrionoid beetles (Coleoptera: Tenebrionidae), Barro Colorado Island, Panama; BG 02-6-15-011B-2, from a beetle of the genus *Alobates* (Coleoptera: Tenebrionidae), Athens, Georgia, USA; NRRL Y-27583, from an unidentified beetle of the Scaphidiinae (Coleoptera: Staphylinidae), Athens, Georgia, USA; BG 02-7-18-032C-1-1 and NRRL Y-27577, from unidentified melandroid beetles (Coleoptera: Melandryidae), Barro Colorado Island, Panama; NRRL Y-27575, from an unidentified histeroid beetle (Coleoptera: Histeridae), Barro Colorado Island, Panama; NRRL Y-27560, from an unidentified ciid beetle (Coleoptera: Ciidae), Athens, Georgia, USA.

Type strain: CBS 9837.

Systematics: *Candida annelliseae* belongs to the *C. tanzawaensis* clade (Fig. 90.5), which includes 17 subclades of beetle gut yeasts (Suh et al. 2004b). One of the 13 strains identified as *C. annelliseae* differs from the type strain by one base pair in the SSU rRNA gene.

Ecology: All known strains of *C. annelliseae* were found in the digestive tract of basidiocarp feeding beetles in a geographical area including the south-eastern part of the USA and Panama (Suh et al. 2004b). *C. annelliseae* was isolated from larvae and adults of the same melandroid beetle species giving indirect evidence that this yeast species is present during the entire life cycle of the beetle host and that parental transmission occurs early in successive generations. Also, isolates from different beetle species showed identical genotypes and small, but consistent differences in physiological traits. In contrast, isolates from different host species, belonging to four different families spread throughout a broad geographical range, still shared the same D1/D2 genotype.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown, but growth is variable at 35°C.

Additional comments: No ascospores were produced after 6 weeks at 17°C on YM agar or on half-strength corn meal agar.

90.14. *Candida anutae* Bab'eva, Lisichkina, Maksimova, Reshetova, Terenina & Chernov (2000)

Phylogenetic placement: Unaffiliated clade (Fig. 90.5).

(Some of the morphological characteristics are based on Bab'eva et al. 2000.)

Growth on wort agar: After 7 days at room temperature, the colony is white, dull or shiny, smooth or slightly rugose and with an even margin.

Growth on YM agar: After 3 days at 25°C, the cells are elongate, often with a central swelling, or lunate, $3-5 \times 8-15 \mu\text{m}$ (Fig. 90.13).

Growth in glucose-peptone yeast extract broth: After 3 days at 20°C, the cells are spherical to ovoid, $2-3 \times 3-5 \mu\text{m}$, and occur singly or in short chains. The cells may be curved. A friable pellicle is formed after a month.

Dalmau plate culture on corn meal agar: Highly branched pseudo-hyphae may be formed by some strains.

Fermentation: Absent.

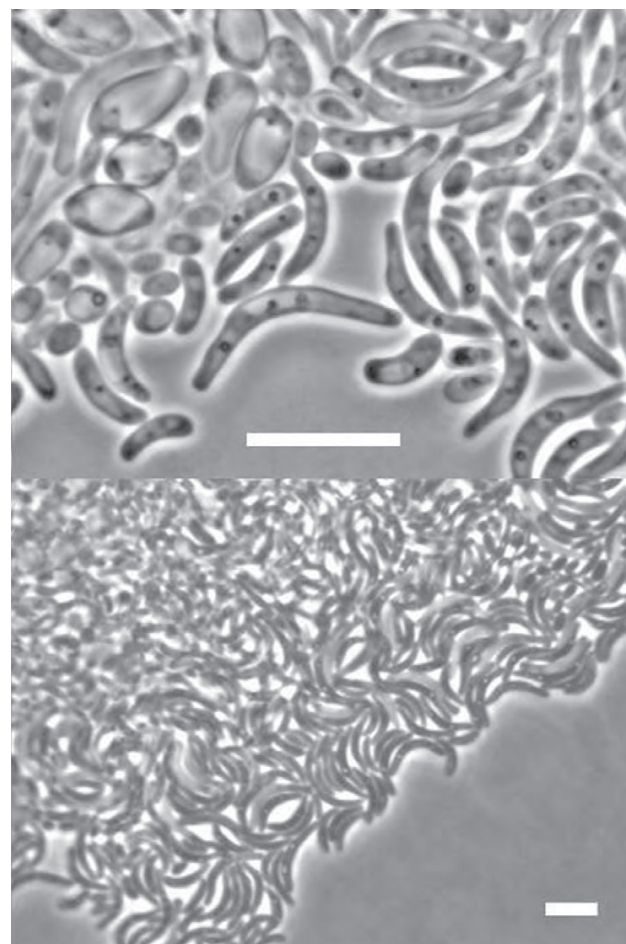


FIGURE 90.13 *Candida anutae* CBS 8787. Budding cells, 3 days, 25°C, YM agar (top) and, 2 weeks, 18°C, YCBAS agar (bottom). Bars = 10 μm .

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	—
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	s
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	+
Salicin	—	D-Gluconate	—
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	—	Hexadecane	s
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	w	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	s
Glucono- δ -lactone	w	Casein	s
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	s
Ethylamine	+	Cycloheximide 0.01%	w
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	w	Growth at 30°C	—
50% Glucose	—	Growth at 37°C	—

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AJ549821.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 8787 (KBP 3575), isolated from insect-infested fruiting body of mushroom (*Russula cyanoxantha*), Istrinskii region, Russia.

Other strains: KBP 3476, isolated from fruiting body of *Russula* sp., Tver Oblast, Kashinskii region; KBP 3680 and seven others, from decomposing fruiting bodies, Moscow region; KBP 3688, from fruiting body of *Amanita muscaria*, Moscow Oblast, Shalhovskoi region; KBP 3670 and KBP 3671, from fungus gnat larvae (Diptera: Mycetophilidae) from fruiting bodies of mushroom (*Pholiota flammans*); KBP 3689, KBP 3690, KBP 3691, all from fungus gnat larvae from fruiting bodies of mushroom (*Pholiota alnicola*), Turku, Finland.

Type strain: CBS 8787.

Systematics: *Candida anutae* was described by Bab'eva et al. (2000) to accommodate a collection of strains recovered from the fruiting bodies of mushrooms and associated insects in Russia and Finland. The authors noted a resemblance in cell morphology to *Metschnikowia lunata*, but the physiological characteristics were different. The D1/D2 LSU rRNA gene sequence is highly divergent and does not establish a reliable connection to a known species, although membership in the Saccharomycetales is unquestionable. Assessment of growth characteristics by replica plating agreed well with the original description with the exception of growth in the presence of 50% glucose, found to be negative. Trehalose is the only sugar assimilated. The general physiological profile shows some

resemblance with that of *Schizoblastosporion starkey-henrici*, but this resemblance is probably fortuitous.

Ecology: An association with insects that feed on basidiocarps is evident.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.15. *Candida apicola* (Hajsig) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

Synonyms:

Torulopsis apicola Hajsig (1958)

Torulopsis bacillaris (Kroemer & Krumbholz) Lodder var. *obesa* Y. Ohara, Nonomura & Yunome (1960a)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are spherical to ovoid, 1.5–2.5 $\times$ 3–4 μ m, and occur singly and in pairs (Fig. 90.14 top).

Dalmau plate culture on YCBAS agar: After 14 days at 18°C, short chains of undifferentiated cells are present (Fig. 90.14 bottom). Aerobic growth on corn meal agar is yellowish to cream colored, glistering, soft, smooth and with an entire margin.

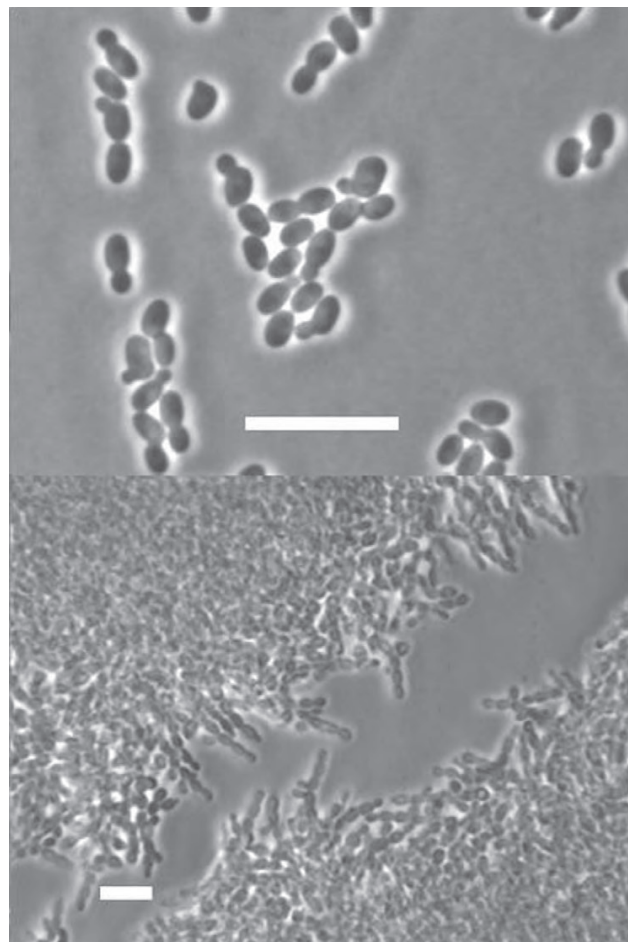


FIGURE 90.14 *Candida apicola* CBS 2868. Budding cells, 3 days, 25°C, YM agar (top) and chains of cells, 2 weeks, 18°C, YCBAS agar (bottom). Bars = 10 μ m.

Fermentation

Glucose	+/s	Lactose	—
Galactose	—	Raffinose	—/s
Sucrose	—	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	+	Ethanol	v
Raffinose	+	Glycerol	s
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	D-Lactate	—
Soluble starch	—	Succinate	v
Cellobiose	—	Citrate	v
Salicin	—	D-Gluconate	v
L-Sorbose	v	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	v	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	v
Glucono- δ -lactone	s	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	v
Ethylamine	v	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	v	Growth at 30°C	v
50% Glucose	+	Growth at 37°C	—

CoQ: 9 (F.-L. Lee et al. 1993).

Mol% G + C: 46.3, CBS 2868 (T_m : Stenderup et al. 1972); 44.3, CBS 2868 (HPLC: F.-L. Lee et al. 1993).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45703.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 2868 and CBS 2869, isolated from gut of bee, Croatia; CBS 1887, CBS 1888, from pickled cucumbers, USA; CBS 2650, from beehive mite control preparation, France; CBS 4078, type strain of *Torulopsis bacillaris* var. *obesa*, from grape must, Japan; CBS 8413, from brine in a cheese factory, The Netherlands; UFMG 07-MC1, from stingless bee (*Melipona* sp., Hymenoptera: Apidae), UFMG Jat 35.1, from hive of stingless bee (*Melipona quadrifasciata*), UFMG Jat 128.2, from stingless bee (*Melipona rufiventris*, UFMG MP448 and UFMG Jat 515.1, from pollen of stingless bee (*Melipona rufiventris*), all from Brazil, C.A. Rosa; UWOPS 01-108b2, from unidentified collected beetle in flower of *Ipomoea batatoides*, UWOPS 01-125.4, from sap beetle (*Conotelus* sp., Coleoptera: Nitidulidae) in flower of *Ipomoea batatas*, UWOPS 01-131.1, UWOPS 01-132.1, UWOPS 01-133.1, UWOPS 01-135a2 and UWOPS 01-135c3, from stingless bee (*Trigona* sp.,

Hymenoptera: Apidae) collected in flower of Bignoniaceae, UWOPS 01-135b3, from unidentified wasp in flower of Bignoniaceae, UWOPS 01-153b1, from leaf beetle (*Diabrotica* sp., Coleoptera: Chrysomelidae) in flower of wood rose (*Merremia tuberosa*, Convolvulaceae), UWOPS 01-193.1 and UWOPS 01-194.1, from stingless bee (*Trigona* sp.) collected in flower of unidentified tree, UWOPS 01-663b2, flower of wood rose, UWOPS 01-677b2, sap beetle (*Conotelus* sp.) in flower of wood rose, all from Costa Rica; UWOPS 05-219.3 and UWOPS 05-243.4, from stingless bee (*Trigona* sp.) collected on flower bud of bertam palm (*Eugeissona tristis*, Arecaceae), Malaysia.

Other strain: CBS 1889, isolated from pickled cucumbers, USA.

Type strain: CBS 2868.

Systematics: In a study of the yeasts associated with honeybees, Hajsig (1958) examined 10 individuals in each of eight beehives. Seven strains were combined with another isolate from a bee trachea to describe *Torulopsis apicola*. The author noted similarities between the new species and *T. apis*, *T. bacillaris* and *T. stellata*. Note that *T. bacillaris* is now a synonym of *Candida* (*Torulopsis*) *stellata*. Description as a new species was based primarily on differences in cell size, colony shape, formation of a ring in liquid media and lack of raffinose fermentation. *C. apicola* is a core member of the *Starmerella* clade (Fig. 71.1). Strain CBS 7444, isolated from a black-currant drink, differed from other strains by some important physiological characteristics and was shown by D1/D2 sequencing to belong to *C. sorbosivorans*, to which it has been transferred.

The physiological profile of the several strains examined varied somewhat in spite of the highly oligophagic nature of the species. Distinction from other related species solely on that basis can be difficult. All strains seem to utilize sucrose and raffinose (sometimes weakly), D-mannitol and D-glucitol, and none utilizes maltose, which can be useful for separation from several other species. However, misidentification as *C. apis* or *C. bombi* is difficult to avoid. Separation from *Starmerella bombicola* is possible on the basis of the ability to grow in the presence of 0.001% cycloheximide, a test that is not commonly used. The test gives positive results in *S. bombicola* and negative results in *C. apicola*.

Strains CBS 5710 and CBS 6366, received as *C. apicola*, were reassigned to *S. bombicola* based on sequence analyses. Lachance et al. (2009) determined the ITS and D1/D2 sequences of other strains tentatively assigned in the species. Strain CBS 4353, isolated from sugar in the UK and MUCL 45721 from bee pollen in Cuba were excluded from the species on the basis of their divergence. The many other strains examined exhibited various degrees of sequence polymorphism, but were retained in *C. apicola*. These variations should take into account the fact that members of the *Starmerella* clade form unusually long branches in phylogenetic trees constructed from rRNA gene sequences (both D1/D2 LSU and SSU). Webster et al. (2003) suggested that longer phylogenetic paths are linked to higher speciation rates. According to this view, the *Starmerella* clade would be expected to yield a large number of new species through continued exploration of yeast biodiversity. Alternatively the higher evolutionary rate detected in the sequences could be due to an accumulation of inconsequential mutations caused by poor DNA repair, such that the clade effectively contains a relatively small number of species that are highly heterogeneous at the level of their rRNA gene sequences. As more isolates are recovered, answers to such questions will be obtained. However, the description of several indistinguishable species based purely on minor sequence differences would serve no worthy purpose.

Ecology: Like other members of the clade, *C. apicola* exhibits an association with bees (Rosa et al. 2003) and is also recovered from plant-based foods.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.16. *Candida apis* (Lavie ex van Uden & Vidal-Leiria) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

Synonyms:

Paratorulopsis apis (Lavie) Novák & Zsolt (1961)

Torulopsis apis Lavie ex van Uden & Vidal-Leiria (1970)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, 2–4 × 3–7 µm, and occur singly, in pairs and short chains (Fig. 90.15 top).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, poorly developed pseudohyphae of short chains of cells are sometimes present (Fig. 90.15 bottom). Aerobic growth is cream colored to beige, soft, smooth and entire.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	w
Raffinose	+	Glycerol	s
Melibiose	–	Erythritol	–
Galactose	w	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	s
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	w
Cellobiose	–	Citrate	w
Salicin	–	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	w	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	s	Cycloheximide 0.01%	–
L-Lysine	s	Cycloheximide 0.1%	–
Cadaverine	s	1% Acetic acid	+
10% NaCl	–	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	–

CoQ: 9 (F.-L. Lee et al. 1993).

Mol% G + C: 48.8, CBS 2674 (BD: Stenderup et al. 1972); 45.6, CBS 2674 (HPLC: F.-L. Lee et al. 1993).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U48237.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 2674, isolated from trachea of a bee, UK.

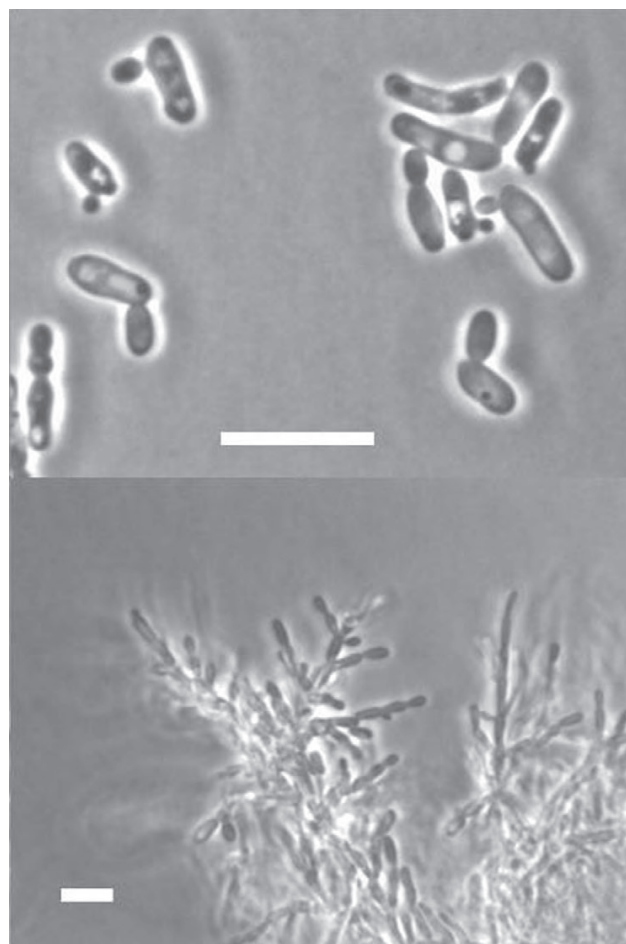


FIGURE 90.15 *Candida apis* CBS 2674. Budding cells, 3 days, 25°C, YM agar (top) and rudimentary pseudohyphae, 2 weeks, 18°C, YCBAS agar (bottom). Bars = 10 µm.

Type strain: CBS 2674.

Systematics: van Uden and Vidal-Leiria (1970) validated the description of *Torulopsis apis*, which had been isolated by Lavie (1954). The former variety *galacta* was described as *C. galacta* (F.-L. Lee et al. 1993) on the basis of DNA reassociation. The latter is part of the *Wickerhamiella* clade (Fig. 79.1), whereas *C. apis* belongs to the *Starmerella sensu lato* subclade (Fig. 71.1).

Candida apis is known from a single authentic strain and is hardly distinguishable from *C. apicola* on the basis of physiology, except for glucose fermentation, which is negative in the former, and positive in the latter. At variance with the description given by Meyer et al. (1998), the type did not grow on gluconic acid or in the presence of 10% NaCl when examined by replica plating.

Ecology: Like many members of the *Starmerella* clade, *C. apis* was isolated from a bee, suggesting an adaptation to this insect and its environment.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.17. *Candida arabinofermentans* Kurtzman & Dien (1998)

Phylogenetic placement: *Ogataea* clade (Figs 39.1, 90.4).

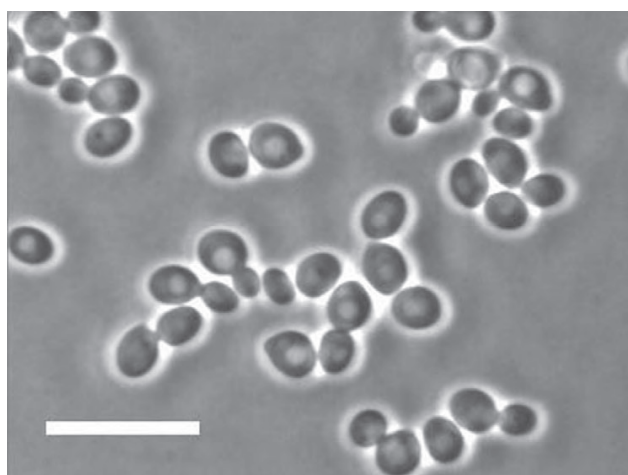


FIGURE 90.16 *Candida arabinoferrmentans* CBS 8468. Budding cells, 3 days, 25°C, YM agar. Bar = 10 μ m.

(Some of the morphological characteristics are based on Kurtzman and Dien 1998.)

Growth on 5% malt agar: After 3 days at 25°C, the cells are spherical, 2–7 μ m, to ellipsoidal, 2–5.5 $\times$ 2.5–7 μ m, and occur singly or in pairs (Fig. 90.16). Growth is tannish-white, glistening and mucoid. In contrast, growth on YM agar is butyrous. Growth under nitrogen limitation (YCB agar) is mucoid and runny.

Growth on the surface of liquid media: Pellicles are not formed.

Dalmau plate culture on morphology agar: After 7 days at 25°C, pseudohyphae or true hyphae are not formed under the coverglass. Occasionally, small, branched outgrowths of undifferentiated cells occur. Aerobic growth is glistening, tannish-white, butyrous and raised, but with a slightly depressed center, and the margin is entire or rarely indented. The odor is faintly acidic.

Fermentation

Glucose	s	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	s
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	+
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	D-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	–
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	s
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	s

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF017248.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 8468 (NRRL YB-2248), isolated from insect frass of a dead larch (*Larix* sp., Pinaceae), Alaska; CBS 8469 (NRRL YB-1299), from insect frass of a loblolly pine (*Pinus taeda*), Mississippi; CBS 8470 (NRRL Y-1984), from insect frass of a long-leaf pine (*Pinus australis*), Florida, all from USA.

Type strain: CBS 8468.

Systematics: Kurtzman and Dien (1998) re-examined some unidentified strains collected by L.J. Wickerham from insect frass of various coniferous trees. D1/D2 LSU rRNA gene sequencing showed the strains to be closely related to *C. ovalis*, but an 18 nucleotide difference between the strains supported the description of a new species, *C. arabinoferrmentans*. The species was found to be indistinguishable from *Pichia* (*Ogataea*) *pini* on the basis of conventional growth tests. These species are members of a large clade that comprises methanol-utilizing *Candida* species and relatives in the ascomycetous genus *Ogataea*.

The growth characteristics are similar to those of several related species. In addition to *Ogataea pini*, *O. methanolica* appears to be nearly identical in growth responses. Other similar species can be separated on the basis of D-arabinose or erythritol assimilation and the lack of growth on citric acid.

Ecology: The existence of three independent isolates from insect frass of conifers is regarded as evidence that the species is associated with tree-boring insects.

Biotechnology: As implied by the specific epithet, the species ferments L-arabinose into ethanol to a final concentration of 0.7 to 1.9 g/l under the conditions tested (Kurtzman and Dien 1998). *C. ovalis* produced traces of ethanol from that sugar, and strains of other related species did not. All strains tested fermented D-xylose.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.18. *Candida arcana* S.-O. Suh & M. Blackwell (2005)

Phylogenetic placement: *Kodamaea* clade; see Systematics (Fig. 90.3). (The description is based on Suh and Blackwell 2005.)

Growth on YM agar: After 7 days at 25°C, colonies are white to cream colored, butyrous and smooth on the surface.

Growth in YM broth: After 7 days at 25°C, yeast cells are globose to fusiform, 2.5–5 $\times$ 3.7–5 μ m, occur singly, in pairs or in short chains, and pseudohyphae are absent.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae are present. Aerobic growth is white, glistening and smooth.

Fermentation

Glucose	w	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–	D-Xylose	–

Growth (in Liquid Media)¹

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	d
Raffinose	–	Glycerol	d
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	d
Cellobiose	–	Citrate	d
Salicin	d	D-Gluconate	w
L-Sorbose	–	D-Glucosamine	d
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	–	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

¹Nitrogen growth tests were conducted on agar media.

Additional Growth Tests and Other Characteristics

Xylitol	–	16% NaCl	–
2-Keto-D-gluconate	+	1% Acetic acid	–
D-Glucuronate	–	Starch formation	–
Quinic acid	–	Acetic acid production	–
D-Glucarate	–	Urease	–
D-Galactonate	–	DBB reaction	–
D-Glucono-1,5-lactone	d	Cycloheximide 0.01%	d
L-Arabinitol	–	Cycloheximide 0.1%	–
Arbutin	d	Growth at 25°C	+
Propane 1,2 diol	–	Growth at 30°C	–
Butane 2,3 diol	–	Growth at 35°C	–
Cadaverine	+	Growth w/o myo-inositol	+
Creatinine	–	Growth w/o panthotenate	+
L-Lysine	+	Growth w/o biotin	–
Ethylamine	+	Growth w/o thiamine	+
D-Glucosamine (as N compound)	w	Growth w/o biotin & thiamine	–
Imidazole	–	Growth w/o pyridoxine	+
D-Tryptophan	–	Growth w/o pyridoxine & thiamine	+
50% Glucose	–	Growth w/o niacin	+
10% NaCl/5% glucose	–	Growth w/o PABA	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY 242347, SSU rRNA = AY 242235.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 9883 (NRRL Y-27712), isolated from the body surface of a beetle (*Derodontus esotericus*, Derodontidae), in Athens, Georgia, USA (Suh and Blackwell 2005).

Type strain: CBS 9883.

Systematics: *Candida arcana* is part of a subclade within the larger *Kodamaea* clade (Suh and Blackwell 2005). Other members of the subclade are *C. mesenterica*, *C. suecica* and *C. derodonti*.

Ecology: The species is known from the body surface of a derodontid beetle. It is interesting that *C. derodonti*, the closest species to *C. arcana*,

was also isolated from the same derodontid beetle, while the other members of the subclade, *C. suecica* and *C. mesenterica*, were found respectively in seawater and beer (Suh and Blackwell 2005).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: No ascospores were produced after 6 weeks at 17°C on half-strength corn meal agar.

90.19. *Candida asparagi* Bai & Lu (Lu et al. 2004a)

Phylogenetic placement: *Metschnikowia* clade (Fig. 90.1).

(The description is based on Lu et al. 2004a.)

Growth on YM agar: After 1 month at 25°C, the streak culture is butyrous, cream colored and semi-glossy, with an entire to slightly undulating margin.

Growth in YM broth: After 3 days at 25°C, cells are ellipsoidal to elongate, 1.2–4.5 $\times$ 1.8–5.5 μ m, reproduce by multilateral budding, and occur singly, in pairs or in groups (Fig. 90.17 top).

Growth on the surface of liquid media: After 1 month at 25°C, sediment is present.

Dalmau plate culture on YCBAS agar: After 14 days at 25°C, pseudohyphae consist of slightly differentiated cells with axillary buds (Fig. 90.17 bottom).

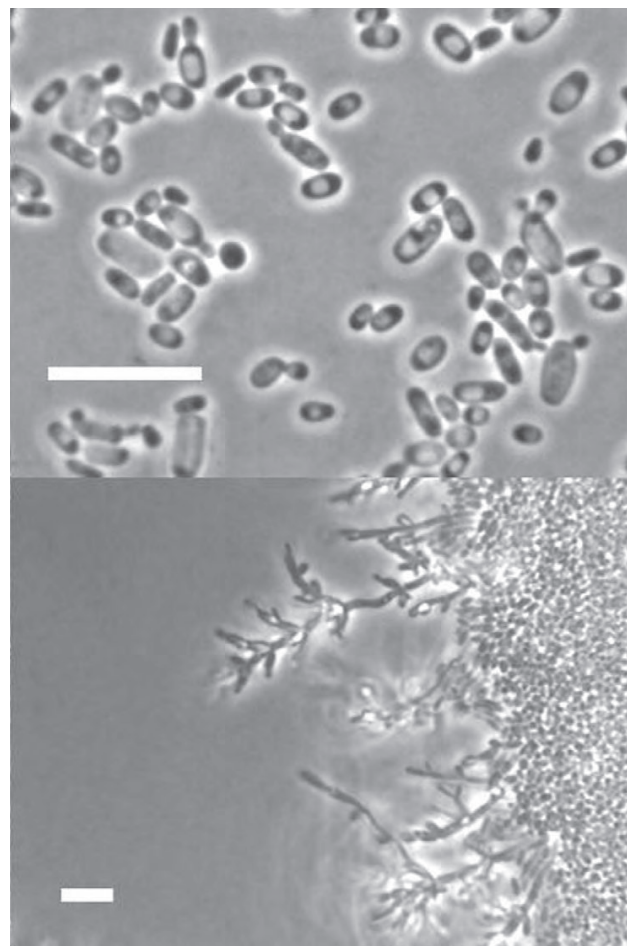


FIGURE 90.17 *Candida asparagi* CBS 9770. Budding cells, 3 days, 25°C, YM agar (top) and pseudohyphae, 2 weeks, 18°C, YCBAS agar (bottom). Bars = 10 μ m.

Fermentation

Glucose	+	Lactose	—
Galactose	+	Raffinose	—
Sucrose	—	Trehalose	n
Maltose	—		

Growth (in Liquid Media)

Glucose	+	D-Ribose	w
Inulin	—	Methanol	—
Sucrose	+	Ethanol	d
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	d	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	w
Salicin	d	D-Gluconate	n
L-Sorbose	+	D-Glucosamine	d
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	w
L-Arabinose	—	Nitrate	—
D-Arabinose	w	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Nitrite	—	Urease	—
Cadaverine	+	Growth at 25°C	+
L-Lysine	+	Growth at 33°C	+
Ethylamine	+	Growth at 35°C	—
Starch formation	—	DBB	—

CoQ: Not determined.**Mol% G + C:** Not determined.**Gene sequence accession numbers, type strain:** D1/D2 LSU rRNA = AY450920, ITS and 5.8S rRNA = AY450921.**Cell carbohydrates:** Not determined.**Origin of the strain studied:** CBS 9770 (isolation number SN 15-1, CGMCC AS 2.2526), isolated from the fruit of a fern asparagus (*Asparagus filicinus*, Asparagaceae) collected in Shennongjia, Hubei Province, China, in October 2002 (Lu et al. 2004a).**Type strain:** CBS 9770.**Systematics:** *Candida asparagi* clusters with *C. fructus* and *Clavispora lusitaniae* in a group with 74% bootstrap support (Lu et al. 2004a). The support increases to 100% between the first two species, which differ by 10 mismatches and one gap. The distinction is confirmed in the ITS region with 13 substitutions and six gaps.**Ecology:** The type strain, which is the only known isolate of *C. asparagi*, was isolated from a fruit of fern asparagus (Lu et al. 2004a).**Biotechnology:** Unknown.**Agriculture and food:** Unknown.**Clinical importance:** Unknown.**90.20. *Candida atakaporum* S.-O. Suh & M. Blackwell (Suh et al. 2004b)****Phylogenetic placement:** *Candida tanzawaensis* clade (Fig. 90.5).

(The description is based on Suh et al. 2004b.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, butyrous, with small filamentous spots and with a membranous margin.**Growth in YM broth:** After 7 days at 25°C, cells are subglobose, ellipsoidal or cylindrical, 3–5 $\times$ 5–9 μ m, occur singly, in pairs or in short chains, and pseudohyphae and septate hyphae may be present.**Dalmau plate culture on corn meal agar:** After 10 days at 25°C, pseudohyphae and septate hyphae are present. Aerobic growth is off-white and fuzzy.**Fermentation**

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	d
Maltose	—	D-Xylose	—

Growth (in Liquid Media and on Agar Media)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	d
Soluble starch	w	Succinate	d
Cellobiose	+	Citrate	d
Salicin	+	D-Gluconate	w
L-Sorbose	n	D-Glucosamine	d
L-Rhamnose	n	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	w	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	10% NaCl/5% glucose	+
2-Keto-D-gluconate	+	16% NaCl	w
D-Glucuronate	—	Starch formation	—
Arbutin	+	Urease	—
Propane 1,2 diol	w	Cycloheximide 0.01%	—
Butane 2,3 diol	—	Cycloheximide 0.1%	—
D-Arabinitol	—	Growth on 1% acetic acid	—
D-Glucono-1,5-lactone	+	DBB	—
Quinic acid	—	Growth at 25°C	+
D-Glucarate	—	Growth at 30°C	+
D-Galactonate	—	Growth at 35°C	+
Nitrite	—	Growth at 40°C	—
Cadaverine	+	Growth w/o myo-inositol	+
Creatinine	—	Growth w/o panthotenate	+
L-Lysine	+	Growth w/o biotin	—
Ethylamine	+	Growth w/o thiamine	+
D-Glucosamine (as N compound)	w	Growth w/o biotin & thiamine	—
D-Tryptophan	d	Growth w/o pyridoxine	+
Creatine	—	Growth w/o pyridoxine & thiamine	+
Imidazole	—		
50% Glucose	w	Growth w/o niacin	+
60% Glucose	—	Growth w/o PABA	+

CoQ: Not determined.**Mol% G + C:** Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY309872, SSU rRNA = AY426960.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 9833 (NRRL Y-27570), isolated from an erotlid beetle (*Trypox festiva*, Erotylidae: Coleoptera) on a basidiocarp of *Inonotus cuticularis*, Baton Rouge, Louisiana, USA (Suh et al. 2004b).

Type strain: CBS 9833.

Systematics: *Candida atakaporum* belongs to the *C. tanzawaensis* clade, which includes 17 subclades of gut yeasts from basidiocarp-feeding beetles (Suh et al. 2004b).

Ecology: The type strain, which is the only known isolate of *C. atakaporum*, was isolated from the guts of a beetle, *Trypox festiva*, on fruiting bodies of *Inonotus cuticularis* (Suh et al. 2004b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: No ascospores were produced after 6 weeks at 17°C on YM agar or half-strength corn meal agar.

90.21. *Candida atbi* S.-O. Suh, N.H. Nguyen & M. Blackwell (2006a)

Phylogenetic placement: *Candida kruisii* clade (Fig. 90.5).

(The description is based on Suh et al. 2006a.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, smooth or wrinkled, and have a filamentous margin.

Growth in YM broth: After 7 days at 25°C, cells are globose to fusiform, 2–7 × 2–9 μm, mostly ellipsoidal, occur singly, in pairs, in short chains or in clusters, and pseudohyphae and true hyphae may be present.

Dalmat plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae are present. Aerobic growth is off-white, glistening, smooth and with a filamentous margin.

Fermentation

Glucose	+	Lactose	–
Galactose	v	Raffinose	–
Sucrose	–	Trehalose	+/d
Maltose	–	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	w
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+/d/w
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	v	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	v
L-Sorbose	–	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	w/–	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	d/w	60% Glucose	–
2-Keto-D-gluconate	+	10% NaCl/5% glucose	v
D-Glucuronate	–	16% NaCl	v
L-Arabinitol	–	Starch formation	–
Arbutin	+	Urease	–
Propane 1,2 diol	–	Growth on 1% acetic acid	–
Butane 2,3 diol	–	DBB	–
D-Glucono-1,5-lactone	d/w	Cycloheximide 0.01%	+
Quinic acid	–	Cycloheximide 0.1%	+/d
D-Gluconate	–	Growth at 30°C	+
Nitrite	–	Growth at 35°C	–
Cadaverine	+	Growth w/o myo-inositol	+
Creatinine	–	Growth w/o pantothenate	+
L-Lysine	+	Growth w/o biotin	–
Ethylamine	+	Growth w/o thiamine	+
D-Glucosamine (as N compound)	–	Growth w/o biotin & thiamine	–
D-Tryptophan	–	Growth w/o pyridoxine	+
Creatine	–	Growth w/o pyridoxine & thiamine	+
Imidazole	–	Growth w/o niacin	+
50% Glucose	v	Growth w/o PABA	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY640187, SSU rRNA = AY640182, ITS and 5.8S rRNA = AY640200.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9852 (NRRL Y-27651), isolated from the guts of a sap beetle (*Pallodes pallidus*) on basidiocarps of *Lactarius* sp.; CBS 9853 (NRRL Y-27660, BG 03-7-2-1-1), from the guts of the same beetle species on a deer mushroom (*Pluteus* sp., Agaricales, Plutaceae) in Baton Rouge for the first strain, and on an agaric in Kisatchie Bayou, both Louisiana; M 02-5-27-2-1 was isolated in a gallery of *Pallodes pallidus* on deer mushroom in Baton Rouge, Louisiana; GA 016-1-1, isolated from the guts of *Pallodes austrianus* on a mushroom (*Russula* sp.), Herrick Lane Park, Athens, Georgia. The remaining 12 strains were all isolated from the guts of *Pallodes* sp. (BG 01-9-4-7-1-1 in Baton Rouge, Louisiana; BG 04-5-24-6-3-2 on agaric in Baton Rouge, Louisiana; BG 04-5-29-1-2-1 on *Russula* sp. in Kisatchie Bayou, Louisiana; BG 04-20-1-2 on brown American star-footed amanita (*Amanita brunneascens*), Blount County, Tennessee; BG04-21-1-1 on *Megacollybia platyphylla*, Blount County; BG04-6-1-2 on *Amanita bisporigena*, Sevier County, Tennessee; BG 04-16-1-2 on *Russula* sp., Sevier County; BG 04-16-1-4 on puffball (*Scleroderma* sp.), Sevier County; BG 04-7-17-1-1-1, on *Amanita* sp., Bent Creek Experimental Forest, North Carolina; BG 04-7-17-5-1-6, on *Amanita* cf. *vaginata*, Bent Creek Experimental Forest; BG 04-7-17-7-1-1 on *Tricholomopsis decora*, Bent Creek Experimental Forest; BG 05-5-18-1-1-2 on agaric in Port Hudson, Louisiana, all USA (Suh et al. 2006a).

Type strain: CBS 9852.

Systematics: *Candida atbi* clusters with eight other *Candida* species in a sister group of *C. kruisii* and CBS 9453 (Suh et al. 2006a). The sister clade is well supported by bootstrap and Bayesian analyses and can be divided in two subclusters comprising respectively *C. atbi*, *C. barrocoloradensis*, *C. gatunensis*, *C. aglyptinia* and *C. stri*, and *C. tritomonae*, *C. pallodes*, *C. lycoperdinae* and *C. panamensis*. The above-mentioned clusters can be distinguished by their reaction to 0.01% and 0.1% cycloheximide. The only exception is *C. kruisii*, which is negative for growth in 0.1% cycloheximide, as the rest of its cluster, but will grow in 0.01% cycloheximide. All the strains had an identical D1/D2 LSU rRNA gene sequence, but some isolates varied by 2 bp in the ITS region.

Ecology: All strains from this species were found in the digestive tract of basidioma-feeding beetles, with the exception of M 02-5-27-2-1, which was isolated from a gallery. The majority of the isolates came from *Pallodes* spp. beetles. The yeasts, however, were not specific to a certain mushroom, but rather isolated repeatedly from related beetles collected from unrelated mushrooms (Suh et al. 2006a).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: No ascospores are produced after 6 weeks at 17°C on YM agar or on half-strength corn meal agar.

90.22. *Candida athensensis* S.-O. Suh & M. Blackwell (2004)

Phylogenetic placement: *Meyerozyma* clade (Figs 47.1, 90.2). (The description is based on Suh and Blackwell 2004.)

Growth on YM agar: After 7 days at 25°C, colonies are white, butyrous and smooth.

Growth in YM broth: After 5 days at 25°C, yeast cells are globose to ovoid, $1.25\text{--}5 \times 1.25\text{--}5\text{ }\mu\text{m}$, mostly subglobose, and occur singly, in pairs or in short chains. Pseudohyphae are absent.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae are absent. Aerobic growth is white, glistening and smooth.

Fermentation

Glucose	+/d	Lactose	–
Galactose	d	Raffinose	–
Sucrose	d	Trehalose	d/w
Maltose	d/w	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	+/d
Inulin	–	Methanol	–
Sucrose	+	Ethanol	v
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	v
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	+	D,L-Lactate	+/d
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+/w
L-Sorbose	–	D-Glucosamine	+/d
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	+/d	Hexadecane	n
L-Arabinose	w	Nitrate	–
D-Arabinose	+/d/w	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	10% NaCl/5% glucose	v
2-Keto-D-gluconate	+	16% NaCl	v
D-Glucuronate	–	Starch formation	–
L-Arabinitol	d	Acid acetic production	–
Arbutin	+/d	Urease	–
Propane 1,2 diol	d	Growth on 1% acetic acid	–
Butane 2,3 diol	–	DBB	–

D-Glucono-1,5-lactone	+/w	Cycloheximide 0.01%	+
Quinic acid	–	Cycloheximide 0.1%	+
D-Glucarate	–	Growth at 30°C	+
D-Galactonate	–	Growth at 35°C	v
Nitrite	–	Growth at 40°C	–
Cadaverine	+	Growth w/o myo-inositol	+
Creatinine	–	Growth w/o pantothenate	+
L-Lysine	+	Growth w/o biotin	–
Ethylamine	+/d	Growth w/o thiamine	+
D-Glucosamine (as N compound)	v	Growth w/o biotin & thiamine	–
D-Tryptophan	–	Growth w/o pyridoxine	+
Creatine	–	Growth w/o pyridoxine & thiamine	+
Imidazole	–	Growth w/o niacin	+
50% Glucose	+/d	Growth w/o PABA	+
60% Glucose	–		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY518528, SSU rRNA = AY518522, ITS and 5.8S rRNA = AY553846.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9840 (NRRL Y-27644), isolated from the gut of an unidentified cucujoid beetle, Athens, Georgia, USA; CBS 9841 (NRRL Y-27646), isolated from the surface of red-banded fungus beetle (*Megalodacne fasciata*, Erotylidae), Athens, Georgia, USA; NRRL Y-27645, isolated from an unidentified curculionid, Barro Colorado Island, Panama (Suh and Blackwell 2004).

Type strain: CBS 9840.

Systematics: Based on comparison of SSU and LSU rRNA gene sequences, *C. athensensis* forms a statistically well-supported subclade with *Meyerozyma guilliermondii*, *C. carpophila* (*C. xestobii*), *C. fermentati* and *C. smithsonii* (Suh and Blackwell 2004). *Candida smithsonii* and *C. athensensis* show identical sequences in SSU, but can be distinguished based on assimilation tests and sequence comparison of the D1/D2 and ITS regions. The D1/D2 sequence of NRRL Y-27646 differed by three mismatches from that of the other two strains of *C. athensensis*, but morphological and physiological traits were similar.

Ecology: All isolates of *C. athensensis* were collected from basidiocarp-feeding beetles, two in their digestive tracts and one from the surface of the insect (Suh and Blackwell 2004).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: No ascospores were produced after 2 months at 17°C on half-strength corn meal agar.

90.23. *Candida atlantica* (Siepmann) S.A. Meyer & Simone ex S.A. Meyer & Yarrow (1998)

Phylogenetic placement: *Yamadazyma* clade (Figs 81.1, 90.2).

Synonyms:

Trichosporon atlanticum Siepmann (Siepmann and Höhnk 1962)

Candida atlantica (Siepmann) S.A. Meyer & Simone (1978) nom. inval.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, $2.5\text{--}5 \times 2.5\text{--}6\text{ }\mu\text{m}$, and occur singly, in pairs, short chains and small clusters (Fig. 90.18 top).

Dalmau plate culture on YCBAS agar: After 14 days at 18°C, poorly to well-developed pseudohyphae are formed (Fig. 90.18 bottom).

Aerobic growth on corn meal agar is cream colored, somewhat glistening and soft with some “craters” in the central area of the streak. The margin is entire.

Fermentation

Glucose	w/–	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	s
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	w	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	w	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	w	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	+	Nitrate	–
D-Arabinose	s	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	–	Casein	w
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	s	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	–
50% Glucose	–	Growth at 37°C	–

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 35.8, CBS 5263 (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45799.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5263, isolated from shrimp eggs from the North Atlantic Ocean; PYCC A 39, from seawater, Portugal.

Type strain: CBS 5263.

Systematics: The history of *Trichosporon atlanticum* and the later developments leading to its validation as a member of the genus *Candida* was given by Meyer and Yarrow (1998). Meyer and Simone (1978) had shown the distinct status of *C. atlantica* from *C. diddensiae* by DNA reassociation. Based on rRNA gene sequence analysis (Kurtzman and Robnett 1998a, Sugita and Nakase 1999), *C. atlantica* is a sister species to *C. atmosphaerica* and exhibits affinities with the *Debaryomyces* clade.

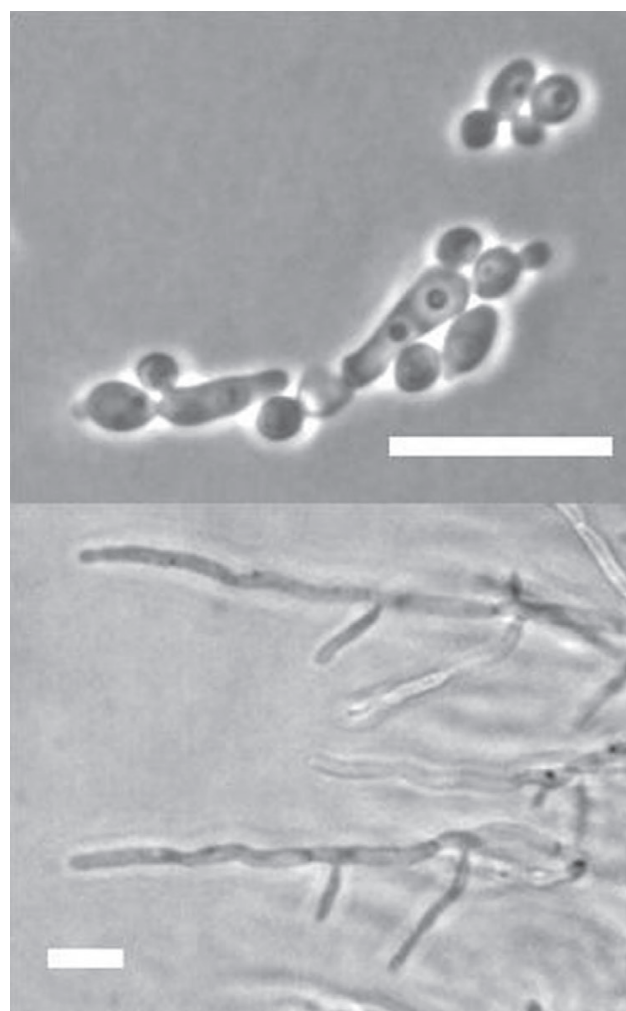


FIGURE 90.18 *Candida atlantica* CBS 5263. Budding cells, 3 days, 25°C, YM agar (top) and pseudohyphae, 2 weeks, 18°C, YCBAS agar (bottom). Bars = 10 μ m.

At variance with the result reported by Meyer et al. (1998), growth at 30°C was not observed by replica plating. The species resembles several others, including *C. atmosphaerica*. Growth on L-rhamnose, D-arabinose, hexadecane or in the presence of 10% NaCl, and the absence of growth on galactitol are useful for separation from similar species.

Ecology: Gadanho et al. (2003) recovered four isolates of *C. atlantica* in seawater, south of Portugal. Although the sampled community consisted mostly of basidiomycetous species, the isolation of these strains from Atlantic water is significant, as the species was previously known from only a single strain.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.24. *Candida atmosphaerica* Santa María (1959c)

Phylogenetic placement: *Yamadazyma* clade (Figs 81.1, 90.2).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to cylindrical, 1.5–3 $\times$ 3–12 μ m, and occur singly, in pairs and in chains (Fig. 90.19 top).

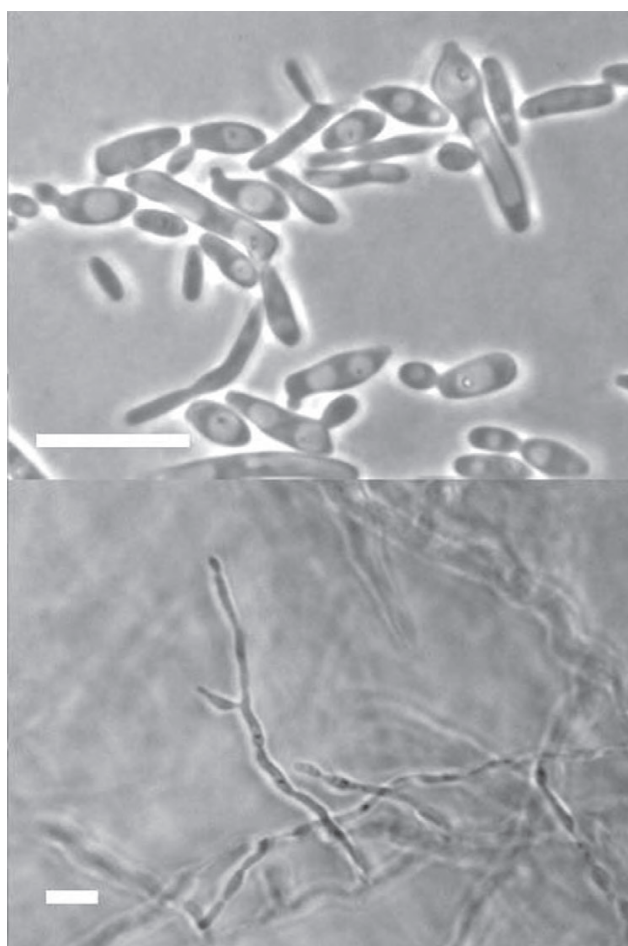


FIGURE 90.19 *Candida atmosphaerica* CBS 4547. Budding cells, 3 days, 25°C, YM agar (top) and pseudohyphae, 2 weeks, 18°C, YCBAS agar (bottom). Bars = 10 µm.

Dalmau plate culture on YCBAS agar: After 14 days at 18°C, well-developed pseudohyphae of long, branched chains of cells, usually with few blastoconidia, are present (Fig. 90.19 bottom). Aerobic growth on corn meal agar is white to cream colored, soft, smooth and butyrous.

Fermentation

Glucose	s	Lactose	—
Galactose	—/s	Raffinose	—
Sucrose	—/s	Trehalose	s
Maltose	—/s		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	—
Sucrose	+	Ethanol	w
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	s	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl-α-D-glucoside	+	DL-Lactate	—

Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	s
Salicin	—	D-Gluconate	s
L-Sorbose	s	D-Glucosamine	s
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	—
D-Arabinose	+	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono-δ-lactone	—	Casein	—
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	w
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 39.0, 38.4, CBS 4547 (T_m : Meyer and Phaff 1972, HPLC: C.-F. Lee et al. 1993, respectively), 39.7, CSAV 29-50-1 (T_m : Stenderup and Bak 1968); 38.8, AJ 5107 (T_m : Nakase and Komagata 1971f).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45779.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 4547, isolated from the atmosphere in Spain (Santa María 1959c).

Type strain: CBS 4547.

Systematics: van Uden and Buckley (1970) reviewed the description of *C. atmosphaerica* by Santa María (1959c) and treated the strain as a member of *C. diddensiae*. Meyer and Simone (1978) showed the two species to be distinct by DNA reassociation. C.-F. Lee et al. (1993) showed insignificant DNA relatedness between the species and *C. dendronema* or *C. terebra* (syn. of *Yamadazyma mexicana*). Based on D1/D2 LSU (Kurtzman and Robnett 1998a) and SSU (Sugita and Nakase 1999) rRNA gene sequences, *C. atmosphaerica* is a sister species to *C. atlantica* and is related to the *Debaryomyces* clade. Strain CBS 7170, isolated from the fruiting body of a fungus (*Tyromyces ptychogaster*) on a fallen trunk of a spruce tree (*Picea abies*) and included in the species by Meyer et al. (1998), differed from the type by a few growth characteristics. D1/D2 LSU rRNA gene sequencing (AY574389) showed the strain to be a basal member of the *C. tanzawaensis* clade and for this reason it is excluded from the species.

The growth characteristics of the type strain agreed with the description given by Meyer et al. (1998) except for the utilization of melezitose and growth in the presence of 50% glucose, which were found negative. Interestingly, triangular to clover-leaf shaped cells may be found on some media.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.25. *Candida aurangiensis* Santa María (1978)

Phylogenetic placement: unaffiliated clade (Fig. 90.3).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, 2.5–4 × 3–5 µm, and occur singly and in pairs. Some cells may be teardrop-shaped (Fig. 90.20 top).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, poorly to well-developed pseudohyphae are present (Fig. 90.20 bottom). Aerobic growth is white, creamy, smooth and glistening. The margin is mostly entire with an occasional tuft of mycelial growth.

Fermentation

Glucose	+	Lactose	s
Galactose	+	Raffinose	—
Sucrose	—	Trehalose	+/s
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	—	Ethanol	s
Raffinose	—	Glycerol	s
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	s
Lactose	+	Galactitol	s
Trehalose	+	D-Mannitol	s
Maltose	—	D-Glucitol	s
Melezitose	—	myo-Inositol	+
Methyl- α -D-glucoside	—	DL-Lactate	—
Soluble starch	—	Succinate	s
Cellobiose	s	Citrate	—
Salicin	+	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	s
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	—
L-Arabinose	+	Nitrate	—
D-Arabinose	w	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	s	Gelatin	—
Glucono- δ -lactone	s	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	s	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	+

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 40.2, CBS 6913; 40.0, CBS 6919 (T_m : S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U62300.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6913, isolated from alpechin in Spain.

Other strains: CBS 6919, CBS 6920, both isolated from alpechin in Spain.

Type strain: CBS 6913.

Systematics: *Candida aurangiensis* is known from isolates recovered in alpechin, the solid residue obtained after pressing olives in oil production. Among the many unusual features of this species is the isolated phylogenetic position of the small clade shared with

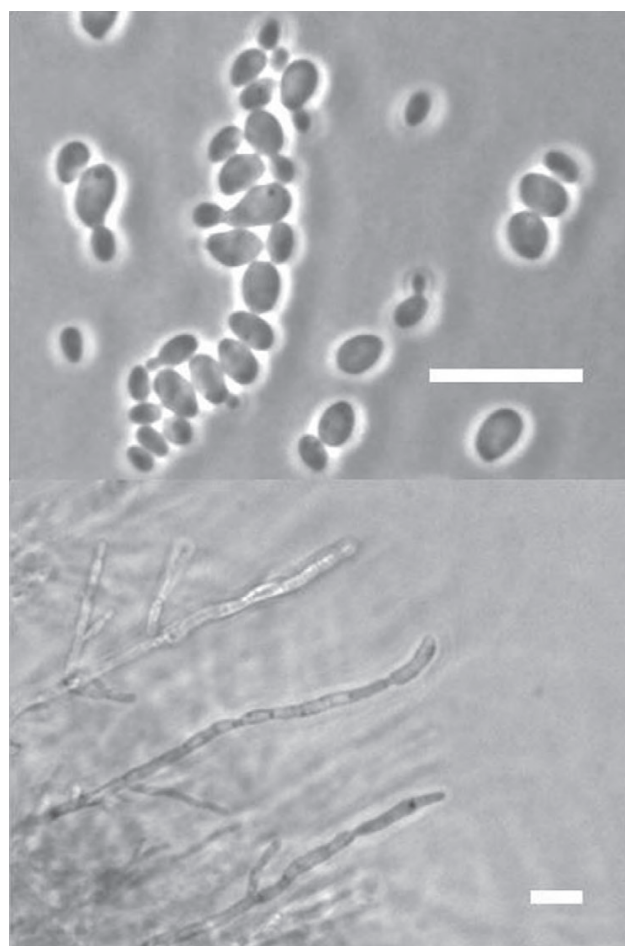


FIGURE 90.20 *Candida aurangiensis* CBS 6913. Budding cells, 3 days, 25°C, YM agar (top) and pseudohyphae, 2 weeks, 18°C, YCBAS agar (bottom). Bars = 10 μ m.

C. tartarivorans and *C. salmanticensis*, as evidenced by analysis of D1/D2 LSU (Fonseca et al. 2000c, Kurtzman and Robnett 1998a) or SSU (Suzuki et al. 1999) rRNA gene sequences.

Dien et al. (1996) identified *C. aurangiensis* as one of the few yeast species able to ferment L-arabinose. Sugar utilization by *C. aurangiensis* is unusual in that lactose and trehalose are the only hexodisaccharides assimilated. These two sugars are also assimilated by strain UWOPS 93-324.2, a close relative isolated from a rot of an *Agave* sp. in the Bahamas, but the latter also exhibits β -fructosidase and β -glucosidase activity. Lactose is not utilized by other closely related, undescribed species that include strain UWOPS 85-228.1.3 and several others found in sap fluxes of mesquite (*Prosopis juliflora*) and associated *Drosophila* species in Arizona and Baja California, as well as strain UWOPS 99-304.7 and others from sap fluxes of guapinol (*Hymenaea courbaril*, Mimosaceae) in Costa Rica. At variance with previous reports, the type culture did not utilize salicin and gluconic acid when tested by replica plating. The physiological profile is sufficiently unique to allow discrimination from other species. In particular, myo-inositol and glucuronic acid are not assimilated by physiologically similar species.

Ecology: Alpechin is a significant source for the isolation of yeasts. How *C. aurangiensis* is introduced to that habitat is not known.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.26. *Candida aurita* Polyakova & Chernov (2002)

Phylogenetic placement: unaffiliated clade (Fig. 90.2).

(Some of the morphological characteristics are based on Polyakova and Chernov 2002.)

Growth on wort agar: After 7 days at 20°C, the colonies are white and dense with a smooth semi-glossy surface and an even margin.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to elongate, $1-2 \times 6-7 \mu\text{m}$, and buds form near the apices (Fig. 90.21 top). A ring is formed.

Dalmat plate culture on YCBAS agar: After 2 weeks at 18°C, cylindrical pseudohyphae with small clusters of spherical blastoconidia are formed. (Fig. 90.21 bottom)

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

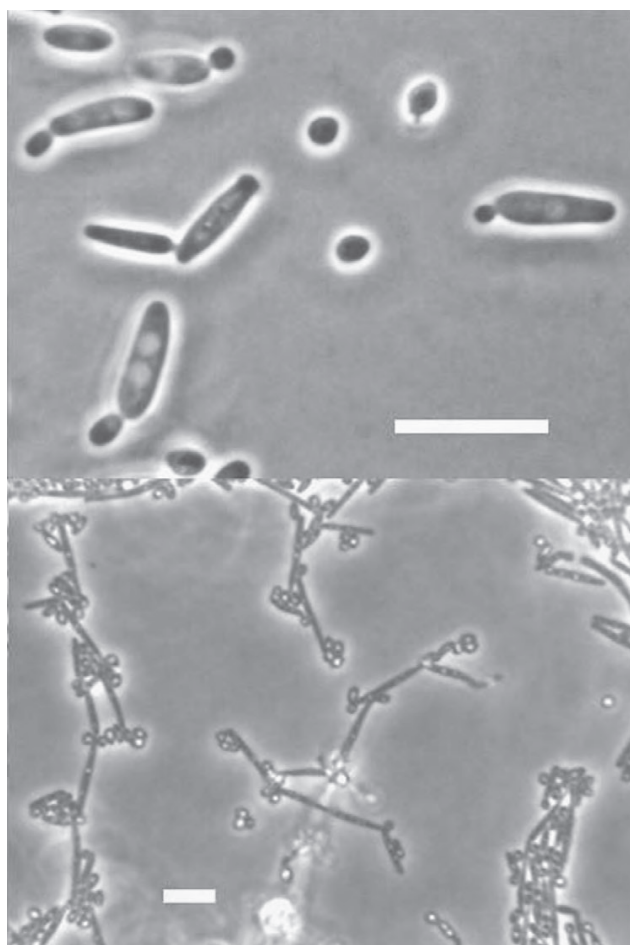


FIGURE 90.21 *Candida aurita* CBS 9724. Budding cells, 3 days, 25°C, YM agar (top) and pseudohyphae, 2 weeks, 18°C, YCBAS agar (bottom). Bars = 10 μm .

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	–
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	D-Lactate	s
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	s
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	w	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	s	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	–
50% Glucose	–	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: 36.6–36.7, three strains, including CBS 9724 (T_m : Polyakova and Chernov 2002).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AJ549217.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 9724 (VKM 2910, KBP3738), isolated from soil of a peat bog in Siberia.

Type strain: CBS 9724.

Systematics: Polyakova and Chernov (2002) described *C. aurita* from five strains isolated from the soil of oligotrophic peat bogs in Siberia. The physiological profile was suggestive of *C. austromarina* (syn. *C. sake*) but DNA reassociation between the isolates and the type of *C. sake* did not support conspecificity. The authors later determined the sequences of the ITS rDNA regions and D1/D2 domains of the LSU rRNA gene, which suggested a close relationship with *C. sophiae-reginae* (12 substitutions and 2 gaps in the D1/D2 region), and a connection with *Debaryomyces*.

Candida aurita can be separated from many other oligophagic species by the ability to utilize galactose and succinic acid, and the absence of growth on sucrose, D-glucitol and lactic acid. Interestingly, the original description did not report the presence of pseudohyphae.

Ecology: The narrow nutritional range of *C. aurita* would suggest that its presence in bog soil is linked to an invertebrate, as yeasts thought to be soil-associated tend to be nutritional generalists (Lachance and Starmer 1998).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.27. *Candida azyma* (van der Walt, E. Johannsen & Yarrow) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Wickerhamiella* clade (Fig. 79.1).

Synonym:

Torulopsis azyma van der Walt, E. Johannsen & Yarrow (1978)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to long ovoid, 2–4 × 5–9 µm, and occur singly, in pairs or in short chains (Fig. 90.22).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae, if present, consist of branched chains of ovoid cells. Aerobic growth is slightly beige to cream colored, smooth and shiny. The margin may be smooth to undulating.

Fermentation: Absent.

Growth (on Agar Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	s
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	v
Lactose	–	Galactitol	v
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	v
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	v	Hexadecane	w
L-Arabinose	v	Nitrate	–
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	w
Glucono-δ-lactone	–	Casein	–
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	v	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	–

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 54.4, CBS 6826 (T_m : van der Walt et al. 1978).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U62312.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 6826 isolated from a lichen, South Africa; UWOPS 95-693.4 and others, from flowers of *Hibiscus* spp. (Malvaceae) and morning glory (*Ipomoea* spp., Convolvulaceae), Eastern and Northern Australia; UWOPS 04-111.2 and others, from

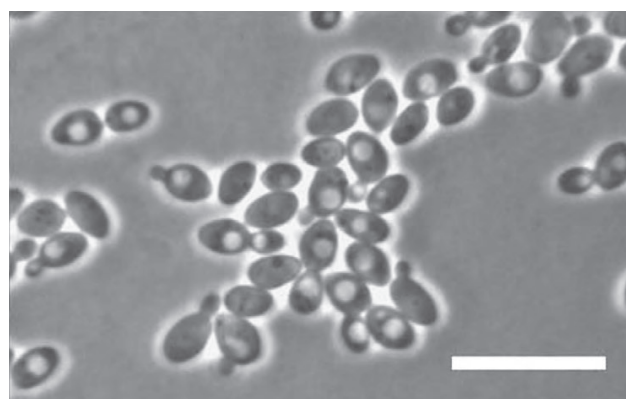


FIGURE 90.22 *Candida azyma* CBS 6826. Budding cells, 3 days, 25°C, YM agar. Bar = 10 µm.

flowers of *Clermontia* spp. (Campanulaceae), Hawai'i; UWOPS 05-260.1 and others, from flowers of *Ipomoea* spp., Cameron Highlands, Malaysia. ST-19, unknown source, Thailand, S. Jindamorakot.

Type strain: CBS 6826.

Systematics: Van der Walt et al. (1978) described *Torulopsis azyma* from two isolates from soil and a lichen. The species was shown to be ascomycetous and haploid. Sequence analyses show that *C. azyma* belongs to a clade that comprises *Wickerhamiella* and related *Candida* species (Fig. 79.1). The *Wickerhamiella* clade is unusual in that the interspecies sequence divergence is high. In fact, a BLAST search of the complete SSU rRNA gene sequence (Suzuki et al. 1999) only returns significant matches for *C. sorbophila* and *C. vanderwaltii*. A search of the D1/D2 LSU rRNA gene sequence (Kurtzman and Robnett 1998a) returns *C. vanderwaltii*, *C. drosophilae* and numerous unrelated species.

The variability reported in previous descriptions was confirmed and exacerbated by the examination of numerous strains of diverse geographical origins. However, some growth characteristics, for example the utilization of sucrose, α-glucosides, sorbose, D-mannitol, D-glucitol, succinic acid and 2-keto-D-gluconic acid, and the hydrolysis of Tween 80 are remarkably constant. Unrelated species with a similar growth profile are all fermentative. Lachance et al. (2009) examined many isolates in some detail and found that strains UWOPS 95-805.2, UWOPS 95-813.3, WOPS 95-863.2, all from hibiscus flowers in Australia, and strain UWOPS 03-446.4, from bertam palm (*Eugeissona tristis*) nectar in Malaysia, should be excluded from the species on the basis of sequence divergence. Another 57 isolates from beetles or flowers worldwide were described as the related species *Candida parazyza*. Four isolates from tropical fruit and associated substrates were found to be closely related to *C. azyma* and described by Rosa et al. (2006) as *C. azymoides*.

Ecology: Van der Walt et al. (1978) regarded *C. azyma* as a rare species, as it was then known from only two isolates. Recent surveys of the yeast community associated with flowers and associated drosophilid flies and nitidulid beetles (Lachance et al. 1988b, 2000a, 2001e) have suggested that the species is globally widespread. A more detailed examination of the isolates (Lachance et al. 2009) suggests that strains identified as *C. azyma* are part of a complex of more or less cryptic species. The distribution of the various phenotypes appears to follow geographical lines in some cases, but not always.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.28. *Candida azymoides* Rosa, Morais, Lachance & Trindade (Rosa et al. 2006)

Phylogenetic placement: *Wickerhamiella* clade; see Systematics (Fig. 90.3).

(The description is based on Rosa et al. 2006.)

Growth on YM agar: After 2 days at room temperature, colonies are white, convex, smooth and opalescent.

Growth in 0.5% yeast extract–2% glucose broth: After 3 days at 25°C, the cells are ovoid to ellipsoidal, $2-3 \times 2-4 \mu\text{m}$, and reproduce by multilateral budding (Fig. 90.23).

Growth on the surface of liquid media: Sediment is formed after a month, but no pellicle was observed.

Dalmat plate culture on corn meal agar: After 2 weeks, pseudohyphae or true hyphae are not present.

Fermentation: Absent.

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	s
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	v
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	–	D-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	s	Hexadecane	–
L-Arabinose	s	Nitrate	–
D-Arabinose	–	Vitamin-free	–

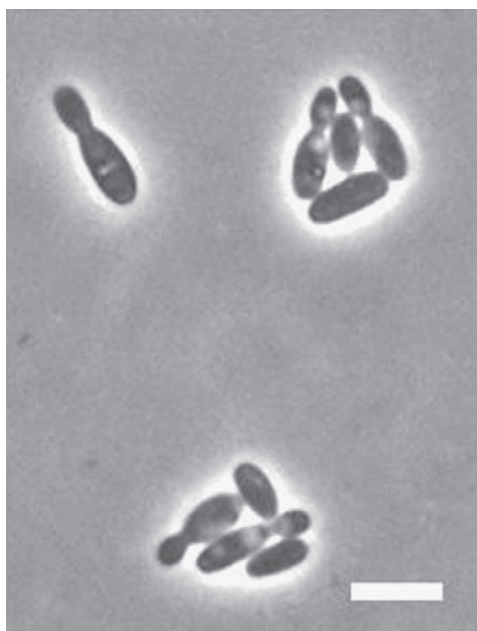


FIGURE 90.23 *Candida azymoides* UFMG R287. Budding cells, 3 days, 25°C, YM agar. Bar = 5 μm . From Rosa et al. (2006), with permission.

Additional Growth Tests and Other Characteristics

Xylitol	+	Ethylamine	+
Isopropanol	–	50% Glucose	v
2-propanol	–	5% NaCl	+
2-Keto-D-gluconate	+	10% NaCl/5% glucose	v
Acetone	–	Starch formation	–
Ethyl acetate	–	Urease	–
Nitrite	–	Cycloheximide 0.01%	+
Amino acid-free	+	DBB	–
Cadaverine	+	Growth at 30°C	+
L-Lysine	+	Growth at 37°C	–

CoQ: Not determined

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: Partial SSU rRNA, ITS and 5.8S rRNA, D1D2 LSU rRNA = DQ985171.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 10508 (UFMG-R287), UFMG-R290, both isolated from ripe fruits of Brazilian cherry (*Eugenia uniflora*, Myrtaceae), Aracajú, Sergipe State, north-east Brazil; UFMG-05-T200.2 and UFMG-05-T201.2, isolated from larvae of a frugivorous fly (*Anastrepha mucronota*) found on bacupari fruits (*Peritassa campestris*, Hippocrateaceae) in the Ipuca ecosystem, Tocantins State, Brazil (Rosa et al. 2006).

Type strain: CBS 10508.

Systematics: *Candida azymoides* is a sister species to *C. azyma* (Rosa et al. 2006). The two species differ by seven substitutions in the D1/D2 domains of the LSU rRNA gene, and 20 in the ITS1 and four in the ITS2 spacers.

Ecology: *Candida azymoides* was found on tropical fruits of Brazilian cherry and on a fly that attacks bacupari fruits as well as, probably, other fruit species in the Ipuca ecosystem (Rosa et al. 2006).

Biotechnology: Unknown.

Agriculture and food: The fly species from which two isolates were collected is not known to be economically important, but other species in the genus are considered pests for many different kinds of fruits (Cruz-López et al. 2006).

Clinical importance: Unknown.

Additional comments: Ascospores were not produced on corn meal agar or other sporulation media such as diluted V8 agar, 5% malt extract agar and Yeast Carbon Base agar supplemented with 0.01% ammonium sulfate.

90.29. *Candida barrocoloradensis* S.-O. Suh, N.H. Nguyen & M. Blackwell (2006a)

Phylogenetic placement: *Candida kruisii* clade (Fig. 90.5). (The description is based on Suh et al. 2006a.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, butyrous, smooth and have a filamentous margin.

Growth in YM broth: After 7 days at 25°C, cells are ellipsoidal to fusiform, $1-5 \times 2-10 \mu\text{m}$, mostly fusiform, occur singly and rarely in pairs, but some cells form clusters, and pseudohyphae are absent but true hyphae do occur.

Dalmat plate culture on corn meal agar: After 10 days 25°C, pseudohyphae and septate hyphae are present. Aerobic growth is off-white, butyrous and with a filamentous margin.

Fermentation

Glucose	+	Lactose	–
Galactose	d	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	d
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	w	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	d	10% NaCl/5% glucose	—
2-Keto-D-gluconate	+	16% NaCl	—
D-Gluconate	—	Starch formation	—
L-Arabinitol	—	Urease	—
Arbutin	+	Growth on 1% acetic acid	—
Propane 1,2 diol	—	DBB	—
Butane 2,3 diol	—	Cycloheximide 0.01%	+
D-Glucono-1,5-lactone	d	Cycloheximide 0.1%	+/d
Quinic acid	—	Growth at 30°C	+
D-Gluconate	—	Growth at 35°C	—
Nitrite	—	Growth at 40°C	—
Cadaverine	+	Growth w/o myo-inositol	+
Creatinine	—	Growth w/o pantothenate	+
L-Lysine	+	Growth w/o biotin	—
Ethylamine	+	Growth w/o thiamine	+
D-Glucosamine (as N compound)	—	Growth w/o biotin & thiamine	—
D-Tryptophan	—	Growth w/o pyridoxine	+
Creatine	—	Growth w/o pyridoxine & thiamine	+
Imidazole	—		
50% Glucose	+	Growth w/o niacin	+
60% Glucose	+	Growth w/o PABA	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = DQ647640, SSU rRNA = DQ647639, ITS and 5.8S rRNA = DQ647641.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 10310 (NRRL Y-27934), isolated from the guts of a sap beetle (*Pallodes* sp.) on a mushroom (*Gerronema* sp., Agaricales); BG 05-8-6-006A-1-1, from the guts of *Pallodes* sp. on a mushroom (*Hydropus* sp., Agaricales), both from Barro Colorado Island, Panama (Suh et al. 2006a).

Type strain: CBS 10310.

Systematics: *Candida barrocoloradensis* clusters with eight other *Candida* species in a sister group of *C. kruisii* and strain CBS 9453 (Suh et al. 2006a). The sister clade is well supported by bootstrap

and Bayesian analyses and can be divided in two subclusters comprising, respectively, *C. barrocoloradensis*, *C. atbi*, *C. gatunensis*, *C. aglyptinia* and *C. stri*, and *C. tritomonae*, *C. pallodes*, *C. lycoperdinae* and *C. panamensis*. The above-mentioned clusters can be distinguished by their reaction to 0.01% and 0.1% cycloheximide. The only exception is *C. kruisii*, which is negative for growth in 0.1% cycloheximide, as is the rest of its cluster, but it will grow in 0.01% cycloheximide.

Ecology: Both strains were found in the digestive tract of mushroom-feeding beetles (Suh et al. 2006a).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Ascospores were not produced after 6 weeks at 17°C on YM agar or on half-strength corn meal agar.

90.30. *Candida batistae* Rosa, Viana, Martins, Antonini & Lachance (1999)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

Growth on malt agar: After 2 weeks at 17°C, the colonies are small, low convex, glabrous, smooth, white and butyrous.

Growth in glucose–yeast extract broth: After 3 days at 25°C, the cells are ovoid to ellipsoidal, 1–3 $\times$ 2–4 μ m, and occur singly, in parent–bud pairs or occasionally in short chains (Fig. 90.24). Rings or pellicles are not formed.

Dalmau plate culture on corn meal agar: After 2 weeks at 18°C, pseudohyphae or true hyphae are not formed.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

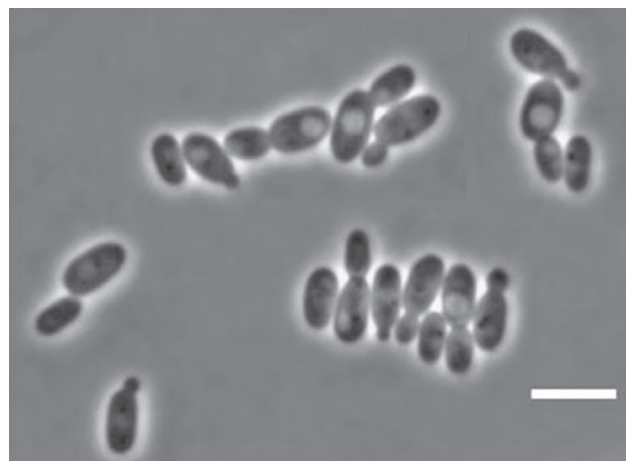


FIGURE 90.24 *Candida batistae* CBS 8550. Budding cells, 3 days, 25°C, YM agar. Reproduced from Rosa et al. (1999) with permission.

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	—
Raffinose	—	Glycerol	s
Melibiose	—	Erythritol	—
Galactose	w	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	—
Soluble starch	—	Succinate	—
Cellobiose	—	Citrate	—
Salicin	—	D-Gluconate	w
L-Sorbose	v	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	w	Casein	—
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	s	Cycloheximide 0.01%	w
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	w	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF072843.

Cell carbohydrates: Not determined.

Origin of the strains studied: UFMG96-Y192 (CBS 8550) and many other strains were isolated from larvae of a ground-nesting solitary bee (*Diadasina distincta*, Hymenoptera: Apidae), Brazil.

Type strain: CBS 8550.

Systematics: *Candida batistae* was described by Rosa et al. (1999) to accommodate nearly 100 isolates from larval provisions, larvae and pupae of the solitary bees *Diadasina distincta* and *Ptilothrix plumata* in Brazil. The species is closely related to *Starmellera bombicola* and other *Candida* species, as evidenced by analysis of D1/D2 LSU rRNA gene sequences (Fig. 71.1).

Based on growth abilities, *C. batistae* could be mistaken for a *Zygosaccharomyces* species, but the morphology is typical of *Candida* species in the *Starmerella* clade. Growth at 37°C, assimilation of ethylamine and cadaverine, absence of growth on sucrose, raffinose and nitrate can be useful in distinguishing the species from its relatives.

Ecology: Rosa et al. (1999) found that *C. batistae* and a *Mucor* species were the only dominant fungi in nearly 100 nests of the solitary bee *Diadasina distincta* examined. Larval provisions contained as many as 10^7 cfu per gram, and larvae had counts as high as 10^5 cfu per individual. *C. batistae* is resistant to a killer toxin produced by the *Mucor* species found in the same community. The authors speculated that the yeast may play a role in pollen maturation by virtue of its

fermentative ability and a strong lipolytic activity, in combination with the mold's proteolytic and pectinolytic functions.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.31. *Candida bentonensis* Kurtzman (2005b)

Phylogenetic placement: *Yarrowia* clade (Fig. 82.1).

(The description is based on Kurtzman 2005b.)

Growth on 5% malt extract agar: After 3 days at 25°C, yeast cells are ellipsoidal to elongate, $1.5-4 \times 2.5-10 \mu\text{m}$, occur singly or infrequently in pairs and reproduce by multilateral budding (Fig. 90.25A). Growth is white, semi-glistening and butyrous.

Growth on the surface of liquid media: Incomplete pellicles were formed on the surface of stationary liquid media.

Dalmau plate culture on yeast morphology agar: After 7 days at 25°C, growth under the coverglass is moderate with abundant pseudohyphae bearing elongate blastoconidia (Fig. 90.25B), but true hyphae do not occur. Aerobic growth is raised with a slightly depressed center, white, dull, butyrous and with finely and irregularly lobed margins.

Fermentation

Glucose	w	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

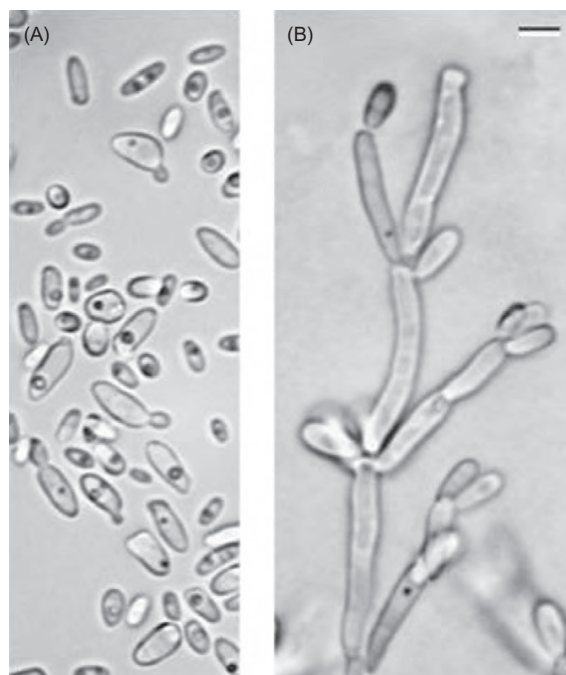


FIGURE 90.25 *Candida bentonensis* NRRL YB-2364. Budding cells after 3 days, 25°C, 5% malt extract agar (A) and pseudohyphae after 7 days, 25°C, yeast morphology agar (B). Bar = $5 \mu\text{m}$. Reproduced from Kurtzman (2005b) with permission.

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	w	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	+
Methyl- α -D-glucoside	+	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	–	Nitrate	+
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	n	Starch formation	–
2-Keto-D-gluconate	+	Gelatin liquefaction	–
5-Keto-D-gluconate	+	Cycloheximide 0.01%	+
D-Glucuronate	n	Cycloheximide 0.1%	+
Saccharate	–	Growth at 37°C	+
Cadaverine	+	DBB	–
10% NaCl/5% glucose	w		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY789653.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 9994 (NRRL YB-2364), the only isolate for this species, was collected from apple cider purchased in Benton, Illinois, USA, by L.J. Wickerham in October 1950 (Kurtzman 2005b).

Type strain: CBS 9994.

Systematics: *Candida bentonensis*, with *Yarrowia lipolytica*, *Aciculoconidium aculeatum*, *C. galli*, *C. incommunis* and *C. hispaniensis*, is part of the well-supported *Yarrowia* clade (99%), where *Yarrowia lipolytica* was the only ascosporic member at the time of the analysis (Kurtzman 2005b).

Ecology: The type strain, which is the only isolate for this species, was collected from apple cider (Kurtzman 2005b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Neither conjugation nor ascospores were observed on YM, 5% malt extract agar and McClary's acetate agar media at 15 and 25°C, after 3 months of weekly examinations.

90.32. *Candida berthetii* Boidin, Pignat, Mermier & Arpin (1963)

Phylogenetic placement: *Starmera* sister clade (Figs 70.1, 90.1).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to subglobose, 4–6 $\times$ 4.5–6.5 μ m, and occur singly and in pairs (Fig. 90.26). A dry pellicle is present.

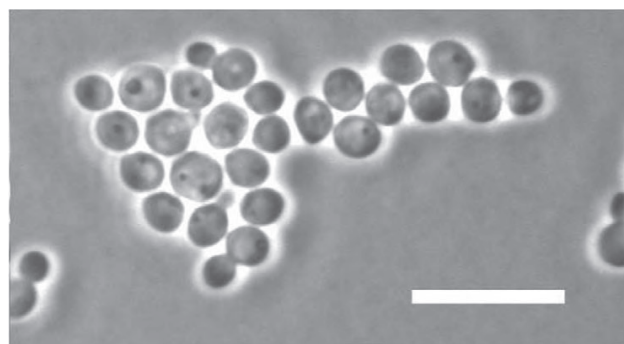


FIGURE 90.26 *Candida berthetii* CBS 5452. Budding cells after 3 days, 25°C, YM agar.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, short densely branched pseudohyphae usually with verticils of globose blastoconidia may be present. Aerobic growth is off-white to cream colored, soft, mostly smooth and the margin entire.

Fermentation

Glucose	s	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	v
Maltose	–	D-Glucitol	v
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	+
D-Arabinose	–	Vitamin-free	+

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	v	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	+	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: 39.8, type strain (T_m : Stenderup et al. 1972).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U62298.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 5452, isolated from gum arabic on a tree, Cameroun.

Other strains: CBS 5453, from gum arabic on a tree in Cameroun; CBS 6112, from tunnel of pin-borer beetle (*Xyleborus torquatus*, Coleoptera: Scolytidae) in spiked cabbage tree (*Cussonia umbellifera*, Araliaceae); CBS 6113, from tunnel of platypodid beetles (*Platypus externedentatus*, Coleoptera: Platypodidae) in wild poplar (*Macaranga capensis*, Euphorbiaceae); CBS 6229, from tunnel of *Platypus externedentatus*, in *Ficus sycomorus* (Moraceae), South Africa.

Type strain: CBS 5452.

Systematics: Boidin et al. (1963) described *C. berthetii* based on isolates from tree gum in Cameroun. A sister species to *C. dendrica*, *C. berthetii* exhibits a moderate relationship to *Starmera* (*Pichia*) *dryadoides* and *S. (Pichia) quercuum* (Fig. 90.1).

The original description reported the assimilation of inulin, sucrose and D-glucitol. These results were not confirmed in later studies. *C. berthetii* is nutritionally specialized, sugar utilization being restricted to β -glucosides. Organic acids and a few alcohols, including 1-propanol, are utilized, and ethanol resistance is high (12%).

Ecology: Like the related species *C. dendrica*, *C. berthetii* is apparently associated with tree-boring beetles.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.33. *Candida bituminiphila* Robert, Bonjean, Karutz, Paschold, Peeters & Wubbolts (2001)

Phylogenetic placement: *Sugiyamaella* clade (Fig. 90.3).

(Some of the morphological characteristics are based on Robert et al. 2001.)

Growth on 5% malt agar: After 3 days at 20°C, colonies are cream colored, smooth, soft, convex, with a glistening surface and a finely fimbriate margin. Budding cells are 1–2.5 $\times$ 2.5–8 μ m, ovoid, ellipsoid, citriform, allantoid or irregular, and budding is unipolar or bipolar (Fig. 90.27 left). Conidiophores are usually short, producing

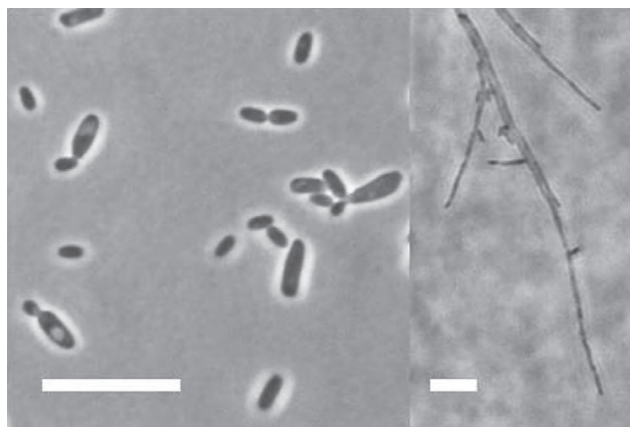


FIGURE 90.27 *Candida bituminiphila* CBS 8813. Budding cells after 3 days, 25°C, YM agar (left) and pseudohyphae after 14 days, 18°C, YCBAS agar (right). Bars = 10 μ m.

blastoconidia sympodially, giving rise to a denticulate rachis-like structure. Pseudohyphae are rare and true hyphae are sparse.

Growth in glucose–yeast extract–peptone broth: After 2 weeks at 20°C, a ring and a pellicle are formed.

Dalmau plate culture on potato dextrose agar: After 8 days at 20°C, true hyphae are produced as well as pseudohyphae and a few budding cells (Fig. 90.27 right).

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	–	Methanol	–
Sucrose	w	Ethanol	s
Raffinose	w	Glycerol	s
Melibiose	–	Erythritol	–
Galactose	s	Ribitol	s
Lactose	–	Galactitol	s
Trehalose	+	D-Mannitol	+
Maltose	s	D-Glucitol	+
Melezitose	–	myo-Inositol	+
Methyl- α -D-glucoside	–	DL-Lactate	s
Soluble starch	w	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	s
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	w	Hexadecane	w
L-Arabinose	w	Nitrate	–
D-Arabinose	w	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	s	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	+	Gelatin	–
Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	w
Nitrite	–	Acid production	w
Ethylamine	–	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF294910.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 8813, isolated from bitumen in Canada.

Type strain: CBS 8813.

Systematics: Robert et al. (2001) described *C. bituminiphila* from an isolate found in bitumen. The authors reported relationships with *Zygoascus hellenicus* and *C. bertae* based on rRNA gene sequences (LSU and SSU), linking the species to the *Sugiyamaella* clade (Fig. 90.3). *C. polysorbophila* is a close relative.

Candida bituminiphila resembles other related species (Fig. 90.3). A few differences were noted between the original description and the results obtained by replica plating, including the utilization of galactitol (slow) and citric acid, and the near absence of growth on starch or D-xylose. The utilization of *myo*-inositol and the lack of growth at 37°C are useful for separation from related species.

Ecology: *Candida bituminiphila* is known only from a single isolate from bitumen.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.34. *Candida blankii* H.R. Buckley & van Uden (1968)

Phylogenetic placement: unaffiliated clade (Fig. 90.3).

Synonym:

Candida hydrocarbofumarica K. Yamada, Furukawa & Nakahara ex C. Ramírez (1974)¹

¹ Synonymy is based on nuclear DNA reassociation studies (Meyer et al. 1998).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are spherical to ovoid to elongate, 2–5 × 2–13 µm, and occur singly, in pairs and short chains (Fig. 90.28 top).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of cells with blastoconidia formed in verticils (Fig. 90.28 bottom). True hyphae may be present. Aerobic growth is white to cream colored, soft and smooth to wrinkled.

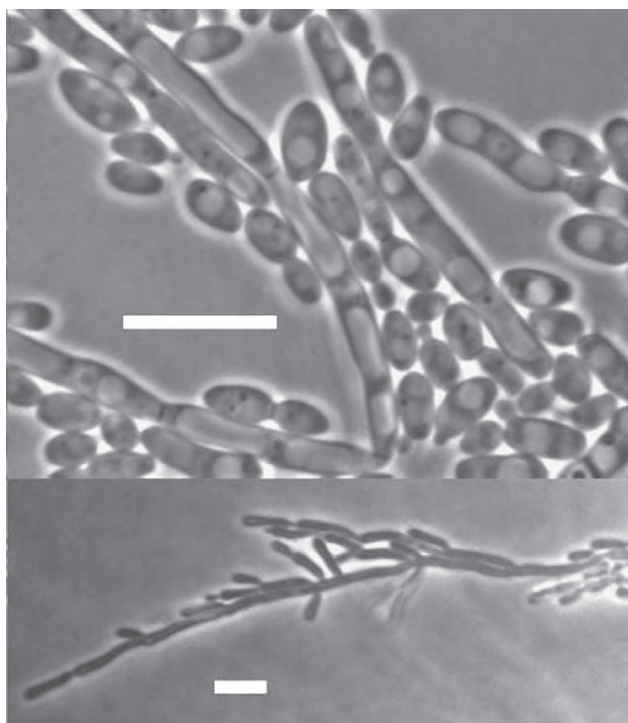


FIGURE 90.28 *Candida blankii* CBS 1898. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCB agar (bottom). Bars = 10 µm.

Fermentation

Glucose	–/s	Lactose	–
Galactose	–/s	Raffinose	–
Sucrose	s	Trehalose	–
Maltose	–/s		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	v	Glycerol	v
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	v
Lactose	+	Galactitol	v
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	<i>myo</i> -Inositol	+
Methyl-α-D-glucoside	+	D-Lactate	v
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	v
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	–
D-Arabinose	v	Vitamin-free	+

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	+	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	w
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	+

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 55.1, CBS 1898 (T_m : Meyer et al. 1984); 56.6, CBS 6734 (BD: Meyer et al. 1984); 56.6, AJ 5204 (T_m : Nakase and Komagata 1971f); 54.1, CBS 6427, CBS 6788; 54.4, CBS 7205 (T_m).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45704.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 1898, isolated from blood of a mink (*Putorius vison*), Canada; CBS 6734, type strain of *C. hydrocarbofumarica*, from soil, Japan.

Other strains: CBS 6427, CBS 6788 and CBS 6789, all from soil, Japan; CBS 7205, from uterus of a mare, New Zealand.

Type strain: CBS 1898.

Systematics: Buckley and van Uden (1968) described *C. blankii* from a strain recovered from organs of a mink. Meyer et al. (1998) reduced *C. hydrocarbofumarica* to synonymy with *C. blankii* because of the high degree (90%) of nuclear DNA reassociation between the type strains. *C. blankii* shows an affinity for the *Sugiyamaella* clade as evidenced by analysis of SSU rRNA gene sequences (Suzuki et al. 1999). Connections using the D1/D2 LSU rRNA gene sequence are tenuous,

as the nearest known species other than *C. digboiensis* differ by 100 or more substitutions (Fig. 90.3). As a result, the affinity with the *Starmerella* clade suggested by Kurtzman and Robnett (1998a) may be due to long branch attraction.

The types of *C. hydrocarbofumarica* and *C. blankii* have nearly identical growth responses, but they can be distinguished from most other polyphagic ascomycetous yeasts by the utilization of lactose and myo-inositol. Middelhoven and Kurtzman (2003) also found the species capable of assimilating a number of compounds that require special metabolic pathways, namely, glycine, uric acid, leucine, isoleucine and putrescine. Unlike what is observed in several other species in the clade, adenine and isobutanol were not assimilated. The growth profile assessed by replica plating matched previous descriptions well and further revealed that the species grows on 1-propanol and 1-butanol, but not isopropanol. Costamagna et al. (1986) screened strains from 53 species for their ability to grow at the expense of ascorbic acid. *C. blankii* was one of four ascomycetous yeast species capable of doing so.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Mihyar et al. (1997) found *C. blankii* to be uncommonly resistant to familiar food preservatives such as sodium benzoate and potassium sorbate, causing the yeast to be a significant agent of spoilage of labaneh, a Middle-Eastern dairy product derived from yogurt.

Clinical importance: Based on isolation sources, a veterinary significance might be inferred.

90.35. *Candida blattariae* S.-O. Suh, N.H. Nguyen & M. Blackwell (2005b)

Phylogenetic placement: *Yamadazyma* clade (Fig. 90.2).

(The description is based on Suh et al. 2005b.)

Growth on YM agar: After 7 days at 25°C, colonies are white, butyrous and smooth.

Growth in YM broth: After 7 days' growth at 25°C, cells are subglobose to ellipsoidal, 3–5 × 3–6 μm, occur singly, in pairs, in short chains or in clusters, and pseudohyphae may be present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae are present. Aerobic growth is white to off-white, smooth and glossy.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	d
Maltose	–	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	–
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D-Lactate	d
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+

L-Sorbose	–	D-Glucosamine	+
L-Rhamnose	+	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	10% NaCl/5% glucose	+
2-Keto-D-gluconate	+	16% NaCl	w
D-Glucuronate	–	Starch formation	–
Arbutin	+	Urease	–
Propane 1,2 diol	–	Growth on 1% acetic acid	–
Butane 2,3 diol	–	DBB	–
L-Arabinitol	–	Cycloheximide 0.01%	–
D-Glucono-1,5-lactone	+	Cycloheximide 0.1%	–
Quinic acid	–	Growth at 30°C	+
D-Gluconate	–	Growth at 35°C	–
Nitrite	–	Growth w/o myo-inositol	+
Cadaverine	+	Growth w/o panthotenate	+
Creatinine	–	Growth w/o biotin	–
L-Lysine	+	Growth w/o thiamine	+
Ethylamine	+	Growth w/o biotin & thiamine	–
D-Glucosamine (as N compound)	+	Growth w/o pyridoxine	+
D-Tryptophan	w	Growth w/o pyridoxine & thiamine	+
Creatine	–	Growth w/o niacin	+
Imidazole	–	Growth w/o PABA	+
50% Glucose	+		
60% Glucose	–		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1D2 LSU rRNA = AY640213, SSU rRNA = AY640210.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 9876 (NRRL Y-27703), which is the only known strain for this species, was isolated from the guts of an unidentified cockroach (*Blattaria* sp.) in Barro Colorado Island, Panama (Suh et al. 2005b).

Type strain: CBS 9876.

Systematics: *Candida blattariae* clusters within the *C. membranifaciens* subclade with *C. membranifaciens*, *C. friedrichii* and *C. buinensis* (Suh et al. 2005b). The subclade is well supported with an 83% bootstrap value and is related (97% boot) to a sister subclade comprised of *C. cerambycidarum*, *C. gorgasii*, *C. michaelii*, *C. endomychidarum* and *C. lessepsii*.

Ecology: The type strain, which is the only representative of *C. blattariae*, was isolated from a cockroach in Barro Colorado Island, Panama (Suh et al. 2005b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Ascospores were not produced after 6 weeks at 17°C on YM agar or on half-strength corn meal agar.

90.36. *Candida bohiensis* S.-O. Suh, N.H. Nguyen & M. Blackwell (2008)

Phylogenetic placement: *Lodderomyces–Spathaspora* clade (Fig. 90.5). (The description is based on Suh et al. 2008.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, smooth and butyrous with fuzzy areas on the surface.

Growth in YM broth: After 7 days of growth at 25°C, cells are globose to ovoid, $2-5 \times 3-6 \mu\text{m}$, mostly subglobose, occur singly, in pairs, in short chains or in clusters, and pseudohyphae are present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae are present. Aerobic growth is white to off-white with a fuzzy margin.

Fermentation

Glucose	+	Lactose	—
Galactose	+	Raffinose	—
Sucrose	v	Trehalose	—
Maltose	d	D-Xylose	—

Growth (in Liquid Media)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellulobiose	w	Citrate	+
Salicin	d	D-Gluconate	+
L-Sorbose	d	D-Glucosamine	+
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+/d	16% NaCl	—
2-Keto-D-gluconate	+	Starch formation	—
D-Glucuronate	—	Urease	—
L-Arabinitol	—	Growth on 1% acetic acid	—
Arbutin	+	DBB	—
Propane 1,2 diol	—	Cycloheximide 0.01%	+
Butane 2,3 diol	—	Cycloheximide 0.1%	+
D-Glucono-1,5-lactone	+	Growth at 25°C	—
Quinic acid	—	Growth at 30°C	+
D-Gluconate	—	Growth at 35°C	—
Nitrite	—	Growth at 37°C	—
Cadaverine	+	Growth at 40°C	—
Creatinine	—	Growth w/o myo-inositol	+
L-Lysine	+	Growth w/o pantothenate	+
Ethylamine	+	Growth w/o biotin	—
Creatine	—	Growth w/o thiamine	+
D-Glucosamine (as N compound)	—	Growth w/o biotin & thiamine	—
Imidazole	—	Growth w/o pyridoxine	+
Tryptophan	—	Growth w/o thiamine & pyridoxine	+
50% Glucose	+	pyridoxine	—
60% Glucose	—	Growth w/o niacin	+
10% NaCl/5% glucose	w	Growth w/o PABA	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY520317, SSU rRNA = AY520187.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9897 (NRRL Y-27737), isolated from the gut of an unidentified click beetle (Coleoptera, Elateridae) caught under light; NRRL Y-27754, from the gut of an unidentified leaf beetle (Coleoptera, Cerambycidae, Chrysomelidae) on leaves, both on Barro Colorado Island, Panama (Suh et al. 2008).

Type strain: CBS 9897.

Systematics: *Candida bohiensis*, with *C. chauliodes* and *C. corydalidis*, forms a basal subclade to *C. albicans*/Lodderomyces elongisporus clade (Suh et al. 2008). The two sister species in the subclade were also isolated from insects, specifically from neuropterans such as fishflies and dobflies.

Ecology: Both known isolates of this species were isolated from beetles in Barro Colorado Island, Panama (Suh et al. 2008).

Biotechnology: Unknown.

Agriculture and food: There is no evidence for food spoilage activity of the present yeast isolates. A few characteristics such as osmotolerance on 50% glucose agar and good fermentation ability suggest, however, that they may have the capacity to cause spoilage (Suh et al. 2008).

Clinical importance: Unknown.

Additional comments: Ascospores were not produced after 6 weeks on YM agar or on half-strength corn meal agar.

90.37. *Candida boidinii* C. Ramírez (1953)

Phylogenetic placement: *Ogataea* clade (Figs 53.2, 90.4).

Synonyms:¹

Candida kosuensis Yokotsuka & S. Goto (1955)

Candida olivarium Santa María (1958a)

Candida alcomigas Urakami (1975)

Candida methanolica Oki & Kounu (Oki et al. 1972)

Candida methylica Trotsenko & Bykovskaya (Trotsenko et al. 1974)

Hansenula alcolica Urakami (1975)

Torulopsis enokii Urakami (1975)

Candida queretana Herrera & Ulloa (1978)

Candida silvicola Shifrine & Phaff var. *melibiosica* Nowakowska-Waszcuk & Pietka (1983)

Candida ootensis Kumamoto & Seriu (Kumamoto et al. 1986)

¹ Synonymy determined from phenotype and from rRNA gene sequences (Kurtzman and Robnett 1998a, Suzuki and Nakase 2002).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are long-ovoid to cylindrical, $2-4 \times 4-20 \mu\text{m}$, and occur singly, in pairs and chains (Fig. 90.29 top). A pellicle is formed.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consisting of long branched chains of cells with verticils of ovoid blastoconidia are present (Fig. 90.29 bottom). Septate hyphae may be present. Aerobic growth is off-white, cream colored or beige, moist, shiny to dull, butyrous to membranous and with an irregular or a fringed margin.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

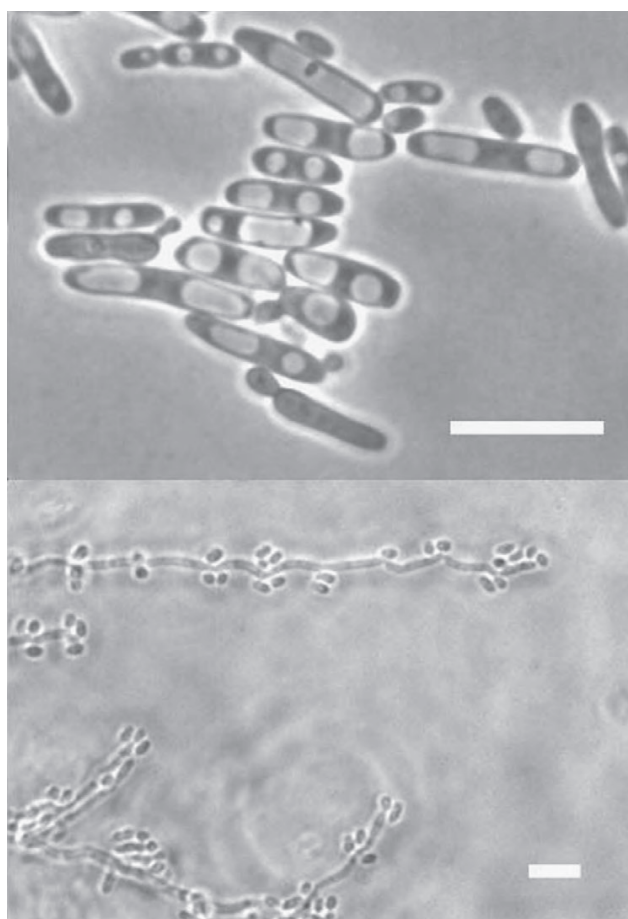


FIGURE 90.29 *Candida boidinii* CBS 2428. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 µm.

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	+
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	v
Melibiose	–	Erythritol	+
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D,L-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	v	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	v	Nitrate	+
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	v	DBB	–

D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	v	Casein	–
Amino acid-free	+	Lipase	s
Nitrite	+	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	v

CoQ: 7 (J.-D. Lee and Komagata 1980a, Lin et al. 1995).

Mol% G + C: 30.5, AJ 4778, 32.4, AJ 4939 (T_m : Nakase and Komagata 1971f), 33.0, CBS 2428 (T_m : Meyer and Phaff 1972); 31.0, CBS 2428 and CBS 8051, 30.8, CBS 8030 (HPLC: C.-F. Lee et al. 1994b); 34.6, CBS 7299 (T_m : Kumamoto et al. 1986); 35.6, CBS 8030 (T_m : Trotsenko et al. 1974); 31.0–32.9, 19 strains (HPLC: Lin et al. 1995).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70242.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 2428, isolated from tanning fluid in Spain; UWOPS 79-66 and several others from sap fluxes of Douglas fir (*Pseudotsuga menziesii*, Pinaceae), California, USA; UWOPS 79-107 and others, from sap fluxes of California black oak (*Quercus kelloggii*, Fagaceae), California, USA; UWOPS 82-5 and others, from sap fluxes of northern red oak (*Quercus rubra*), Ontario, Canada; UWOPS 85-330.4 and others, from sap fluxes of western cottonwood (*Populus fremontii*, Salicaceae), Arizona, USA; UWOPS 87-2000.2 and others, from fruit of *Opuntia megacantha* (Cactaceae), Island of Hawai'i; UWOPS 87-2030.1 and many others, from necrotic cladodes of *Opuntia megacantha*, Hawai'i Island; UWOPS 87-2431.2, from fermenting stem of *Clermontia* sp. (Araliacae) Maui, Hawai'i; UWOPS 91-782.2 and others, from sap fluxes of koa (*Acacia koa*, Fabales: Mimosaceae), Hawai'i Island; UWOPS 92-234.1, from fruit fly (*Drosophila* sp.), tequila distillery, Mexico; UWOPS 99-304.2, sap flux of guapinol (*Hymenaea courbaril*, Fabales: Caesalpinaceae), Costa Rica; UWOPS 99-342.2, from flower of *Heliconia* sp. (Heliconiaceae), Costa Rica; UWOPS 00-220.2, from gummy exudate of Guanacaste tree (*Enterolobium cyclocarpum*, Fabales: Mimosaceae), Costa Rica; UWOPS 00-610.1 and others, from sap fluxes of breadfruit (*Artocarpus altilis*, Moraceae), Islands of Oahu and Hawai'i; UWOPS 00-728.1, from sap flux of koa (*Acacia koa*), Molokai, Hawai'i; UWOPS 99-222.2, from sap flux of hemlock (*Tsuga canadensis*, Pinaceae), W.T. Starmer, Tennessee, USA; PYCC A49, from seawater, J.P. Sampaio, Portugal.

Other strains: CBS 2429, from soil in South Africa; CBS 3092, type of *C. olivarium*, from alpechin, Spain; CBS 5325, from seawater, Florida, USA; CBS 5777, type of *C. koshuensis*, from wine, Japan; CBS 6056, from ginger ale, USA; CBS 6202, from floor of hospital ward in Finland; CBS 6295, from soil, The Netherlands; CBS 6368, from washed soft-drink bottles; CBS 6990, type of *C. queretana*, from tepache, a spicy pineapple drink, Mexico; CBS 7299, type of *C. ootensis*, from slimy mud in Japan; CBS 8051 (NRRL Y-8025), CBS 8052 (NRRL Y-8023), origin unknown; CBS 8106, from soil; CBS 8251, type of *C. silvicola* var. *melibiosica*, from soil, Poland; CBS 8030, type of *C. methylica*, from soil.

Type strain: CBS 2428.

Systematics: Ramírez (1953) isolated *C. boidinii* from tanning liquors. Various synonyms have since been added, as new methods allowed the genetic relatedness of physiologically variable yeasts to be elucidated. The latest addition was that of *C. ootensis* by Kurtzman and Robnett (1998a), who found the D1/D2 LSU rRNA gene sequences of the types to be identical. Suzuki and Nakase (2002) determined the SSU rRNA gene sequences of these as well as the type strain of

C. methylica and found the latter to differ from the type of *C. boidinii* by only two substitutions and one gap, which does not argue strongly in favor of retaining them as separate species. Strain UWOPS 99-304.2, isolated from a sap flux of the amber tree *Hymenaea courbaril* in Costa Rica, differs by many growth characteristics. As the D1/D2 LSU rRNA gene sequence matches perfectly that of the type, and because only one strain of that phenotype is known, it is included in the species. Variation appears to be an inherent property of *C. boidinii*. Lee and Komagata (1983) compared the electrophoretic patterns of enzymes of several strains and identified two distinct groups. Lin et al. (1996) examined 19 strains, including many of the CBS strains listed above, and found the distribution of cellular fatty acids, CoQ, DNA base composition and lengths of the ITS/5.8S rDNA region to be within the range expected for a species. However, restriction analysis of the amplified ITS sequences elicited a higher degree of variation and also supported division into two groups. Electrophoretic karyotypes were variable, but in view of the results obtained previously by Lee et al. (1994b), did not support division into two species. Analysis of rRNA gene sequences places *C. boidinii* in a clade that contains many other methylotrophic yeast species, including several teleomorphs in the genus *Ogataea*.

The type strain of *C. methylica* assimilates L-rhamnose and not D-ribose whereas most other strains of *C. boidinii* assimilate D-ribose and not L-rhamnose. *C. ootensis* was reported (Kumamoto et al. 1986) to differ from *C. boidinii* in the assimilation of galactose, L-sorbose and succinic acid and the absence of growth on nitrate. Meyer et al. (1998) confirmed the differences in L-sorbose (positive) and nitrate (negative) utilization. Strain UWOPS 99-304.2 assimilates sucrose, α -glucosides, β -glucosides, L-rhamnose, inositol, citric acid and hexadecane. Lin et al. (1996) detected variation in the assimilation of L-sorbose, L-arabinose and D-glucosamine among the 19 strains examined by them. In spite of the variation observed among strains, *C. boidinii* can be resolved from similar species based on growth on methanol, erythritol, lactic acid and nitrite, and absence of growth in the presence of 50% glucose.

Ecology: *Candida boidinii* has been isolated from a variety of sources, sometimes in relation to human activity. The species is found with high regularity in the sap fluxes of many tree species in geographically distinct regions of the world. A common link to many of the substrates is drosophilid flies that visit materials rich in sugar and volatile organic compounds, including methanol that arises from the action of pectin esterase on the tissue plants undergoing microbial decay. Conceivably, the flies benefit by introducing to their feeding sites yeasts that metabolize methanol.

Biotechnology: *Candida boidinii* has gained notoriety as a so-called "non-conventional" yeast. Methanol utilization confers upon the species a number of properties that are useful in heterologous protein expression. The literature on this and related subjects is abundant. A recent example is the identification of regulatory elements involved in the induction of NAD⁺-dependent formate dehydrogenase (Komeda et al. 2003) and that are useful in the control of protein secretion.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.38. *Candida bokatorum* S.-O. Suh & M. Blackwell (Suh et al. 2004b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5). (The description is based on Suh et al. 2004b.)

Growth on YM agar: After 7 days at 25°C, colonies are white to cream in color, butyrous and smooth.

Growth in YM broth: After 7 days, growth at 25°C, cells are globose to ellipsoidal, 2–6 × 3–6 μ m, mostly subglobose, occur singly, in pairs or in short chains, and pseudohyphae may be present.

Dalmay plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and hyphae may be present. Aerobic growth is white and smooth.

Fermentation

Glucose	+/d	Lactose	–
Galactose	–	Raffinose	–
Sucrose	v	Trehalose	+/d
Maltose	v	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+/d/w
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+/d
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	d/w
L-Sorbose	n	D-Glucosamine	v
L-Rhamnose	n	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	+/d/w	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	10% NaCl/5% glucose	+/w
2-Keto-D-gluconate	+	16% NaCl	–
D-Glucuronate	–	Starch formation	–
Arbutin	+	Urease	–
Propane 1,2 diol	v	Growth on 1% acetic acid	–
Butane 2,3 diol	–	DBB	–
D-Arabinitol	–	Cycloheximide 0.01%	v
D-Glucono-1,5-lactone	+/d/w	Cycloheximide 0.1%	–
Quinic acid	–	Growth at 25°C	+
D-Glucarate	–	Growth at 30°C	+
D-Galactonate	–	Growth at 35°C	v
Nitrite	–	Growth at 40°C	–
Cadaverine	+	Growth w/o myo-inositol	+
Creatinine	–	Growth w/o panthotenate	+
L-Lysine	+	Growth w/o biotin	–
Ethylamine	+	Growth w/o thiamine	+
D-Glucosamine (as N compound)	v	Growth w/o biotin & thiamine	–
D-Tryptophan	–	Growth w/o pyridoxine	+/d
Creatine	–	Growth w/o thiamine & pyridoxine	+
Imidazole	–		
50% Glucose	+	Growth w/o niacin	+
60% Glucose	–	Growth w/o PABA	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY309798, SSU rRNA = AY426950.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9824 (NRRL Y-27571), isolated from a beetle (*Pselaphacus signatus*, Coleoptera: Erotylidae) on basidiocarps of *Polyporus tenuiculus*. The following strains are from different beetles, all feeding on the same fungal species (*P. tenuiculus*): BG 02-7-16-039A-2-1, from *Mycotretus nitescens* (Erotylidae); BG 02-7-14-001D-1-1, from *Pselaphacus* sp. (Erotylidae); NRRL Y-27558, from an unidentified carabid beetle; NRRL Y-27579, from *Teichostethus testaceus* (Nitidulidae); NRRL Y-27576, from an unidentified melandryid beetle; BG02-7-14-001K-1-2, from an unidentified tenebrionid beetle; BG 02-7-16-030B-3-2, from *Iphiclus (Megaprotus) delineatus* (Erotylidae) on a corticoid fungus; BG 02-7-18-023B-1-2, isolated from a larva of *Ellipticus gemellatus* (Erotylidae) on a wood-inhabiting mushroom *Tinctoporellus epimilitinus*. All isolates came from Barro Colorado Island, Panama (Suh et al. 2004b).

Type strain: CBS 9824.

Systematics: *Candida bokatorum* belongs to the *Candida tanzawaensis* clade (Fig. 90.5), which includes 17 subclades of gut yeasts from basidiocarp-feeding beetles. *C. bokatorum* and *C. guaymorum* share the same sequence in SSU, but differ in the D1/D2 regions (Suh et al. 2004b).

Ecology: All isolates for this species were collected from basidiocarp-feeding beetles, Barro Colorado Island, Panama. The majority of the isolates were from beetles feeding on *Polyporus tenuiculus* (Suh et al. 2004b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown

Additional comments: Ascospores were not produced after 6 weeks at 17°C on YM agar or on half-strength corn meal agar.

90.39. *Candida boleticola* Nakase (1971b)

Phylogenetic placement: Kurtzmanella clade (Figs 40.1, 90.2).

Synonyms:¹

Candida laureliae C. Ramírez & A. González (1984f)

Candida ralunensis C. Ramírez & A. González (1984f)

¹ Synonymy based on D1/D2 LSU rRNA gene sequences (Kurtzman and Robnett 1998a).

Growth in glucose–yeast extract–peptone broth: After 5 days at 25°C, the cells are ovoid to elongate, 2.5–5 × 5–10 μm, and occur singly, in pairs and short chains (Fig. 90.30 top). The type strain forms a thin pellicle.

Dalmau plate culture on corn meal agar: After 5 days at 25°C, well-developed pseudohyphae consisting of branched chains of cylindroid cells with small verticils of ovoid blastoconidia are present (Fig. 90.30 bottom). Aerobic growth is white to cream colored, smooth to wrinkled, dull to shiny and with a fringed margin or tufts of pseudohyphal development.

Fermentation

Glucose	+/-	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

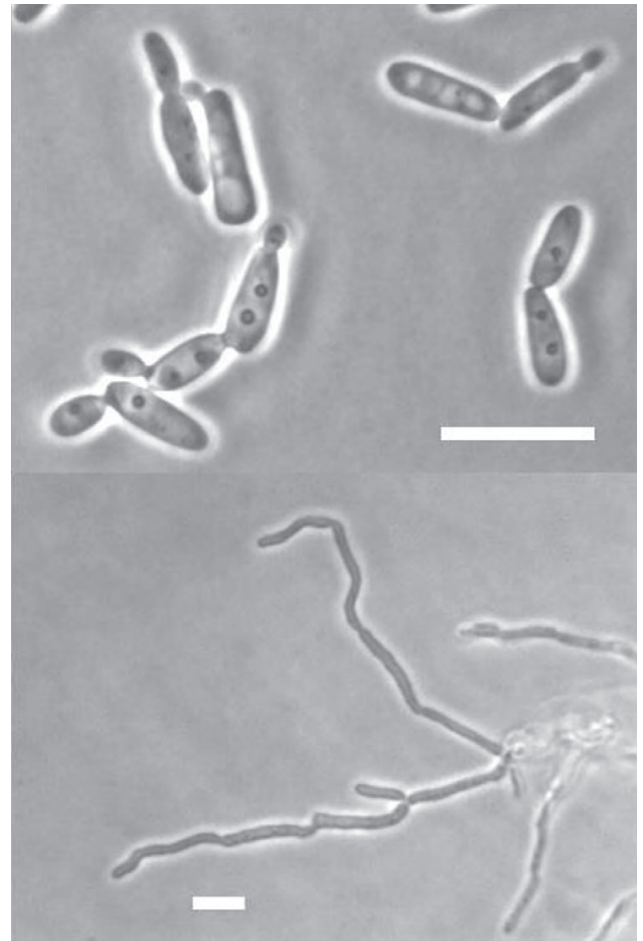


FIGURE 90.30 *Candida boleticola* CBS 6420. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μm.

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	–	Methanol	–
Sucrose	–	Ethanol	s
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	v	Citrate	+
Salicin	+	D-Gluconate	v
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	v
L-Arabinose	–	Nitrate	–
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono-δ-lactone	s	Casein	—
Amino acid-free	+	Lipase	w
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+/w
L-Lysine	+	Cycloheximide 0.1%	v
Cadaverine	+	1% Acetic acid	—
10% NaCl	v	Growth at 30°C	v
50% Glucose	v	Growth at 37°C	—

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 43.2–44.1, three strains (T_m : Nakase 1971b); 44.4, CBS 6420; 43.6, CBS 8179 (T_m : S.A. Meyer, unpublished data); 44.9, CBS 8180, type strain of *C. laureliae* (T_m : Tengku Zainal Mulok 1988).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45777.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 6420, isolated from a fruiting body of an earthstar mushroom (*Astraeus hygrometricus*) in Japan; CBS 8179, type strain of *C. ralunensis*, from rotten trunk of Chilean laurel (*Laurelia sempervirens*, Atherospermataceae), Chile; CBS 8180, type strain of *C. laureliae*, from fallen trunk of tepa (*Laurelia philippiana*), Chile; UWOPS 79-100, from beetle in a polypore fungus, Sierra Nevada, California, USA.

Other strain available: CBS 7844, from rotten leaf; CBS 7847, from soil, Mongolia.

Type strain: CBS 6420.

Systematics: *Candida boleticola* was described by Nakase (1971b) to accommodate eight strains isolated from mushrooms, based principally on differences in DNA base composition from *C. conglobata*, which was similar in morphology and physiology. Kurtzman and Robnett (1998a) found *C. laureliae* and *C. ralunensis* to have identical sequences in the D1/D2 LSU rRNA gene and to differ by only one nucleotide from *C. boleticola*, suggesting that the three taxa may be conspecific. Sugita and Nakase (1999) found identical SSU rRNA gene sequences for these species as well as *C. schatavii*, lending additional support to the close relatedness of these species. The sequences of the ITS regions and the 5.8S rRNA gene of these species were determined in an attempt to clarify their circumscriptions. The types of *C. boleticola* (AY569005), *C. ralunensis* (Wu and Bai, GenBank AY821842) and *C. laureliae* (Wu and Bai, GenBank AY821841) had identical sequences and are considered synonyms. These differed by 21 substitutions and six gaps from *C. schatavii* (AY569006), favoring the retention of that species as separate.

Most of the differences in growth responses reported by Ramírez and González (1984f) between the types of *C. boleticola*, *C. laureliae* and *C. ralunensis* could not be reproduced by replica plating. The physiological distinction between the three species is tenuous, as these strains may be unstable with respect to their distinguishing characteristics. There was good agreement with the original description of *C. boleticola* (Nakase 1971b).

Ecology: The isolation sources for *C. boleticola* suggest an association with fungi, including those involved in tree decay.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.40. *Candida bolitotheri* S.-O. Suh & M. Blackwell (Suh et al. 2004b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5). (The description is based on Suh et al. 2004b.)

Growth on YM agar: After 7 days at 25°C, colonies are white to cream colored, and somewhat pale-pinkish from center to edge, smooth to slightly wrinkled in the center and with a mycelial edge.

Growth in YM broth: After 7 days at 25°C, cells are globose to subglobose, 2–6 × 2–6 μm, occur singly or in short chains and pseudohyphae may be present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae are present and septate hyphae may be present. Aerobic growth is white, glistening, smooth and with a filamentous margin.

Fermentation

Glucose	+	Lactose	—
Galactose	+/d	Raffinose	—
Sucrose	—	Trehalose	d
Maltose	—	D-Xylose	—

Growth (in Liquid Media)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+/d/w
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl-α-D-glucoside	—	DL-Lactate	—
Soluble starch	—	Succinate	+/d/w
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	d/w
L-Sorbose	n	D-Glucosamine	+
L-Rhamnose	n	N-Acetyl-D-glucosamine	n
D-Xylose	+/d/w	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+/w	10% NaCl/5% glucose	+/d/w
2-Keto-D-gluconate	+	16% NaCl	—
D-Glucuronate	—	Starch formation	—
Arbutin	+	Urease	—
Propane 1,2 diol	—	Growth on 1% acetic acid	—
Butane 2,3 diol	—	DBB	—
D-Arabinitol	—	Cycloheximide 0.01%	v
D-Glucono-1,5-lactone	+/d	Cycloheximide 0.1%	—
Quinic acid	—	Growth at 25°C	+
D-Glucarate	—	Growth at 30°C	+
D-Galactonate	—	Growth at 35°C	v
Nitrite	—	Growth at 40°C	—
Cadaverine	+	Growth w/o myo-inositol	+
Creatinine	—	Growth w/o pantothenate	+
L-Lysine	+	Growth w/o biotin	v
Ethylamine	+	Growth w/o thiamine	+
D-Glucosamine (as N compound)	+/w	Growth w/o biotin & thiamine	v
D-Tryptophan	—	Growth w/o pyridoxine	+

Creatine	—	Growth w/o thiamine & pyridoxine	+
Imidazole	—	Growth w/o niacin	+
50% Glucose	+/d	Growth w/o PABA	+
60% Glucose	v		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY242249, SSU rRNA = AY242142.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9832 (NRRL Y-27587), isolated from a tenebrionid beetle (*Bolithotus cornutus*) on fruiting body of a polypore (*Ganoderma* sp.), Athens, Georgia; the following strains were isolated from the same beetle and the same fungal genus: BG 00-7-3-1-1, Burlington, Vermont; BG 02-3-29-2-2, Sulphur, Louisiana; BG BG 02-5-27-1-2-3, Baton Rouge, Louisiana; NRRL- Y27562, collected from the red-banded fungus beetle (*Megalodacne fasciata*, Erotylidae) on a fruiting body of *Ganoderma applanatus*, Athens, Georgia. All isolates came from the USA (Suh et al. 2004b).

Type strain: CBS 9832.

Systematics: *Candida bolithotus* belongs to the *C. tanzawaensis* clade (Fig. 90.5), which includes 17 subclades of gut yeasts from basidiocarp-feeding beetles (Suh et al. 2004b).

Ecology: All the isolates for this species were collected from beetles feeding on fungal species of the genus *Ganoderma* in the USA. The majority of the isolates were from the beetle *Bolithotus cornutus* (Suh et al. 2004b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Ascospores were not produced after 6 weeks at 17°C on YM agar or on half-strength corn meal agar.

Lactose	—	Galactitol	—
Trehalose	v	D-Mannitol	v
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	D-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	v
Salicin	—	D-Gluconate	v
L-Sorbose	+	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Gluconate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	—
Amino acid-free	+	Lipase	s
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	v

CoQ: 9 (F.-L. Lee et al. 1993).

Mol% G + C: 48.3, 46.6, CBS 5836 (T_m : Meyer and Phaff 1972; HPLC: F.-L. Lee et al. 1993, respectively).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45706.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5836, isolated from a bumble bee (*Bombus* sp., Hymenoptera: Apidae), France; MH21 (CBS 9017), from nectar of true oxlip (*Primula elatior*, Primulaceae); MH265 (CBS 9105) and four others, from body of *Bombus terrestris*; H300 and four others, from body of *Bombus hortorum*; H272, from proboscis of *Bombus cryptarum*; H301, from proboscis of *Bombus hortorum*; MH384 (CBS 9106) and six others, from nectar of stinking hellebore (*Helieborus foetidus*, Ranunculaceae); M. Brysch-Herzberg, all from Germany.

Type strain: CBS 5836.

Systematics: Montrocher (1967) described *C. bombi* based on two strains recovered from a bumblebee. The author noted similarities with *C. catenulata*, *C. krusei* and *C. sorbosa*, principally based on the small number of compounds utilized. Sequencing studies have shown instead that *C. bombi* is a member of the *Starmerella* clade (Fig. 71.1).

Characterization of authentic strains by replica plating confirmed the variability of properties such as the utilization of trehalose, D-mannitol, succinate, citrate and D-gluconate, growth at 37°C, Tween 80 hydrolysis, and growth on ethylamine as nitrogen source. Variability in some of these properties had been noted also by Montrocher (1967). The utilization of melibiose and D-ribose, reported in the original description, was not confirmed. None of the strains in the *Starmerella* clade examined so far is capable of growth on melibiose, but a weak utilization of D-ribose is seen in some strains in several species. All this makes it difficult to differentiate *C. bombi* from *C. apicola*, *C. gropengiesseri* and *Starmerella bombicola* on the basis of physiology.

Ecology: A broad array of members of the *Starmerella* clade have been isolated in tropical and temperate regions of the New World

90.41. *Candida bombi* Montrocher (1967)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, 2–4 $\times$ 4–6 μ m, and occur singly, in pairs, and in small groups.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae may be sparse or consist of branched chains of cells, sometimes with verticils of blastopores. Aerobic growth is cream colored to light tan, smooth and soft with an entire to slightly irregular margin.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	+	Trehalose	s
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	—
Raffinose	+	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—

and the Australia-Pacific biogeographical regions (Lachance et al. 2001e, Rosa et al. 2003). *C. bombi* was conspicuously absent from those collections, in contrast to European reports, indicating that the species may be palaearctic in distribution, thus tracking the co-radiation of bees and angiosperms, which is thought to have taken place in the Cretaceous (Danforth and Ascher 1999).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.42. *Candida bombiphila* Brysch-Herzberg & Lachance (2004)

Phylogenetic placement: *Wickerhamiella* clade (Fig. 79.1).

(The description is based on Brysch-Herzberg and Lachance 2004.)

Growth on malt agar: After 10 days at 25°C, colonies are cream colored, butyrous, convex to umbonate, with a smooth and glossy surface and an entire edge. Occasionally the colonies are convoluted with a lobate edge. True hyphae are formed after 2 weeks.

Growth on YM agar: After 1 day at 25°C, pseudohyphae are formed.

Growth in 5% malt extract: After 3 days at 25°C, the cells are ovoid, 2.7–4 × 1.9–2.5 µm, and occur singly or in parent–bud pairs.

Fermentation

Glucose	w	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (on Agar Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	–	Ethanol	–
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	+
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	10% NaCl/5% glucose	–
2-Keto-D-gluconate	–	60% Glucose	+
D-Glucuronate	–	Starch formation	–
Malate	s	Casein hydrolysis	w
Glucono-δ-lactone	+	Gelatin liquefaction	–
Cadaverine	+	Amino acid-free	+
L-Lysine	+	DBB	–
Ethylamine	+	Cycloheximide 0.01%	–
5% NaCl/5% glucose	s	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AJ620185.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9712 (NRRL Y-27640), isolated from the proboscis of a bumblebee (*Bombus terrestris*) queen in early spring; CBS 9713, isolated from the honey provision in a nest of *Bombus pascuorum* bumblebees in the summer, both from the New Botanical Garden of Philipps University, Marburg, Germany (Brysch-Herzberg and Lachance 2004).

Type strain: CBS 9712.

Systematics: *Candida bombiphila* belongs to the *Wickerhamiella* clade (Fig. 90.3), a loose monophyletic clade of *Candida* and *Wickerhamiella* species that exhibit a relatively low value of DNA sequence identity in the D1/D2 rRNA gene region (Brysch-Herzberg and Lachance 2004). Most species in the clade are associated with insects. The D1/D2 sequence of the type strain differs from that of the most closely related species, *Wickerhamiella domercqiae*, by 57 substitutions and three gaps. CBS 9713 differs from the type strain by one substitution and one gap.

Ecology: The two isolates for this species were collected from a bumblebee and bumblebee honey in Germany (Brysch-Herzberg and Lachance 2004).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Ascosporeulation was not observed on YM agar, 5% malt-extract agar and on restricted growth medium at room temperature.

90.43. *Candida boreocaroliniensis* Kurtzman (2007a)

Phylogenetic placement: *Sugiyamaella* clade (Figs 90.3, 72.1).

(The description is based on Kurtzman 2007a.)

Growth on 5% malt extract agar: After 3 days at 25°C, yeast cells are spherical, 1.8–4 µm, to elongate, 1.8–4 × 2–7 µm, to occasionally triangular, reproduce by multilateral budding, and occur singly or in pairs (Fig. 90.31A). Growth is tannish-white, semi-glistening, butyrous and with an entire margin. True hyphae were infrequently detected on 5% malt extract agar, but not on the other media used.

Growth on the surface of assimilation media: Pellicles were not formed on stationary liquid media.

Dalmau plate culture on potato, corn meal or morphology agar: After 7 days at 25°C, pseudohyphae with blastoconidia occur (Fig. 90.31B).

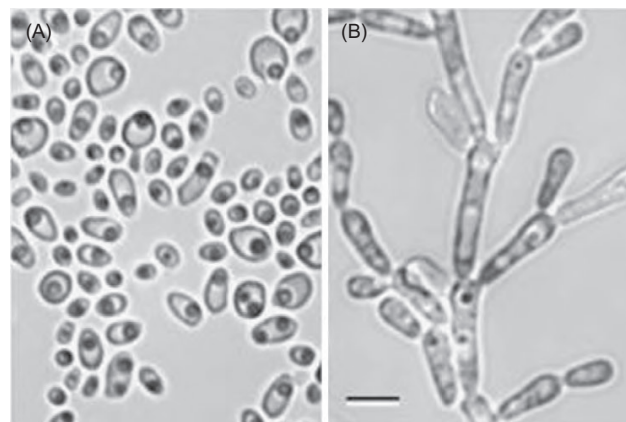


FIGURE 90.31 *Candida boreocaroliniensis* NRRL YB-1835. Budding cells after 3 days, 25°C, 5% malt extract agar (A) and pseudohyphae after 5 days at 25°C on yeast morphology agar (B). Bar = 5 µm. Reproduced from Kurtzman (2007a) with permission.

Fermentation: Absent.

Growth (in Liquid Media)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	+	Erythritol	—
Galactose	+	Ribitol	+
Lactose	v	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	+
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	+
D-Arabinose	+	Vitamin-free	—

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	v	Starch formation	—
5-Keto-D-gluconate	+	Gelatin liquefaction	—
Saccharate	—	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 37°C	—
10% NaCl/5% glucose	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ438221, ITS and 5.8S rRNA = DQ911441, mitochondrial SSU rRNA = DQ442725, cytochrome oxidase II = DQ443065.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 10344 (NRRL YB-1835), isolated from frass on loblolly pine (*Pinus taeda*), Spring Valley, North Carolina; a second strain was found on frass from blackjack oak (*Quercus marilandica*), Salem, Missouri, both in the USA (Kurtzman 2007a).

Type strain: CBS 10344.

Systematics: *Candida boreocaroliensis* is placed in the *Sugiyamella* clade (Fig. 90.3), which includes four species with known ascospore states (Fig. 72.1). In the D1/D2 region, the closest species is *C. floridensis* separated by three mismatches (Kurtzman 2007a).

Ecology: The two isolates were found in frass from a loblolly pine and a blackjack oak in forest habitats (Kurtzman 2007a).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Cultures grown on YM, 5% ME and RG agar media incubated at 15 and 25°C produced no ascospores after 6 weeks. Because of its close relatedness with *C. boreocaroliensis* and *C. floridensis*, CBS10350 was also paired with the two species, but conjugation or ascospore formation was not observed (Kurtzman 2007a).

90.44. *Candida bracarensis* Correia, P. Sampaio, James & Pais (2006)

Phylogenetic placement: *Nakaseomyces* clade (Figs 50.1, 90.1).

Growth on yeast morphology agar: After 10 days at 25°C, the colony is flat or lowly button-like, 7 mm wide, whitish-cream to pale cream-beige, butyrous, shiny, smooth, toward the margin striated

and with an entire, but lobate margin. Cells are ellipsoid, $3.9\text{--}6 \times 2\text{--}4 \mu\text{m}$, and reproduce with polar to multilateral budding. **Growth in 3% glucose broth in yeast nitrogen base:** After 10 days at 25°C, the cells are broad ellipsoid to ellipsoid, $4\text{--}5.1 \times 1.9\text{--}4.3 \mu\text{m}$, reproduce by polar budding and occur singly or in pairs. Filaments, pseudohyphae and hyphae are absent. A sediment is formed.

Dalmat plate culture on PDA agar: After 10 days at 25°C, pseudohyphae and hyphae are not formed.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	s
Maltose	—		

Growth (in Liquid Media)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	v
Raffinose	—	Glycerol	v
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	—
Maltose	—	D-Glucitol	—
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	—
Soluble starch	—	Succinate	—
Cellobiose	—	Citrate	—
Salicin	—	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	—	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	L-Lysine	—
2-Keto-D-gluconate	—	Ethylamine	—
5-Keto-D-gluconate	—	50% Glucose	—
D-Glucuronate	—	10% NaCl/5% glucose	+
L-Arabinitol	—	Starch formation	—
Arbutin	—	Urease	—
Propane 1,2 diol	—	DBB	—
Butane 2,3 diol	—	Cycloheximide 0.01%	—
Isopropyl alcohol	n	Cycloheximide 0.1%	—
Nitrite	—	Growth at 37°C	+
Cadaverine	—	Growth at 42°C	+
Creatinine	—		

CoQ: Not determined.

Mol% G + C: 35.5, CBS 10154 (T_m : Wahyunsin et al. 2008).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY589572, ITS and 5.8S rRNA = AY589573.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 10154 (CECT 12000, NCYC D3853, NRRL Y-48270), isolated from a case of vaginal candidiasis in a medical institution in Braga, Portugal; NCYC 3133, collected from a hospital patient in the UK (Correia et al. 2006).

Type strain: CBS 10154.

Systematics: *Candida bracarensis* was described based on PCR-fingerprints and sequence divergence in the D1/D2 domains of the LSU

rRNA gene. The D1/D2 domains differed in 30 substitutions of a total of 581 from those of *C. glabrata* (Correia et al. 2006). In addition, AFLP and RAPD fingerprints were different and DNA–DNA reassociation experiments showed 16% similarity with the DNA of *C. glabrata* and 26.9% with that of *C. nivariensis* (Wahyuningsih et al. 2008). Reported growth with sucrose and 0.1% cycloheximide (Correia et al. 2006) could not be confirmed. In the present experiments, growth on ethanol and glycerol was found to be variable.

Ecology: The two isolates were found in candidiasis patients in two medical institutions, one in Portugal and the other in the UK (Correia et al. 2006).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: *Candida bracarensis* is an emerging human pathogen (Boekhout et al. 2009, Bishop et al. 2008, Correia et al. 2006, Johnson 2009, Lockhart et al. 2009). Lockhart et al. (2009) observed an incidence of *C. bracarensis* of 0.2% among 1598 phenotypically identified *C. glabrata* isolates. In another study, three (2.2%) out of 137 phenotypically identified *C. glabrata* isolates were reidentified as *C. bracarensis* by molecular tools (Bishop et al. 2008). The type strain of *C. bracarensis* was found to be susceptible to amphotericin B, 5-flucytosine, itraconazole, fluconazole, voriconazole, posaconazole, isavuconazole and caspofungin (Wahyuningsih et al. 2008), but one clinical isolate showed *in vitro* resistance to fluconazole, itraconazole, voriconazole and posaconazole (Bishop et al. 2008).

Additional comments: Ascospores were not detected in the type strain following incubation at 25°C for up to 3 months on YM agar or sodium acetate agar.

90.45. *Candida bribrorum* S.-O. Suh & M. Blackwell (Suh et al. 2004b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5). (The description is based on Suh et al. 2004b.)

Growth on YM agar: After 7 days at 25°C, colonies are white to cream, butyrous, smooth and have slightly fuzzy spots on the surface.

Growth in YM broth: After 7 days at 25°C, cells are globose to ellipsoidal, 3–8 × 3–8 µm, mostly subglobose, occur singly, in pairs or in short chains, and pseudohyphae are present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae are present. Aerobic growth is white to cream colored with a fuzzy margin.

Fermentation

Glucose	+	Lactose	–
Galactose	v	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	v	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–

Methyl-α-D-glucoside	+	D-Lactate	–
Soluble starch	–	Succinate	+/d
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	n	D-Glucosamine	+/w
L-Rhamnose	n	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	v	Nitrate	–
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+/d	10% NaCl/5% glucose	+/d/w
2-Keto-D-gluconate	+	16% NaCl	v
D-Glucuronate	–	Starch formation	–
Arbutin	+	Urease	–
Propane 1,2 diol	–	DBB	–
Butane 2,3 diol	–	Growth on 1% acetic acid	–
D-Arabinitol	–	Cycloheximide 0.01%	w
D-Glucono-1,5-lactone	+	Cycloheximide 0.1%	v
Quinic acid	–	Growth at 25°C	+
D-Glucarate	–	Growth at 30°C	+
D-Galactonate	–	Growth at 35°C	v
Nitrite	–	Growth at 40°C	–
Cadaverine	+	Growth w/o myo-inositol	+
Creatinine	–	Growth w/o panthotenate	+
L-Lysine	+	Growth w/o biotin	v
Ethylamine	+	Growth w/o thiamine	+
D-Glucosamine (as N compound)	v	Growth w/o biotin & thiamine	v
D-Tryptophan	–	Growth w/o pyridoxine	+
Creatine	–	Growth w/o thiamine & pyridoxine	+/w
Imidazole	–		
50% Glucose	+/d	Growth w/o niacin	+
60% Glucose	v	Growth w/o PABA	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY309875, SSU rRNA = AY426962.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9835 (NRRL Y-27572), isolated from larvae of an erotyliid beetle (*Pselaphacus* sp., Eroteyliidae) on a polypore mushroom (*Polyporus tenuiculus*); BG 02-7-14-002A-2-1, from an erotyliid beetle (*Megalodacne audouini*, Eroteyliidae) on a basidiocarp; BG 02-7-14-002B-2-1, from a pupa of *Megalodacne* sp. (Eroteyliidae) on a basidiocarp; BG 02-7-14-002A-1-1, from *Megalodacne* sp. (Eroteyliidae) on polypore (*Ganoderma* sp.); NRRL Y-27591 and NRRL Y-27592, both from an unidentified tenebrionid beetle on a basidiocarp, all from Barro Colorado Island, Panama; NRRL Y-27564, isolated from *Megalodacne fasciata* (Eroteyliidae) on *Ganoderma applanatum*, Athens, Georgia, USA (Suh et al. 2004b).

Type strain: CBS 9835.

Systematics: *Candida bribrorum* belongs to the *C. tanzawaensis* clade, which includes 17 subclades of gut yeasts from basidiocarp-feeding beetles (Suh et al. 2004b). NRRL Y-27592 differs by one substitution in the D1/D2 region from the type strain, and strain NRRL Y-27564 differs by two substitutions in the D1/D2 region and by one in the SSU.

Ecology: The majority of the isolates were collected from different life stages of basidiocarp-feeding beetles in Barro Colorado Island, Panama. Only strain NRRL Y-27564 was found in Athens, Georgia, USA (Suh et al. 2004b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Ascospores were not produced after 6 weeks at 17°C on YM agar or on half-strength corn meal agar.

90.46. *Candida bromeliacearum* Ruivo, Pagnocca, Lachance & Rosa (Ruivo et al. 2005)

Phylogenetic placement: *Phaffomyces*/*Komagataella* clade (Fig. 90.3). (The description is based on Ruivo et al. 2005.)

Growth on YM agar: After 4 days at 25°C, the colonies are white to cream, smooth and butyrous.

Growth in yeast extract–glucose broth: After 3 days at 25°C, the cells are ellipsoidal to elongate, 3–5 × 4–6 μm, occur singly, in budding pairs or in short chains, and buds are produced multilaterally.

Dalmau plate culture on corn meal agar: After 2 weeks at 25°C, neither pseudohyphae nor true hyphae are formed.

Fermentation

Glucose	+	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	v
Melibiose	–	Erythritol	v
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	w	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D,L-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	+	Citrate	w/v
Salicin	+	D-Gluconate	v
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	+	50% Glucose	s
2-Keto-D-gluconate	+	10% NaCl/5% glucose	+
5-Keto-D-gluconate	–	Urease	–
D-Glucuronate	–	Cycloheximide 0.01%	–
Saccharate	–	Cycloheximide 0.1%	–
Glucono-δ-lactone	+	Starch formation	–
L-Arabinitol	–	Acid formation	+
Nitrite	–	DBB	–
Cadaverine	+	Growth on 1% acetic acid	–
L-Lysine	+	Growth at 35°C	+
Ethylamine	+	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY695394, SSU rRNA = AY695396.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 10002 (NRRL Y-27811), isolated from the water tanks of a bromeliad, *Canistropsis seidelii*, in a sandy coastal plain ecosystem site in the Atlantic rainforest of south-eastern Brazil, during springtime (Ruivo et al. 2005). Three other isolates of *C. bromeliacearum* were found in the water tanks of six plants over a large area of the forest.

Type strain: CBS 10002.

Systematics: The physiological characteristics of *C. bromeliacearum* are typical of other species in the *Metschnikowia* clade, and Ruivo et al. (2005) reported that the closest species is *C. haemulonii* (Fig. 90.1). However, the sequences of the D1/D2 regions are highly divergent from all the other members of the clade, and the species is placed in a weakly supported subclade in Fig. 90.3 with a possible relationship to the *Phaffomyces* clade.

Ecology: All the isolates were found in the water tanks of bromeliads in an Atlantic rainforest in south-eastern Brazil during springtime (Ruivo et al. 2005).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Asci are not formed on common sporulation media, such as malt extract agar, corn meal agar, Fowell acetate agar and diluted V8 agar.

90.47. *Candida buenavistaensis* S.-O. Suh, N.H. Nguyen & M. Blackwell (2008)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Fig. 90.5). (The description is based on Suh et al. 2008.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, smooth and butyrous.

Growth in YM broth: After 7 days at 25°C, cells are globose to ovoid, 2.5–8.75 × 2.5–10 μm, mostly globose or subglobose, and occur singly, in pairs, in short chains or in clusters.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae are not present. Aerobic growth is white and smooth.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	v	Trehalose	v
Maltose	+/d	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+/d
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D,L-Lactate	–
Soluble starch	–	Succinate	v
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	d
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	v	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	16% NaCl	—
2-Keto-D-gluconate	+	Starch formation	—
D-Glucuronate	—	Urease	—
L-Arabinitol	—	Growth on 1% acetic acid	—
Arbutin	+/d	DBB	—
Propane 1,2 diol	v	Cycloheximide 0.01%	+
Butane 2,3 diol	—	Cycloheximide 0.1%	+
D-Glucono-1,5-lactone	+	Growth at 25°C	+
Quinic acid	—	Growth at 30°C	+
D-Glucarate	—	Growth at 35°C	v
Nitrite	—	Growth at 37°C	v
Cadaverine	+	Growth at 40°C	—
Creatinine	—	Growth w/o <i>myo</i> -inositol	+
L-Lysine	+	Growth w/o pantothenate	+
Ethylamine	+	Growth w/o biotin	—
Creatine	—	Growth w/o thiamine	+
D-Glucosamine (as N compound)	—	Growth w/o biotin & thiamine	—
Imidazole	—	Growth w/o pyridoxine	+
Tryptophan	—	Growth w/o thiamine & pyridoxine	+
50% Glucose	+	pyridoxine	—
60% Glucose	—	Growth w/o niacin	+
10% NaCl/5% glucose	+/w	Growth w/o PABA	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY242341, SSU rRNA = AY242229.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9895 (NRRL Y-27734), isolated from the guts of an unidentified cerambycid beetle caught under light; NRRL Y-27735, BG 02-7-16-009A-2-1, BG 02-7-21-004K-1-1 and BG 02-7-21-004B-1-2, collected from the guts of a scarab beetle (*Cyclocephala* sp.); BG 02-7-16-009A-C-1, from the body surface of *Cyclocephala* sp., all from Barro Colorado Island, Panama (Suh et al. 2008).

Type strain: CBS 9895.

Systematics: *Candida buenavistaensis* forms a well-supported subclade in the *Lodderomyces*–*Spathaspora* clade (Fig. 90.5) with *C. gigantensis*, a sister species also found on beetles in Barro Colorado Island, and *C. dubliniensis* and *C. albicans*, two clinically relevant species (Suh et al. 2008).

Ecology: All isolates were collected on beetles in Barro Colorado Island, Panama (Suh et al. 2008).

Biotechnology: Unknown.

Agriculture and food: There is no evidence for spoilage activity caused by *C. buenavistaensis*, but osmotolerance on 50% glucose agar and good fermentation ability indicate that the species may have the capacity to cause food or beverage spoilage.

Clinical importance: Unknown.

Additional comments: Ascospores were not produced after 6 weeks on YM agar or on half-strength corn meal agar.

90.48. *Candida buinensis* Soneda & S. Uchida (1971)

Phylogenetic placement: *Yamadazyma* clade (Figs 81.1, 90.2).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are spherical to ovoid and cylindroid, 2–4 × 3.5–6 µm, and occur singly, in pairs, clusters and short chains (Fig. 90.32 left).

Dalmeu plate culture on corn meal agar: After 5 days at 25°C, pseudohyphae consist of branched chains of elongate cells with blastoconidia (Fig. 90.32 right). Aerobic growth is white, smooth, creamy, soft and entire.

Fermentation

Glucose	+	Lactose	—
Galactose	+	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—/s		

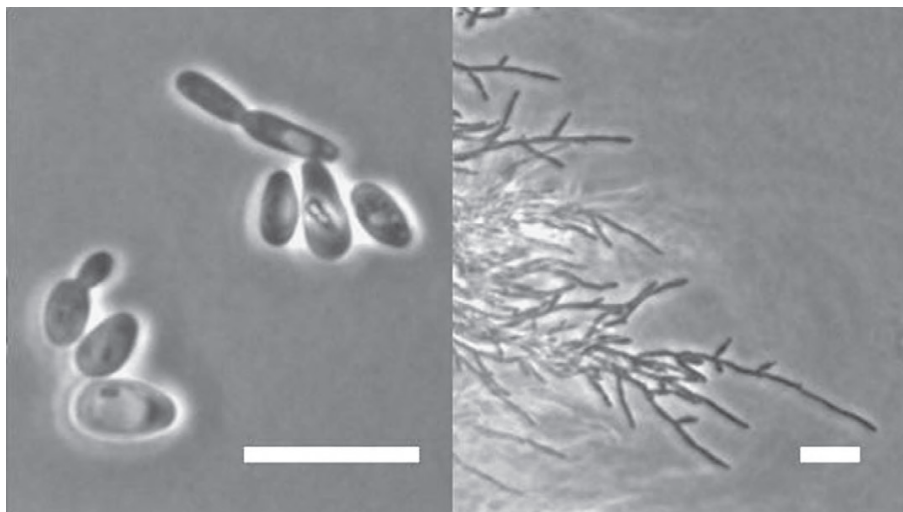


FIGURE 90.32 *Candida buinensis* CBS 6796. Budding cells after 3 days, 25°C, YM agar (left) and pseudohyphae after 14 days, 18°C, YCBAS agar (right). Bars = 10 µm.

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	s
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	v
Maltose	+	D-Glucitol	v
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	s	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	+	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	w
Glucono- δ -lactone	+	Casein	w
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 31.5, CBS 6796 (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45778.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6796, isolated from the gelatinous exudate of a tree fern from Papua New Guinea.

Type strain: CBS 6796.

Systematics: Analysis of rRNA gene sequences (Kurtzman and Robnett 1998a, Sugita and Nakase 1999) positions *C. buinensis* near *C. membranifaciens* (Fig. 90.2). The growth characteristics assessed by replica plating differed from the description given by Meyer et al. (1998) for responses on D-mannitol and D-glucitol, both found to be negative. The species is physiologically similar to *C. quercitrusa* and related *Candida* species in the *Kurtzmaniella* clade as well as more distant *Metschnikowia* species. Separation can be effected on the basis of D-arabinose (positive) and 2-keto-D-gluconate (negative) assimilation as well as resistance of 0.01% cycloheximide (negative).

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.49. *Candida californica* (Anderson & Skinner) Bai, Wu & Robert (Wu et al. 2006)

Phylogenetic placement: *Pichia* clade; see Systematics.

Synonym:

Cryptococcus californicus Anderson & Skinner (1947)

(The description is based on Mrak and McClung 1940 and the CBS database.)

Growth in malt extract broth: After 3 days, yeast cells are globose, $3.5\text{--}5 \times 4.5\text{--}9\ \mu\text{m}$.

Growth on malt extract agar: The streak culture is buff, smooth, to slightly punctuate, dull, dry and pulvinate, with entire to undulate borders.

Dalmau plate culture on morphology agar: Unknown.

Fermentation

Glucose	w/s	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	—
Maltose	—	D-Glucitol	—
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	+
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	+
Salicin	—	D-Gluconate	—
L-Sorbose	—	D-Glucosamine	v
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	v	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	w

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	—	Casein	n
Amino acid-free	n	Lipase	n
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	n
Cadaverine	+	1% Acetic acid	n
10% NaCl	+	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = DQ104729.

Cell carbohydrates: Not determined.

Origin of the strain: CBS 989, isolated from grapes, California, USA. E.M. Mrak.

Type strain: CBS 989.

Systematics: Mrak and McClung (1940) isolated yeasts from grapes, using grape must enrichment techniques. Three of the 118 cultures were assigned to the new species *Torulopsis californicus*, but a Latin diagnosis was not given. Anderson and Skinner (1947) isolated a number of yeasts from decaying mushrooms. Some were identified as the same species reported by Mrak and McClung (1940).

The authors provided a Latin diagnosis and reassigned the species to the genus *Cryptococcus* without giving a reason for the transfer. Wu et al. (2006) examined a large number of strains considered possible synonyms of *Pichia membranifaciens* and found the strain deposited by Mrak to be sufficiently unique in the D1/D2 LSU rRNA gene sequence to be considered a separate species in the *P. membranifaciens* clade. In reporting the new combination, *Candida californica*, they noted a close relationship to a strain labeled *Pichia* AWRI 1272, although the taxonomic status of the latter has not been clarified (de Barros Lopes et al. 1998).

Ecology: The only confirmed isolate was recovered from grapes. Assuming that the strain labeled *Pichia* AWRI 1272 is conspecific, an affinity for fermenting grapes might be inferred.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.50. *Candida canberraensis* Kurtzman (2001b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5). (The morphological and growth characteristics are taken from Kurtzman 2001b.)

Growth on 5% malt agar: After 3 days at 25°C, yeast cells range from spherical, 2–4.5 µm to ellipsoidal, to elongate, 2–3.5 × 3–20 µm, and occur singly or in pairs (Fig. 90.33A). Budding is multi-lateral but predominantly near the poles of the cells. Elongated cells may be straight or curved and some cells form small denticles that bear blastoconidia. Not uncommonly, elongated cells form an inflated spherical tip cell that may also form denticles with blastoconidia. Colonies are white, dull to almost powdery and butyrous in texture.

Dalmat plate culture on yeast morphology agar: After 7 days at 25°C, growth under the coverglass is composed of abundant pseudohyphae with blastoconidia (Fig. 90.33B,C). True hyphae were not found, but some of the pseudohyphae exhibit well-defined septa. Aerobic growth is dull, white and butyrous to hyphal. Colonies are low convex with a slightly raised center and with margins that are entire or infrequently lobed.

Fermentation

Glucose	+	Lactose	–
Galactose	w	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	n	Starch production	–
2-Keto-D-gluconate	+	DBB	n
D-Glucuronate	n	Gelatin	–
Glucono-δ-lactone	n	Casein	n
Amino acid-free	n	Lipase	n
Nitrite	n	Acid production	n
Ethylamine	n	Cycloheximide 0.01%	–
L-Lysine	n	Cycloheximide 0.1%	n
Cadaverine	+	1% Acetic acid	n
10% NaCl	+	Growth at 30°C	n
50% Glucose	n	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY013718.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 8846 (NRRL YB-2417), isolated from soil, Canberra, Australia.

Type strain: CBS 8846.

Systematics: *Candida canberraensis* is related to *C. tanzawaensis* (Kurtzman 2001b) and is part of a rapidly expanding clade (see discussion of *C. tanzawaensis*). The species is characterized by a broad

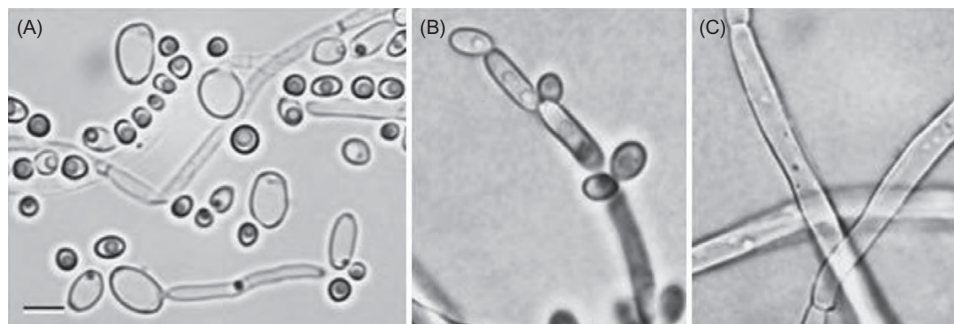


FIGURE 90.33 *Candida canberraensis* NRRL YB-2417. Budding cells after 3 days, 25°C, 5% malt extract agar (A) and pseudohyphae after 7 days, 25°C, yeast morphology agar (B, C). Bar = 5 µm. Reproduced from Kurtzman (2001b) with permission.

nutritional range and resembles *C. ambrosiae* and other members of the clade. The assimilation of L-arabinose and erythritol, combined with the lack of growth on raffinose or starch, is useful in separating the species.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.51. *Candida carpophila* (Phaff & M.W. Miller) Vaughan-Martini, Kurtzman, S.A. Meyer & O'Neill (2005)

Phylogenetic placement: *Meyerozyma* clade (Figs 47.1, 90.2).

Synonyms:¹

Torulopsis carpophila M.W. Miller & Mrak (1953) nom. nud.

Candida guilliermondii (Castellani) Langeron & Guerra var. *carpophila* Phaff & M.W. Miller (1961)

Torulopsis xestobii Jurzitza (1970) nom. nud.

Candida xestobii Yarrow & S.A. Meyer (1978)

Candida fukuyamaensis Nakase, M. Suzuki, Takashima & Hamamoto (1994c)

¹ Synonymy based on D1/D2 LSU rRNA gene sequences and nuclear DNA reassociation experiments (Kurtzman and Robnett 1998a, Vaughan-Martini et al. 2005).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, 2–4 × 3–4 μm, occurring singly and in pairs.

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent. Aerobic growth is off-white to beige, smooth, glistening, soft and entire.

Fermentation

Glucose	s	Lactose	—
Galactose	v	Raffinose	v
Sucrose	v	Trehalose	v
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	v	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	v	Glycerol	+
Melibiose	v	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—/s
Trehalose	+	D-Mannitol	v
Maltose	w	D-Glucitol	v
Melezitose	v	myo-Inositol	—
Methyl-α-D-glucoside	+	D-Lactate	—
Soluble starch	v	Succinate	+
Cellobiose	v	Citrate	v
Salicin	v	D-Gluconate	v
L-Sorbose	v	D-Glucosamine	v
L-Rhamnose	—	N-Acetyl-D-glucosamine	v
D-Xylose	+	Hexadecane	s
L-Arabinose	+	Nitrate	—
D-Arabinose	v	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Gluconate	—	Gelatin	—
Glucono-δ-lactone	v	Casein	—
Amino acid-free	+	Lipase	v
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	—/s	Growth at 37°C	v

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 47.8, CBS 5975 (T_m : Stenderup et al. 1972); 48.7, CBS 5975 (BD: Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U62311.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5256, isolated from fig wasp (*Blastophaga psenes*, Hymenoptera: Agaonidae) in fruit of *Ficus* sp.; CBS 5975, type strain of *C. xestobii*, from bark beetle (*Xestobium plumbeum*, Coleoptera: Anobiidae); CBS 7921 (JCM 9396), type strain of *C. fukuyamaensis*, from pond water, Japan. Other strains available: AS 2.1676, from gum of a tree; CBS 8302 (AS 2.1796), from an ant; CBS 8303 (AS 2.1797), from soil; China, F.-Y. Bai, all from China.

Type strain: CBS 5256.

Systematics: The taxonomic status of the *C. guilliermondii* complex has been in a long-lasting state of confusion. Daniel (2002) reviewed much of the available evidence, including her own actin sequences, and concluded that taxa in the complex may not be fully speciated. However, the more recent work of Vaughan-Martini et al. (2005) may have provided a satisfactory solution. To start with, the epithet *guilliermondii* will now apply to a holomorph typified by *Meyerozyma* (*Pichia*) *guilliermondii*, without any varieties.

As to *C. carpophila*, the species was first referred to as *Torulopsis carpophila* by Miller and Mrak (1953) to designate isolates recovered from dried fruit and associated insects. Upon re-examining the strains and comparing them with isolates that were repeatedly recovered from the fig wasp, *Blastophaga psenes*, Phaff and Miller (1961) validated the name as a variety of *C. guilliermondii*, being convinced that the fig wasp isolates were closely related, but fundamentally distinct from the species proper. Meyer et al. (1984) considered the differences insufficient to warrant recognition even at the variety level, taking also into consideration DNA reassociation data of Meyer and Phaff (1972). This view was reiterated by Kurtzman (1998c).

The former species *C. fukuyamaensis* was described by Nakase et al. (1994c), who examined several strains that shared the interesting property of strong utilization of carboxymethylcellulose. One of these was found to be similar in many properties to several other species, including *C. guilliermondii*, and was described as *C. fukuyamaensis*. The description was based in part on DNA reassociation data, where *C. fukuyamaensis* gave values of 35 to 42% in a reciprocal experiment with the type of *C. guilliermondii*. O'Neill and Meyer (2000) obtained compatible results between the type of *Meyerozyma* (*Pichia*) *guilliermondii* and *C. fukuyamaensis* (56%) or *C. xestobii* (55%), and further demonstrated a moderate relationship (68%) between *C. fukuyamaensis* and *C. fermentati*. Bai et al. (2000) examined many strains in the *C. guilliermondii* complex by electrophoretic karyotyping and concluded that *C. fukuyamaensis* deserved species status. The electrokaryotypes of the strains assigned to the species were

homogeneous and distinct from those of all members of the complex except for *C. guilliermondii* var. *carpophila*. Yarrow and Meyer (1978) formalized the description of *C. xestobii*, which had been published without a Latin diagnosis in a study of the yeasts of anobiid beetles (Jurzitza 1970). Kurtzman and Robnett (1997) found identical sequences for *C. xestobii* and *C. fukuyamaensis* in the D1/D2 domains of the LSU rRNA gene and suggested that they were conspecific in addition to representing anamorphs of *M. guilliermondii*, from which the sequences differ by one substitution.

Several strains assigned to *C. fermentati*, including CBS 5674, type of the former species *Torulopsis kestonii*, also gave high reassociation values (95–100%) among one another and moderate values (35–78%) with members of the other two taxa. Many strains were found to be ascosporic, leading to the description of the new species *Meyerozyma (Pichia) caribbica*.

Torula fermentati (Saito 1922) had been treated as a synonym of *C. guilliermondii* by Diddens and Lodder (1942) and subsequent taxonomic treatments, and was included in *Pichia guilliermondii* by Kurtzman (1998c). However, Bai (1996) found the type of *C. fermentati* and three additional isolates to be distinct in DNA base composition (49–50%) from the type of *C. guilliermondii* (44–45%). The two species could be separated clearly by electrophoretic karyotyping and *C. fermentati* was reinstated as a separate species. This conclusion was also reached by San Millán et al. (1997) based on isoenzyme and DNA polymorphisms. Bai et al. (2000) assigned several more strains, including the type of *Torulopsis kestonii*, to the species based on electrophoretic karyotypes. Daniel (2002) reported that the actin gene sequences of the two species differ by 18 base positions and their SSU rRNA gene sequences by six positions.

This perplexing state of affairs seems to have been resolved by Vaughan-Martini et al. (2005), who examined growth characteristics, DNA reassociation, D1/D2 LSU rRNA gene sequences and electrophoretic karyotypes of a number of strains related to *Pichia guilliermondii*. High values of DNA reassociation (90–100%) were found between the types of *C. guilliermondii* var. *carpophila*, *C. fukuyamaensis* and *C. xestobii*, leaving little doubt as to their conspecificity. The strains gave moderate DNA reassociation values (25–63%) with the type and several other strains of *M. guilliermondii*, leading the authors to elevate the variety *carpophila* to the rank of species, with *C. fukuyamaensis* and *C. xestobii* as synonyms. The fusion did little to create a phenotypically homogeneous assemblage, as witnessed by the large number of growth characteristics for which the responses are variable. However, the D1/D2 LSU rRNA gene sequence differs by one substitution from *M. guilliermondii*, and two from *P. caribbica*. It is worth mentioning that the former variety *C. guilliermondii* var. *membranifaciens* was found by sequencing a strain thought to belong to *Kodamaea ohmeri* (Kurtzman and Robnett 1998a).

The rationalization of the “*guilliermondii* complex” by Vaughan-Martini et al. (2005) is a welcome development. The clade now consists of *M. guilliermondii*, *M. caribbica*, *C. carpophila*, *C. glucosiphila* and three recently discovered species defined on the basis of rRNA gene sequences (Suh and Blackwell 2004), *C. athensisensis*, *C. smithsonii* and *C. elateridarum*, isolated from basidiocarp-feeding beetles in various families.

Ecology: Accumulating evidence clearly suggests that *C. carpophila* and relatives in the *M. guilliermondii* clade are associated with intimate insect–plant interactions.

Biotechnology: The identification of cellulolytic activity in some strains now assigned to *C. carpophila* (Nakase et al. 1994c) is of considerable interest, although recent literature on the subject was not found.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.52. *Candida caryicola* Kurtzman (2001b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5).

(Some of the morphological characteristics are based on Kurtzman 2001b.)

Growth on 5% malt agar: After 3 days at 25°C, yeast cells are spherical, 2–6 µm, to ellipsoidal to elongate, 2–5 × 3–25 µm, and occur singly or in pairs (Fig. 90.34A). Budding is multilateral with one to three buds per cell that generally form near the poles of the cells. Longer cells are straight or curved, and produce small denticles that give rise to blastoconidia. Some of the longer cells divide forming a globose inflated terminal cell that often detaches. These globose cells may form rachis-like outgrowths that produce blastoconidia. Colonies are white with a dull, almost powdery surface. The texture of the colony is butyrous.

Dalmau plate culture on yeast morphology agar: After 7 days at 25°C, growth under the coverglass shows moderately branched pseudohyphae with blastoconidia (Fig. 90.34B). True hyphae are absent, but occasional pseudohyphae show distinct septa much like the preceding species. Aerobic growth is dull and white, and colonies are low with a crateriform center. Margins are entire or with small denticulate outgrowths. The texture of the colony is butyrous to somewhat hyphal.

Fermentation

Glucose	w	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	s
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	w	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	w
L-Sorbose	–	D-Glucosamine	s
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	s	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	w	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	s	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	w	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	–

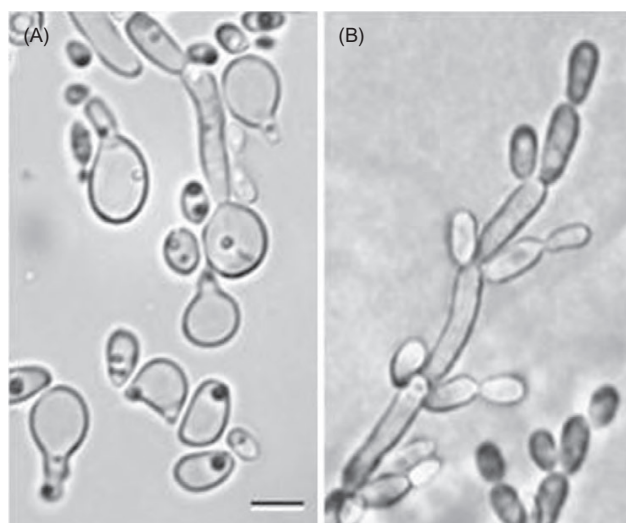


FIGURE 90.34 *Candida caryicola* NRRL YB-1499. Budding cells after 3 days, 25°C, 5% malt extract agar (A) and pseudohyphae after 7 days, 25°C, yeast morphology agar (B). Bar = 5 µm. Reproduced from Kurtzman (2001b) with permission.

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY013717.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 8847 (NRRL YB-1499), isolated from pignut hickory tree (*Carya glabra*, Juglandaceae), Illinois, USA.

Type strain: CBS 8847.

Systematics: Kurtzman (2001b) described *C. caryicola* from a tree isolate based on differences in physiology and D1/D2 LSU rRNA gene sequences, which further show that the species is a member of a small clade that is basal to the *C. tanzawaensis* clade. The nearest relative is the newly described *C. tibetensis* (Wu and Bai 2006). An approximately equal affinity exists with *C. sequanensis* and the recently described *C. linzhienensis*.

The physiology is similar to that of *C. tanzawaensis*, but the two species can be differentiated based on the utilization of β-glucosides and D-arabinose. The reported ability to assimilate trehalose and hexadecane was not confirmed by replica plating.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.53. *Candida caseinolytica* Phaff, Starmer, Lachance & Ganter (1994)

Phylogenetic placement: Unaffiliated clade (Fig. 90.3).

Growth in YM broth: After 3 days at 30°C, the cells are ovoid to short cylindroid, 1–2 × 2–5 µm, and occur singly, in pairs or in short chains (Fig. 90.35).

Growth on YM agar: After 3 days, the streak culture is white, smooth, glossy, butyrous, convex and slow growing.

Dalmau plate culture on corn meal agar: After 10 days, no pseudohyphae or true hyphae are produced.

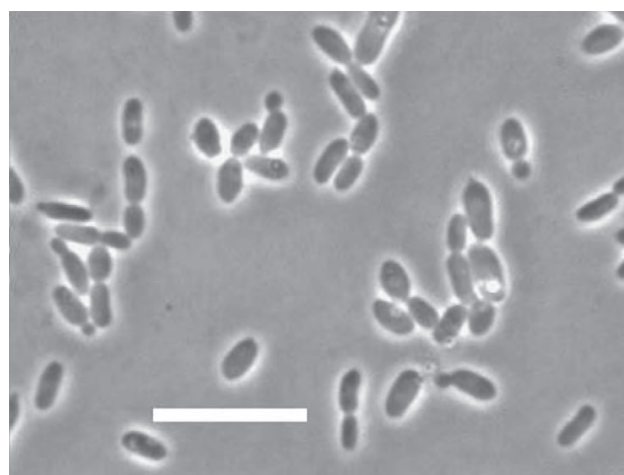


FIGURE 90.35 *Candida caseinolytica* CBS 7781. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	s
Raffinose	–	Glycerol	–
Melibiose	–	Erythritol	–
Galactose	s	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	s	D-Mannitol	w
Maltose	–	D-Glucitol	w
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D,L-Lactate	s
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	+
L-Sorbose	w	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	s
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	w	Gelatin	v
Glucono-δ-lactone	+	Casein	+
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	s	Cycloheximide 0.1%	+
Cadaverine	s	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: 46.4–47.4, eight strains; 46.9, type strain (BD: Phaff et al. 1994).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70250.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 7781, isolated from *Opuntia phaeacantha* (Cactaceae), Arizona, USA; many other strains from necrotic tissue of cacti or associated *Drosophila* spp. in the Sonoran Desert (USA and Mexico), Hawai'i and Argentina; UWOPS 90-1105.2, isolated from sop fruit (*Annona* sp., Annonaceae), Bahamas.

Type strain: CBS 7781.

Systematics: Phaff et al. (1994) described *C. caseinolytica* from numerous isolates from necrotic tissue of neotropical cacti. The small size of the cells and the strong proteolytic activity of the species were noted. Based on an analysis of D1/D2 LSU rRNA gene sequences (Kurtzman and Robnett 1998a), as well as from multigene analysis, *C. caseinolytica* appears to have a basal position in the Saccharomycetales with no close relatives. Although *C. caseinolytica* has no described relatives, unassigned strain UWOPS 94-257.6, isolated from an acetic agave rot (*Agave tequilana* var. *azul*) in Mexico, differs by 5.4% in the D1/D2 sequence, and strains UWOPS 99-344.4 from necrotic tissue of a columnar cactus and UWOPS 00-157.1 from the sap flux of an unidentified tree in Costa Rica differ by 10.4%. The ascosporeogenous strain SU(B) 86-469.5, provisionally named "*Tortispora* sp." (Lachance et al. 1988b), was isolated by P.F. Ganter in the columnar cactus *Stenocereus gummosus* in Baja California, Mexico. His several attempts to recover additional isolates have unfortunately not succeeded. The yeast gave a moderate degree of DNA reassociation with *C. caseinolytica* (H.J. Phaff, personal communication) and had the interesting property of forming single spirilloid ascospores in an apical ascus. The three undescribed species represented by these strains share with *C. caseinolytica* a strong proteolytic activity and small cell size.

Phaff et al. (1994) observed variation in the utilization of D-xylose, D-gluconate, glucono-δ-lactone and L-sorbose (latently), as well as for growth at 42 and 45°C. Gelatin hydrolysis is positive in many strains, but the activity is less evident under mildly acidic conditions. Although *C. catenulata* bears some similarity in growth characteristics, separation can be effected on the basis of 2-keto-D-gluconate utilization, which is strong in *C. caseinolytica*.

Ecology: Phaff et al. (1994) commented on the unusual nature of *C. caseinolytica* in the cactus yeast community, noting that strong proteolytic activity is not encountered in other species found in necrotic cactus tissue. The species is conspicuously absent in the many cacti sampled in the Caribbean.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Poza et al. (2001) studied the production and some properties of the protease of *C. caseinolytica*. The pH response was broad (4.5–11/12). The enzyme was shown to be secreted under conditions of carbon limitation. Casein induced excretion of the enzyme, but not egg or bovine albumin.

90.54. *Candida castellii* (Capriotti) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Nakaseomyces* clade (Fig. 90.1).

Synonym:

Torulopsis castellii Capriotti (1961d)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to cylindrical, 2–3 × 3–7 μm, and occur singly or in pairs (Fig. 90.36).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, no pseudohyphae are present. Aerobic growth is white to cream colored, soft, smooth, glistening and entire.

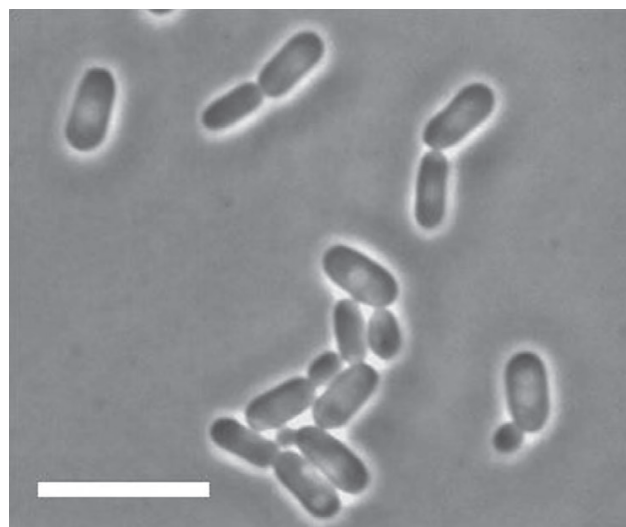


FIGURE 90.36 *Candida castellii* CBS 4332. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	v
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	v	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	–	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	–	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	+

CoQ: 6 (Suzuki and Nakase 1998).

Mol% G + C: 43.3, CBS 4332 (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U79876.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 4332, isolated from soil in Finland.

Type strain: CBS 4332.

Systematics: Capriotti (1961d) isolated 22 strains from various soil samples in Finland. Of these, seven represented new species, one of which was described as *Torulopsis castellii* based on seven strains. The species was found to resemble *C. glabrata*, but differed in fermentation properties. In a multigene phylogenetic analysis, Kurtzman and Robnett (2003) determined that *C. castellii* is related to species in the *Nakaseomyces* clades (Fig. 50.1).

The species is physiologically similar to many other oligophagic species, not only those assigned to *Nakaseomyces* (Kurtzman 2003) or to the broader *Saccharomyces sensu lato* clade, but to others as well. The most important key characteristics are the utilization of glycerol and 2-keto-D-gluconate, and the lack of growth on galactose and ethanol. Identification by rRNA gene sequencing is clearly preferable. Separation from *C. glabrata* can be based on the assimilation of L-lysine as sole nitrogen source, which is positive in *C. castellii*.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.55. *Candida castreensis* C. Ramírez & A. González (1984a)

Phylogenetic placement: *Sugiyamaella* clade (Figs 72.1, 90.3).

Growth in glucose–yeast extract–peptone broth: After 3 days at 20°C, the cells are elongate, 1.5–2.5 × 6–15 μm, and occur singly or in pairs (Fig. 90.37 left).

Dalmau plate culture on corn meal agar: After 7 days at 22°C, pseudohyphae consist of branched chains of elongate cells with pyriform blastoconidia; septate hyphae are also present (Fig. 90.37 right). Aerobic growth is white, dull and smooth with a hyphal border.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	–
Melibiose	–	Erythritol	–
Galactose	s	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	s	D-Mannitol	s
Maltose	+	D-Glucitol	s
Melezitose	+	myo-Inositol	+
Methyl-α-D-glucoside	+	D-Lactate	s
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	–	D-Gluconate	s
L-Sorbose	s	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	s
D-Xylose	+	Hexadecane	s
L-Arabinose	–	Nitrate	–
D-Arabinose	s	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	s	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	s	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	–
50% Glucose	–	Growth at 37°C	–

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 41.7, CBS 8172 (T_m : S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45807.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

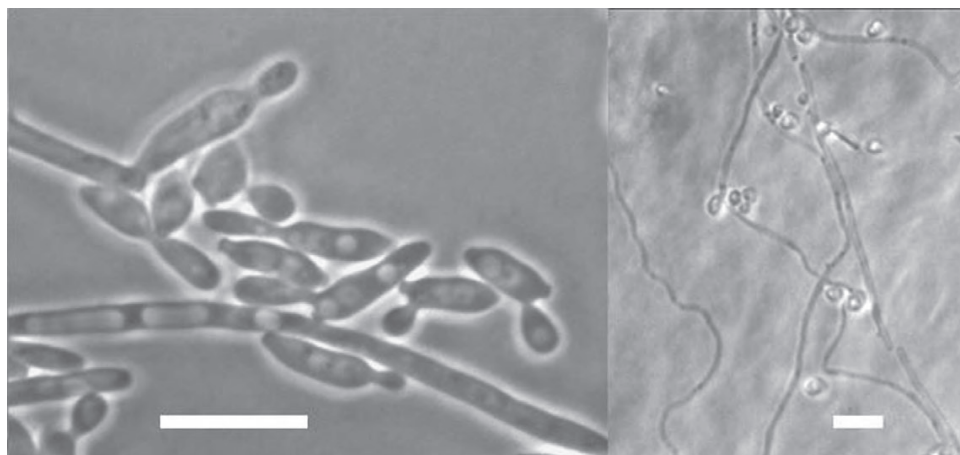


FIGURE 90.37 *Candida castreensis* CBS 8172. Budding cells after 3 days, 25°C, YM agar (left) and pseudohyphae after 14 days, 18°C, YCBAS agar (right). Bars = 10 μm.

Origin of the strain studied: CBS 8172, isolated from decaying wood of southern beech (*Nothofagus dombeyi*, Fagaceae), Chile.

Type strain: CBS 8172.

Systematics: Ramírez and González (1984a) described *C. castrensis* on the basis of five isolates from decaying wood in the Valdivian rainforest. They noted the presence of denticles at the point of blastoconidium formation on hyphal cells and speculated that the species may be an asexual form of *Hyphopichia* (syn. *Pichia*). As noted by Kurtzman (1998c), denticles are also characteristic of species in the *Sugiyamaella* clade, to which the species has affinities based on sequence comparisons. Kurtzman and Robnett (1998a) found *C. castrensis* and *C. paludigena* to differ by only one substitution in the D1/D2 LSU rRNA gene, suggesting that the two taxa might be conspecific. However, the results of a multigene analysis (Kurtzman and Robnett 2007) argue against conspecificity and the two species are retained. Significant differences in physiological abilities add further corroboration to the existence of two natural taxa. The two species are moderate relatives of *C. valdiviana* and *Zygoascus hellenicus*, and represent basal members of the *Sugiyamaella* clade. Utilization of *myo*-inositol and resistance to 0.01% cycloheximide are sufficient to separate the species from other species with a similar nutritional profile.

Ecology: The nutritional profile of *C. castrensis* is unusual but not unlike that of other related species also found in rotting trees by Ramírez and González (1984a, h, i, j).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Trehalose	v	D-Mannitol	+
Maltose	v	D-Glucitol	v
Melezitose	—	<i>myo</i> -Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	—
Soluble starch	v	Succinate	+
Cellobiose	—	Citrate	—
Salicin	v	D-Gluconate	v
L-Sorbose	—	D-Glucosamine	v
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	v	Hexadecane	+
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	—
2-Keto-D-gluconate	v	DBB	—
D-Glucuronate	—	Gelatin	v
Glucono- δ -lactone	v	Casein	v
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	v	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	v

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 54.5, CBS 565; 54.1, CBS 564 (T_m : Stenderup and Bak 1968); 53.2, C-140 (Langeron #495); 53.2, CBS 1904; 53.4, UCD-FST

90.56. *Candida catenulata* Diddens & Lodder (1942)

Phylogenetic placement: Unaffiliated clade (Fig. 90.3).

Synonyms:¹

Blastodendron brumptii Guerra (1935)

Candida brumptii (Guerra) Langeron & Guerra (1938)

Mycotorula brumptii (Guerra) Krasil'nikov (1954c)

Candida ravautii Langeron & Guerra (1938)

¹ Synonymy based on nuclear DNA reassociation experiments (Simione and Meyer 1978).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to cylindroid, 1.5–4.5 $\times$ 4–12 μ m, and occur singly, in pairs or in chains (Fig. 90.38 top).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of chains of ovoid or cylindroid cells, and sometimes bear small verticils of ovoid blastoconidia (Fig. 90.38 bottom). Aerobic growth is grayish to cream colored, somewhat dull, soft and wrinkled.

Fermentation

Glucose	v	Lactose	—
Galactose	—/s	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—/s		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	v
Lactose	—	Galactitol	—

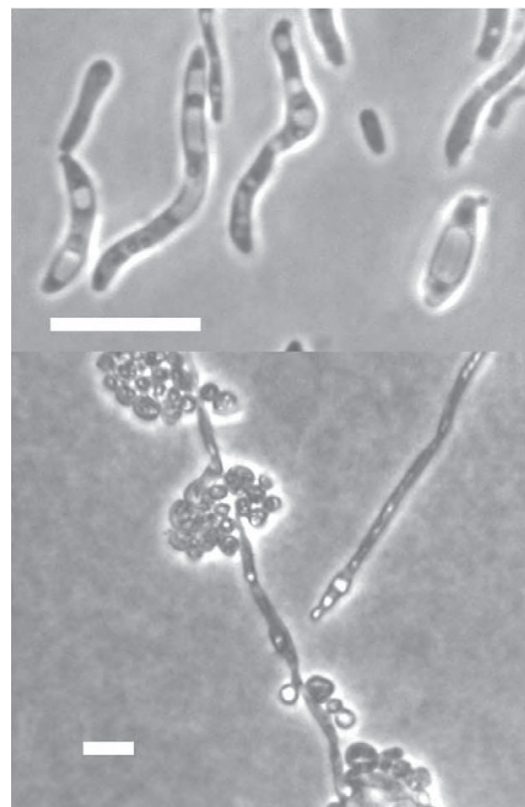


FIGURE 90.38 *Candida catenulata* CBS 565. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μ m.

60-60 (T_m : Meyer and Phaff 1972); 53.2, 54.4, IFO 0745 (CBS 565); 54.4, IFO 0744 (CBS 1904) (T_m : Nakase and Komagata 1971f).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45714.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 564, type strain of *C. brumptii*, isolated from case of perleche; CBS 565, from feces of a dysentery patient, Puerto Rico; CBS 2014, type strain of *C. ravautii*, from gut of chicken with symptoms of blackhead disease, The Netherlands; UFMG-J37.1, from a stingless bee (*Melipona quadrifasciata*, Apidae: Meliponini), Brazil.

Type strain: CBS 565.

Systematics: *Candida catenulata* was described by Diddens and Lodder (1942) to accommodate a clinical isolate originally identified as *Monilia rugosa* (nom. nud.). The conspecificity of *C. catenulata*, *C. brumptii* and *C. ravautii* was established by DNA reassociation experiments (Simione and Meyer 1978). The species cannot be assigned with confidence to any particular phylogenetic group on the basis of D1/D2 LSU (Kurtzman and Robnett 1998a) or SSU (Sugita and Nakase 1999) rRNA gene sequences, although it undoubtedly belongs to the Saccharomycetales. Strains representing the three former taxa differ in the assimilation of maltose, salicin, gluconic acid and D-glucosamine, growth at 37°C and the production of extracellular proteases. The assimilation of lactic and citric acids reported in previous descriptions could not be confirmed, but the utilization of N-acetyl-D-glucosamine and hexadecane was observed in all strains. Separation from most physiologically similar species can be accomplished based on positive growth responses on D-mannitol, D-glucitol and resistance to 0.01% cycloheximide, combined with negative responses for sorbose and erythritol utilization or growth in vitamin-free medium.

Ecology: Although most isolates of *C. catenulata* originate from human related sources, a single strain was found in a large collection from meliponine bees and their habitats in Brazil (Rosa et al. 2003).

Biotechnology: Unknown.

Agriculture and food: *Candida catenulata* is strongly lipolytic, which may account for its frequent occurrence in artisanal or commercial cheeses (Romano et al. 2001, Roostita and Fleet 1996b).

Clinical importance: Keller et al. (2000) identified over a fifth of 174 isolates from mastitic milk as *C. catenulata*. In contrast, the species constituted only a minority of samples of droppings from caged psittacines examined across Italy by Mancianti et al. (2001).

90.57. *Candida cellae* M. Pimentel, Lachance & Rosa (M. Pimentel et al. 2005)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

(The description is based on M. Pimentel et al. 2005.)

Growth on YM agar: After 3 days at room temperature, colonies are white, convex, smooth and opalescent, and have an entire margin.

Growth in yeast extract extract–glucose broth: After 3 days at 25°C, the cells are ovoid to ellipsoidal, $2-3 \times 2-5 \mu\text{m}$, and show multilateral budding.

Growth on the surface of yeast extract extract–glucose broth: After 1 month, sediment is formed.

Dalmau plate culture on corn meal agar: After 2 weeks at room temperature, pseudohyphae and true hyphae are absent.

Fermentation

Glucose	+	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (in Liquid Media)

Glucose	+	D-Ribose	w
Inulin	–	Methanol	–
Sucrose	–	Ethanol	–
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	D-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	+
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Ethylamine	+
2-Keto-D-gluconate	–	50% Glucose	–
D-Glucono-1,5-lactone	–	10% NaCl/5% glucose	+
D-Glucuronate	–	Starch formation	–
Acetone	–	Acid formation	+
Ethyl acetate	–	Urease	–
2-Propanol	–	DBB	–
Amino acid-free	+	Cycloheximide 0.01%	v
Nitrite	+	Growth at 37°C	+
Cadaverine	+	Growth at 40°C	+
L-Lysine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY861673, ITS and 5.8S rRNA = AY861674.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 10086 (NRRL Y-27860), isolated from pollen provisions from a nest of a solitary bee (*Centris tarsata*) at the Ecological Station of the Universidade Federal de Minas Gerais, Minas Gerais, Brazil (M. Pimentel et al. 2005).

Type strain: CBS 10086.

Systematics: *Candida cellae* is part of the *Starmerella* clade, a group of several related species that are generally associated with bees (M. Pimentel et al. 2005). The closest described relative of *C. cellae* is *C. etchellsii* from which it differs by 28 substitutions and one gap in the D1/D2 domains of the LSU rRNA gene. *C. cellae* is also closely related to *Candida* sp. UFMG-LS-02, a strain recovered from a flower of morning glory (*Ipomoea* sp., Convolvulaceae) collected in the region of Lagoa Santa, Brazil. Because the two isolates differ by one substitution in ITS1 and three in the D1 region, they may represent a distinct species. Another relative, *Candida* sp. UFMG-J92.1, was isolated from pollen provisions and honey samples of the social stingless bee *Melipona rufiventris* and differs from *C. cellae* by 18 substitutions and one gap in the D1/D2 region.

Ecology: *Candida cellae* is known from the provisions of a nest of solitary bees (*Centris tarsata*) in the Atlantic rainforest of Brazil. Whether or not *C. cellae* is closely associated with *Centris tarsata* is still a matter of speculation (M. Pimentel et al. 2005).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Neither asci nor conjugation were observed on corn meal agar, Fowell's acetate agar, diluted V8 agar, potato dextrose agar, malt extract agar and Yeast Carbon Base agar supplemented with 0.01% ammonium sulfate.

90.58. *Candida cerambycidarum* S.-O. Suh, N.H. Nguyen & M. Blackwell (2005b)

Phylogenetic placement: *Yamadazyma* clade (Fig. 90.2). (The description is based on Suh et al. 2005b.)

Growth on YM agar: After 7 days at 25°C, colonies are white, smooth and butyrous.

Growth in YM broth: After 7 days' growth at 25°C, cells are globose or subglobose, $2-6 \times 2-6 \mu\text{m}$, and occur singly, in pairs, in short chains or in clusters.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae are present. Aerobic growth is white and furry.

Fermentation

Glucose	+	Lactose	—
Galactose	+	Raffinose	—
Sucrose	—	Trehalose	+
Maltose	—	D-Xylose	—

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	d
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	w
L-Rhamnose	+	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	—
D-Arabinose	w	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	60% Glucose	—
2-Keto-D-gluconate	—	10% NaCl/5% glucose	+
D-Glucuronate	—	16% NaCl	w
Arbutin	+	Starch formation	—
Propane 1,2 diol	w	Urease	—
Butane 2,3 diol	—	Growth on 1% acetic acid	—
L-Arabinitol	+	DBB	—
D-Glucono-1,5-lactone	+	Cycloheximide 0.01%	—
Quinic acid	—	Cycloheximide 0.1%	—
D-Glucarate	—	Growth at 30°C	+
Nitrite	—	Growth at 35°C	w
Cadaverine	+	Growth w/o myo-inositol	+
Creatinine	—	Growth w/o pantothenate	+
L-Lysine	+	Growth w/o biotin	—
Ethylamine	+	Growth w/o thiamine	—

D-Glucosamine (as N compound)	—	Growth w/o biotin & thiamine	—
D-Tryptophan	—	Growth w/o pyridoxine	+
Creatine	—	Growth w/o pyridoxine & thiamine	—
Imidazole	—	Growth w/o niacin	+
50% Glucose	+	Growth w/o PABA	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY520299, SSU rRNA = AY520169, ITS and 5.8S rRNA = AY964669.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9879 (NRRL Y-27706), isolated from the guts of an unidentified cerambycid beetle, Barro Colorado Island, Panama; BG 02-7-15-021A-1-2, origin unknown (Suh et al. 2005b).

Type strain: CBS 9879.

Systematics: *Candida cerambycidarum* clusters within the *Yamadazyma* clade with five other *Candida* species, all associated with beetles (*C. amphyxiae*, *C. gorgasii*, *C. michaelii*, *C. endomychidarum* and *C. lessepsii*, Suh et al. 2005b). *C. cerambycidarum* and *C. gorgasii* were both isolated in Barro Colorado Island from unidentified cerambycid beetles.

Ecology: The species is known from the guts of a cerambycid beetle in Barro Colorado Island, Panama (Suh et al. 2005b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Ascospores were not produced after 6 weeks at 17°C on YM agar or on half-strength corn meal agar.

90.59. *Candida chickasaworum* S.-O. Suh & M. Blackwell (Suh et al. 2004b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5).

(The description is based on Suh et al. 2004b.)

Growth on YM agar: After 7 days at 25°C, colonies are white to cream colored, butyrous and smooth, and have a hyphal edge.

Growth in YM broth: After 7 days at 25°C, cells are globose, subglobose to fusiform, $2-6 \times 2-8 \mu\text{m}$, occurring singly, in pairs or in short chains, and pseudohyphae and septate hyphae may be present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, elongated pseudohyphae and septate hyphae may be present. Aerobic growth is white to cream colored with a hyphal margin.

Fermentation

Glucose	+	Lactose	—
Galactose	+/d	Raffinose	—
Sucrose	—	Trehalose	+/d
Maltose	—	D-Xylose	—

Growth (in Liquid Media)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+/d/w
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+/d
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+

Maltose	+	D-Glucitol	+
Melezitose	v	myo-Inositol	—
Methyl- α -D-glucoside	+	D,L-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+/d/w
Salicin	+	D-Gluconate	v
L-Sorbose	n	D-Glucosamine	d/w
L-Rhamnose	n	N-Acetyl-D-glucosamine	n
D-Xylose	+/d	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	v	60% Glucose	v
2-Keto-D-gluconate	+	10% NaCl/5% glucose	+/w
D-Glucuronate	—	16% NaCl	—
Arbutin	+	Starch formation	—
Propane 1,2 diol	v	Urease	—
Butane 2,3 diol	—	DBB	—
D-Arabinitol	—	Growth on 1% acetic acid	—
D-Glucono-1,5-lactone	+/d/w	Cycloheximide 0.01%	—
Quinic acid	—	Growth at 25°C	+
D-Glucarate	—	Growth at 30°C	+
D-Galactonate	—	Growth at 35°C	—
Nitrite	—	Growth w/o myo-inositol	+
Cadaverine	+	Growth w/o pantothenate	+
Creatinine	—	Growth w/o biotin	v
L-Lysine	+	Growth w/o thiamine	+
D-Glucosamine (as N compound)	v	Growth w/o biotin & thiamine	v
D-Tryptophan	—	Growth w/o pyridoxine	+
Creatine	—	Growth w/o thiamine & pyridoxine	+
Imidazole	—		
Ethylamine	+	Growth w/o niacin	+
50% Glucose	+/d	Growth w/o PABA	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY242263, SSU rRNA = AY242154.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9830 (NRRL Y-27566), isolated from a beetle (*Tritoma* sp., Erotylidae) on a mushroom (*Amanita* sp.); BG 02-6-15-003A-1, from a fungus beetle (*Dacne* sp., Erotylidae); BG 02-6-15-003B-1, from *Tritoma californica* (Erotylidae); NRRL Y-27561, from an unidentified ciid beetle, all from Athens, Georgia; BG 02-2-5-1-1, from *Tritoma* sp. (Erotylidae) on an oyster mushroom (*Pleurotus ostreatus*), Baton Rouge, Louisiana, all from USA (Suh et al. 2004b).

Type strain: CBS 9830.

Systematics: *Candida chickasaworum* belongs to the *Candida tanza-waensis* clade, which includes 17 subclades of gut yeasts from basidiocarp-feeding beetles (Suh et al. 2004b).

Ecology: The majority of the isolates were collected from species of *Tritoma* sp., a basidiocarp-feeding beetle in the south-eastern USA (Suh et al. 2004b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Ascospores were not produced after 6 weeks at 17°C on YM agar or on half-strength corn meal agar.

90.60. *Candida chilensis* Grinbergs & Yarrow (1970a)

Phylogenetic placement: *Nakazawaea* clade (Fig. 90.4).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are short ovoid to elongate, 4–6 $\times$ 4–7 μ m, and occur singly, in pairs or in small groups (Fig. 90.39). After 1 month a creeping pellicle is present and the cell suspension is mucoid.

Dalmeu plate culture on corn meal agar: After 7 days at 25°C, branched chains of cylindrical cells give a wavy appearance. A few to many subglobose to ovoid blastoconidia appear individually or in clusters. Some septate hyphae are evident. Aerobic growth is cream colored to beige, shiny, smooth and butyrous, and the margin is entire to slightly fringed.

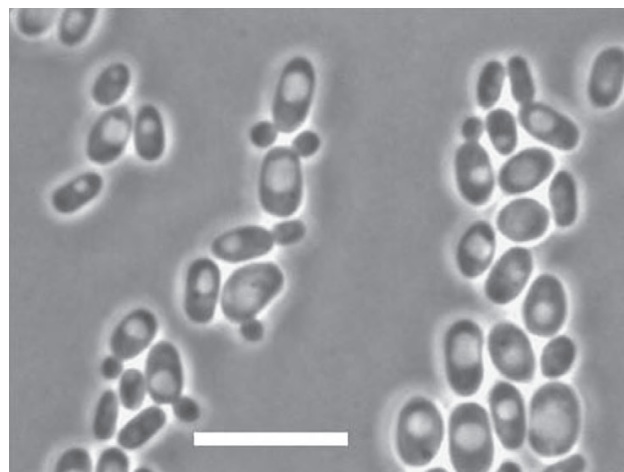


FIGURE 90.39 *Candida chilensis* CBS 5719. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	+
Lactose	+	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	D,L-Lactate	+
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	v
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	—
L-Arabinose	+	Nitrate	+
D-Arabinose	+	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	n
Glucono-δ-lactone	v	Casein	n
Amino acid-free	+	Lipase	n
Nitrite	+	Acid production	n
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	v
50% Glucose	–	Growth at 37°C	–

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 44.0, CBS 5719 (BD: Meyer et al. 1984); 42.7, CBS 5719 (T_m : Stenderup et al. 1972).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45821.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 5719, isolated from decomposed wood of the southern beech tree (*Nothofagus* sp., Fagaceae), Chile.

Type strain: CBS 5719.

Systematics: Grinsbergs and Yarrow (1970a) assigned two strains collected in decaying wood to *C. chilensis*. They noted similarities with *C. tenuis* and *C. aaseri*, but the utilization of lactose, erythritol and nitrate, and the absence of growth on *myo*-inositol warranted separation from these species. According to the analysis of D1/D2 LSU rRNA gene sequences by Kurtzman and Robnett (1998a), *C. chilensis* occupies a basal position with respect to methanol-assimilating yeasts, but this affinity is weak and is not supported by the analysis of SSU rRNA gene sequences (Sugita and Nakase 1999). The latter suggests an affinity for the *Debaryomyces sensu lato* clade. Growth of the type strain on replica plates was poor, and fermentation was not detected, indicating that the strain has special nutritional requirements. The results presented here are those given by Meyer et al. (1998), which are in good agreement with those in the original description. The species is polyphagic and, in principle, easily distinguished from other species by the assimilation of lactose, erythritol and nitrate, as indicated in the original description.

Ecology: Toivola et al. (1984) found *C. chilensis* to ferment D-xylose to ethanol and noted a striking correlation between that property and decaying wood as a source of isolation.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.61. *Candida choctaworum* S.-O. Suh & M. Blackwell (Suh et al. 2004b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5). (The description is based on Suh et al. 2004b.)

Growth on YM agar: After 7 days at 25°C, colonies are white to cream, smooth, butyrous and with a slightly wrinkled edge.

Growth in YM broth: After 7 days at 25°C, cells are globose to ovoid, 2–6 × 2–8 μm, occur singly, in pairs or in short chains, and pseudohyphae may be present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae may be present. Aerobic growth is white, glistening, smooth and slightly fuzzy.

Fermentation

Glucose	+/d	Lactose	–
Galactose	v	Raffinose	–
Sucrose	–	Trehalose	+d/w
Maltose	–	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+/d
Raffinose	–	Glycerol	+/d
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	<i>myo</i> -Inositol	–
Methyl-α-D-glucoside	–	D-Lactate	–
Soluble starch	–	Succinate	+/w
Cellulobiose	+	Citrate	+/d
Salicin	+	D-Gluconate	v
L-Sorbose	n	D-Glucosamine	+/d
L-Rhamnose	n	N-Acetyl-D-glucosamine	n
D-Xylose	+/d	Hexadecane	n
L-Arabinose	v	Nitrate	–
D-Arabinose	+/d/w	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	10% NaCl/5% glucose	+/w
2-Keto-D-gluconate	+	16% NaCl	v
D-Glucuronate	–	Starch formation	–
Arbutin	+	Urease	–
Propane 1,2 diol	v	DBB	–
Butane 2,3 diol	–	Growth on 1% acetic acid	–
D-Arabinitol	v	Cycloheximide 0.01%	+
D-Glucono-1,5-lactone	+/d	Cycloheximide 0.1%	+
Quinic acid	–	Growth at 25°C	+
D-Glucarate	–	Growth at 30°C	+
D-Galactonate	–	Growth at 35°C	v
Nitrite	–	Growth at 40°C	–
Cadaverine	+	Growth w/o <i>myo</i> -inositol	+
Creatinine	–	Growth w/o panthotenate	+
D-Glucosamine (as N compound)	v	Growth w/o biotin	w/–
D-Tryptophan	–	Growth w/o thiamine	+
Creatine	–	Growth w/o biotin & thiamine	v
Imidazole	–	Growth w/o pyridoxine	+
L-Lysine	+	Growth w/o thiamine & pyridoxine	+
Ethylamine	+	pyridoxine	+
50% Glucose	+/d	Growth w/o niacin	+
60% Glucose	+/d/w	Growth w/o PABA	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY242241, SSU rRNA = AY242136.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9831 (NRRL Y-27584), isolated from two-horned darkling beetle (*Neomida bicornis*, Tenebrionidae)

on a basidiocarp of *Fomitella supine*; NRRL Y-27557, from a snout beetle (*Euparius marmoreus*, Anthribidae), Sulphur, Louisiana; NRRL Y-27559, from a beetle (*Ceracis curtus*, Ciidae) on *Fomitella supine*, both in Baton Rouge, Louisiana; BG 02-5-30-001B-1 and BG 02-5-30-08B-1, isolated from an unidentified tenebrionid and an unidentified ciid, respectively, Athens, Georgia; BG 98-12-9-1-1, from *Neomida bicornis* (Tenebrionidae) on *Fomitella supina*, St. Francisville, Louisiana, all from USA (Suh et al. 2004b).

Type strain: CBS 9831.

Systematics: *Candida choctaworum* belongs to the *C. tanzawaensis* clade, which includes 17 subclades of gut yeasts from basidiocarp-feeding beetles (Suh et al. 2004b).

Ecology: The isolates were collected from different species of basidiocarp-feeding beetles at different locations in the south-eastern USA (Suh et al. 2004b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Ascospores were not produced after 6 weeks at 17°C on YM agar or on half-strength corn meal agar.

90.62. *Candida chrysomelidarum* N.H. Nguyen, S.-O. Suh, Erbil & M. Blackwell (2006a)

Phylogenetic placement: *Metschnikowia* clade (Fig. 46.1).

(The description is based on Nguyen et al. 2006a.)

Growth on YM agar: After 7 days at 25°C, colonies are white and butyrous.

Growth in YM broth: After 7 days at 25°C, cells are ellipsoidal, 4–7 × 5–9 µm, and occur singly or in pairs.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, neither pseudohyphae nor true hyphae are present. Aerobic growth is off-white and smooth with a glossy surface.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	d
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	d
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	–	D-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	d
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	d
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	–	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	60% Glucose	+
2-Keto-D-gluconate	+	10% NaCl/5% glucose	w
D-Glucuronate	–	16% NaCl	–
L-Arabinitol	–	DBB	–
Arbutin	+	Starch formation	–
Propane 1,2 diol	–	Urease	–
Butane 2,3 diol	–	1% Acetic acid	–
D-Glucono-1,5-lactone	+	Cycloheximide 0.01%	–
Quinic acid	–	Growth at 30°C	+
D-Glucarate	–	Growth at 35°C	–
Nitrite	–	Growth w/o myo-inositol	+
Cadaverine	+	Growth w/o panthotenate	+
Creatinine	–	Growth w/o biotin	–
L-Lysine	+	Growth w/o thiamine	+
D-Glucosamine (as N compound)	w	Growth w/o biotin & thiamine	–
D-Tryptophan	–	Growth w/o pyridoxine	+
Creatine	–	Growth w/o thiamine & pyridoxine	+
Imidazole	–		
Ethylamine	+	Growth w/o niacin	+
50% Glucose	+	Growth w/o PABA	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY520294, SSU rRNA = AY520164.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9904 (NRRL Y-27749), BG 02-7-16-002A-2-1, both isolated from unidentified chrysomelid beetles, Barro Colorado Island, Panama (Nguyen et al. 2006a).

Type strain: CBS 9904.

Systematics: *Candida chrysomelidarum* belongs to the *Metschnikowia* clade, where it forms a statistically well-supported clade with *C. rancensis* (Nguyen et al. 2006a). The two species differ by more than 40 substitutions in the D1/D2 region. The position of this clade among other members of the *Metschnikowia* clade, however, was not fully resolved by the comparison of D1/D2 sequences. From the analysis based on the combined sequences of SSU and LSU rRNA genes, *C. chrysomelidarum* also belonged to a major subclade of the *Metschnikowia* clade that includes *M. guessii*, *M. australis*, *M. bicuspidata*, *M. krissii*, *M. zobellii*, *M. reukaufii*, *C. kofuensis* and *M. viticola* with comparatively high statistical support of 85% by bootstrapping and 96% by B-MCMC analyses (Nguyen et al. 2006a). The current phylogenetic status of the species can be viewed in Fig. 46.1.

Ecology: The isolates were found in the digestive tract of chrysomelid beetles in Barro Colorado Island, Panama (Nguyen et al. 2006a).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Ascospores were not present on corn meal agar or diluted V8 juice agar after 2 months.

90.63. *Candida cidri* Kurtzman, Robnett & Yarrow (2001a)

Phylogenetic placement: *Ogataea/Kuraishia* clades (Figs 39.1, 53.1, 90.4). (Some of the morphological characteristics are based on Kurtzman et al. 2001a.)

Growth on 5% malt agar: After 3 days at 25°C, the cells are spherical, 2–6 µm in diameter, occur singly or infrequently in pairs and reproduce by multilateral budding (Fig 90.40). Growth is tannish-white, glistening and butyrous to nearly mucoid.

Dalmau plate culture on morphology agar: After 7 days at 25°C, moderately branched rosettes of undifferentiated cells are formed

under the coverglass, but pseudohyphae and true hyphae are not formed. Aerobic growth is tannish-white, smooth, glistening and butyrous, and the colony margin is irregularly lobed.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	v
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	w
Inulin	–	Methanol	+
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	w	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	s	myo-Inositol	–
Methyl- α -D-glucoside	v	DL-Lactate	+
Soluble starch	s	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	s
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	s	Hexadecane	–
L-Arabinose	–	Nitrate	+
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	w	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	+	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	w
50% Glucose	w	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF245402.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 4241 (NRRL-Y-27078), isolated from cider, UK, by F.W. Beech.

Type strain: CBS 4241.

Systematics: Kurtzman et al. (2001a) described *C. cidri* on the basis of a strain isolated by F.W. Beech from apple cider. The strain could not be identified by conventional methods and the D1/D2 LSU rRNA gene differed from that of any other known species. *C. cidri* is related to the more recently described *C. hungarica* (Péter et al. 2003) and has affinities for the larger clade of methylotrophic species.

Growth on L-arabinose and D-arabinose, reported in the original description, was not confirmed by replica plating. The description (Kurtzman et al. 2001a) reported a number of characteristics as variable even though only one strain was studied, which indicates that the reproducibility of growth responses of this species is poor. The species bears a superficial resemblance with others methylotrophs,

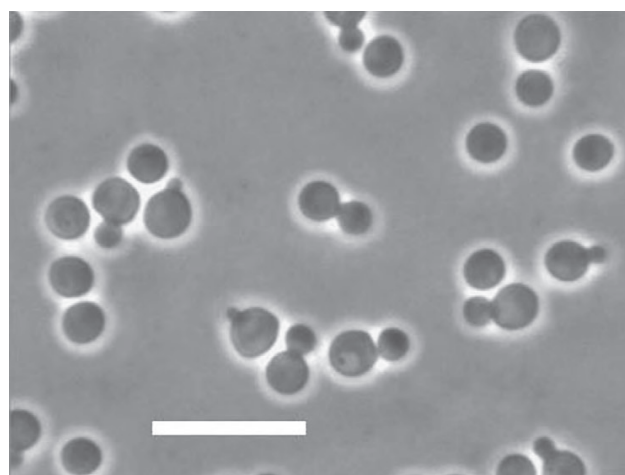


FIGURE 90.40 *Candida cidri* CBS 4241. Budding cells after 3 days, 25°C, YM. Bar = 10 μ m.

but can be separated based on the utilization of maltose, starch and erythritol, and the absence of growth on β -glucosides.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.64. *Candida coipomoensis* C. Ramírez & A. González (1984f)

Phylogenetic placement: *Scheffersomyces* clade (Figs 65.1, 90.2).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 3–4 $\times$ 3–4.5 μ m, single and in pairs. Longer, pleomorphic cells may be present (Fig. 90.41 top).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, well-developed pseudohyphae are present (Fig. 90.41 bottom). Aerobic growth is white, smooth and butyrous with a fringed border.

Fermentation

Glucose	+	Lactose	–
Galactose	s	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	s	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	v	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	s
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	–	Nitrate	–
D-Arabinose	s	Vitamin-free	–

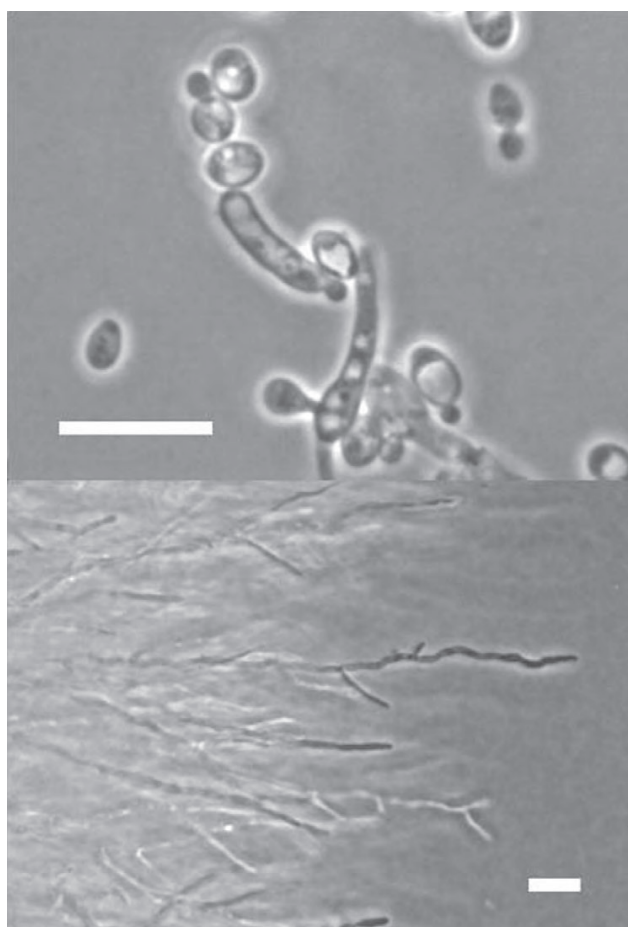


FIGURE 90.41 *Candida coipomoensis* CBS 8178. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μ m.

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Gluconate	—	Gelatin	—
Glucono- δ -lactone	v	Casein	—
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 32.0, CBS 8178 (T_m : S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45747.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 8178, isolated from fallen tree trunks of ulmo (*Eucryphia cordifolia*, Eucryphiaceae) undergoing decay by the mushroom *Ganoderma applanatum*, in Chile; CBS 4604, deposited as *C. butyri*, isolated from larva of cerambycid beetle (*Microlophorus magellanicus*, Coleoptera: Cerambycidae), Chile, by J. Grinbergs.

Type strain: CBS 8178.

Systematics: Present analyses (Fig. 65.1) demonstrate that *C. coipomoensis* is a member of the *Scheffersomyces* clade. Ramírez and González (1984f) described *C. coipomoensis* to accommodate four strains recovered from trees undergoing decay caused by bracket fungi. Analysis of the combined sequences from D1/D2 LSU and the nearly complete SSU rRNA genes placed *C. coipomoensis* in the *Scheffersomyces* clade (Kurtzman and Suzuki 2010). The growth profiles of both strains examined, including one received by the CBS under the name *C. butyri*, matched the species description. The species is mesophilic and resembles a few other species, some of which are in the same large clade. Assimilation of L-sorbose and erythritol, growth at 30°C, and the absence of growth on L-rhamnose are useful in separating *C. coipomoensis* from similar species.

Ecology: An association with beetles involved in wood decay is likely.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.65. *Candida conglobata* (Redaelli) van Uden & H.R. Buckley ex S.A. Meyer & Ahearn (1983)

Phylogenetic placement: *Yamadazyma* clade (Figs 81.1, 90.2).

Synonyms:

Torulopsis conglobata Redaelli (1925)

Cryptococcus conglobatus (Redaelli) Pollacci & Nannizzi (Nannizzi 1934)

Candida conglobata (Redaelli) van Uden & H.R. Buckley (1970) nom. inval.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to cylindrical, 3–5 $\times$ 5–20 μ m, and occur singly or in chains (Fig. 90.42 top).

Dalmau plate culture on corn meal agar: Pseudohyphae consist of long, branched chains of cylindrical cells, usually with few blastoconidia (Fig. 90.42 bottom). Aerobic growth is cream colored and delicately wrinkled.

Fermentation

Glucose	+	Lactose	—
Galactose	s	Raffinose	—
Sucrose	—	Trehalose	s
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	w
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	s
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	s
Maltose	—	D-Glucitol	s
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	—
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	s
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	+	Nitrate	—
D-Arabinose	s	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	w	Starch production	—
2-Keto-D-gluconate	s	DBB	—
D-Glucuronate	—	Gelatin	s
Glucono-δ-lactone	s	Casein	w
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	s	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	s	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	—

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 39.2–40.9, CBS 2018 (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45789.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

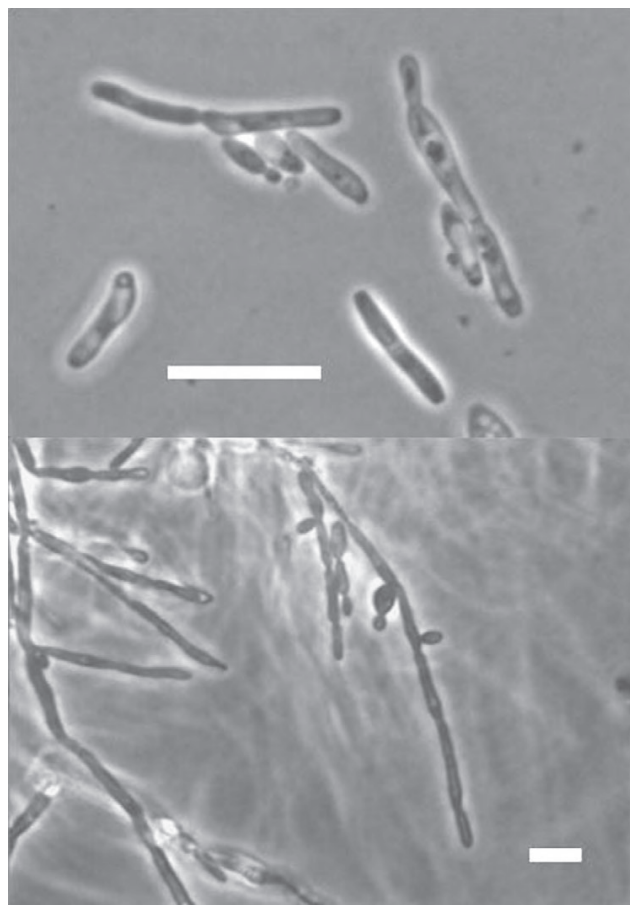


FIGURE 90.42 *Candida conglobata* CBS 2018. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 µm.

Origin of the strains studied: CBS 2018, isolated from tubercular lung; CBS 2019, probably human origin.

Type strain: CBS 2018.

Systematics: Originally described as *Torulopsis conglobata*, the species was transferred to *Candida* by van Uden and Buckley based on the formation of pseudohyphae and later validated by Meyer and Ahearn (1983). *C. conglobata* fits well within the *Yamadazyma* clade as evidenced by D1/D2 LSU rRNA gene sequences (Kurtzman and Robnett 1998a). The SSU rRNA genes of *C. conglobata* and *C. insectorum* differ by only two substitutions (Sugita and Nakase 1999), indicating a close relationship, but the physiological profiles of the two species are distinct. Meyer et al. (1998) listed strain CBS 5808 as a member of the species. The growth characteristics evaluated by replica plating showed considerable differences from the description and a better match with *C. wickerhamii*, except for the absence of nitrate utilization. The D1/D2 sequence was determined (AY366526) and led to the conclusion that the strain is instead related to *C. pomicola* (see discussion of that species).

The growth characteristics of the type strain matched previous descriptions well except for the utilization of 2-keto-D-gluconate, which was found slow positive. The growth profile is unique, due to the assimilation of L-sorbose, the four pentoses tested and erythritol combined with sensitivity to 0.01% cycloheximide.

Ecology: Although the isolation of *C. conglobata* is rarely reported, numerous closely related strains have been isolated from necrotic cacti and related substrates in the Neotropics (M.-A. Lachance, unpublished data) and these strains will be described as new species in due course.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Although the known strains appear to be of human origin, recent literature on the clinical occurrence of *C. conglobata* is lacking.

90.66. *Candida cretensis* Middelhoven & Kurtzman (2007)

Phylogenetic placement: *Candida kruisii* clade (Fig. 90.5).

(The description is based on Middelhoven and Kurtzman 2007.)

Growth on malt extract agar: After 3 days at 25°C, the colony is tannish-white, faintly glistening, flat, butyrous and with entire margins. Cells are ellipsoidal, $2.3\text{--}6 \times 1.8\text{--}4\text{ }\mu\text{m}$, with multilateral budding, and occur singly, in pairs and in small clusters (Fig. 90.43A).

Growth on 1% glucose–0.5% peptone–0.3% yeast extract–0.3% malt extract broth: After 3 days at 25°C, the cells are globose and ovoid, show multilateral budding, occur singly or in pairs and hyphae are not present.

Growth on the surface of GPYM broth: Sediment and some islets are formed. After 1 month a ring and a flocculant sediment are present.

Dalmau plate culture on morphology agar: After 7 days at 25°C, growth under the coverglass is limited and shows only outgrowth of simple pseudohyphae (Fig. 90.43B). Aerobic colonies are light tannish-white, low convex with a central depression, smooth, glistening, butyrous and usually with an entire margin with infrequent small lobes.

Fermentation

Glucose	+	Lactose	n
Galactose	+	Raffinose	n
Sucrose	—	Trehalose	+
Maltose	—	D-Xylose	—

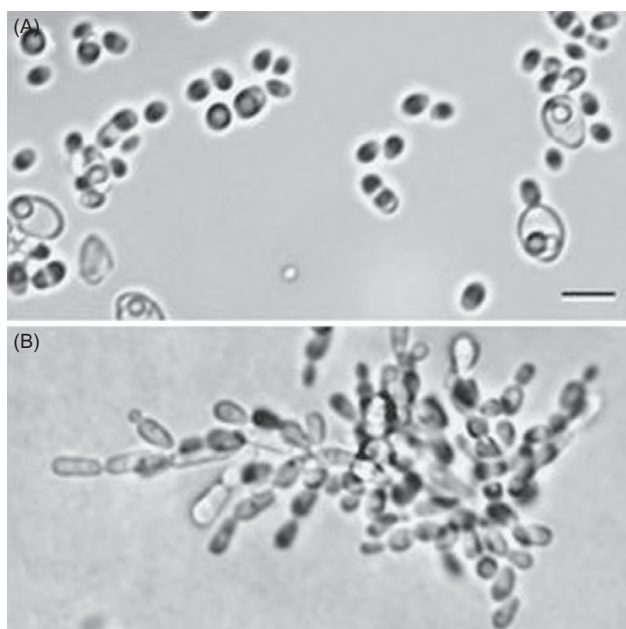


FIGURE 90.43 *Candida cretensis*. Budding cells after 3 days, 25°C, 5% malt extract agar (A) and pseudohyphae after 7 days, 25°C, yeast morphology agar (B). Bar = 5 μm.

Growth (in Liquid Media)

Glucose	+	D-Ribose	d
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D,L-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	d
L-Sorbose	d	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	–	Nitrate	–
D-Arabinose	d	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	+	Nitrite	–
2-Keto-D-gluconate	+	Cadaverine	+
5-Keto-D-gluconate	–	Creatinine	–
D-Glucuronate	–	L-Lysine	+
D-Galacturonate	–	Ethylamine	+
Propane 1,2 diol	d	D-Glucosamine (as N compound)	–/w
Butane 2,3 diol	–	D-Tryptophan	–
L-Arabinitol	–	Creatine	–
D-Glucono-1,5-lactone	+	Imidazole	–
Quinic acid	–	D-Proline	+
D-Glucarate	–	Putrescine	+

D-Galactonate	–	10% NaCl/5% glucose	+
Palatinose	+	16% NaCl	–
Levulinate	–	Urease	–
L-Malic acid	+	DBB	–
L-Tartaric acid	–	Starch formation	–
D-Tartaric acid	–	Cycloheximide 0.01%	+
meso-Tartaric acid	–	Cycloheximide 0.1%	+
Galactaric acid	–	Growth at pH 3	+
Uric acid	–	Growth at pH 9.5	–
Gentobiose	+	Growth at 30°C	+
Ethylene glycol	–	Growth at 32°C	–
Tween 60	d	Growth w/o thiamine	–
Tween 80	d		–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY498861, ITS and 5.8S rRNA = AY498862.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9453 (NRRL Y-27777), isolated from a rotted polypore (*Inonotus tamaricis*) growing on a tamarix tree (*Tamarix* sp. Tamaricaceae), near the seaside in Plakias, Crete, Greece, in October 2000 (Middelhoven and Kurtzman 2007).

Type strain: CBS 9453.

Systematics: *Candida cretensis* is part of the *C. kruisii* clade (Middelhoven and Kurtzman 2007). In addition to *C. cretensis* and *C. kruisii*, the clade comprises nine *Candida* species isolated from the digestive tracts of beetles, primarily nitidulids, which had been feeding on agarics growing in the south-eastern USA and on Barro Colorado Island, Panama (Suh et al. 2006a). The type strain of *C. kruisii*, however, was recovered from a fruiting body of *Boletus purpureus*. *C. cretensis*, which comes from a similar habitat, is closely related to *C. kruisii* and differs from this species by eight nucleotides in the D1/D2 domains of LSU rDNA (Middelhoven and Kurtzman 2007).

Ecology: The type strain of *C. cretensis*, which is the only isolate of this species, was isolated from a decaying polypore growing on a tree in Greece (Middelhoven and Kurtzman 2007).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Ascospores were not formed on 5% malt extract agar and YM agar incubated at 15°C and 25°C for up to 4 weeks.

90.67. *Candida cylindracea* K. Yamada & Machida ex S.A. Meyer & Yarrow (1998)

Phylogenetic placement: Basal to the *Ogataea* clade (Fig. 90.4).

Synonym:

Candida cylindracea K. Yamada & Machida (1962) nom. inval.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are elongate, 2–5 × 4–12 μm, and occur in pairs or chains (Fig. 90.44 left). Growth is predominantly pseudomycelial with few single cells present. A thick wrinkled pellicle is present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of elongate cells with little branching and few blastoconidia (Fig. 90.44 right). A wavy appearance is evident. Aerobic growth is white, smooth and lacy, crater-like and heavily fringed with hyphae.

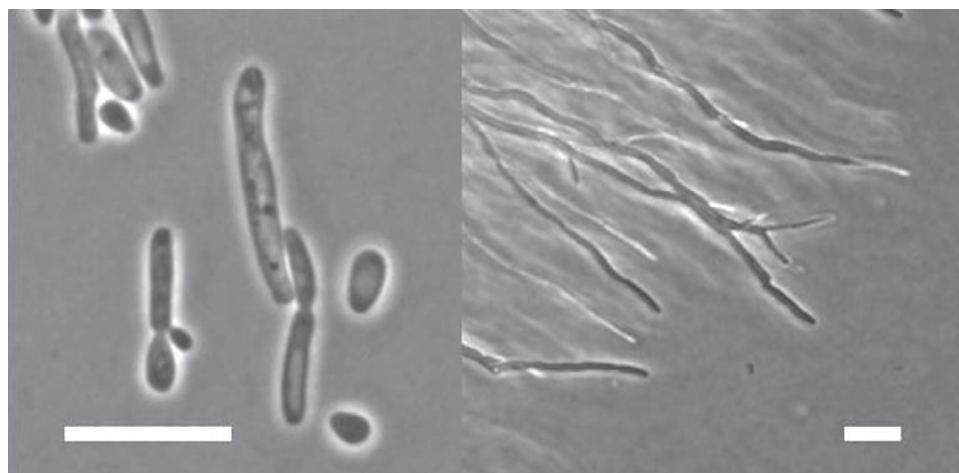


FIGURE 90.44 *Candida cylindracea* CBS 6330. Budding cells after 3 days, 25°C, YM agar (left) and pseudohyphae after 14 days, 18°C, YCBAS agar (right). Bars = 10 μm.

Fermentation

Glucose	s	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl-α-D-glucoside	—	DL-Lactate	w
Soluble starch	—	Succinate	+
Cellulose	—	Citrate	v
Salicin	—	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	v
Glucono-δ-lactone	+	Casein	—
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 62.7, CBS 6330 (T_m : Meyer and Yarrow 1998).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45823.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 6330, isolated from soil, Japan; CBS 8604, from flower of bird of paradise (*Strelitzia* sp., Strelitziaceae), French Guyana; UWOPS 91-623.1, from fruit of *Sapindus* sp. (Sapindaceae), Island of Hawai'i.

Other strain available: CBS 7869, isolated from half-cooked shrimp, Portugal.

Type strain: CBS 6330.

Systematics: A strain referred to as *C. cylindracea* was isolated but not validly described by K. Yamada and Machida (1962) in a screening for lipolytic yeasts. The strain was later reidentified as *C. zeylanoides*, but the species was restored and validated (Meyer and Yarrow 1998) because of a significant difference in DNA base composition between the types. Analysis of available rRNA gene sequences (Kurtzman and Robnett 1998a, Sugita and Nakase 1999) not only confirmed separation of the species, but placed *C. cylindracea* at a basal position with respect to the methylotrophs and the *Debaryomyces* clade. Possible connections to ascosporogenous species are with *Babjeviella* (*Pichia*) *inositovora* and *Yamadazyma* (*Pichia*) *triangularis*.

The strains are physiologically homogeneous except for minor variations in the assimilation of citric acid and the hydrolysis of gelatin. At variance with Meyer et al. (1998), the strains utilized xylitol slowly when examined on agar medium. *C. cylindracea* resembles a few unrelated species, but can be separated on the assimilation of D-gluconic acid, glucono-δ-lactone, and 2-keto-D-gluconate, combined with the absence of growth at 37°C.

As discussed more extensively for *C. rugosa*, there is substantial confusion in the literature regarding the identity of *C. cylindracea*. For a reason that remains unclear, the type strain of the species has been referred to, back and forth, under both names. This is worrisome as *C. rugosa* is the correct name of another valid species that happens to bear only a superficial resemblance at the physiological level and no significant phylogenetic relationship.

Ecology: Unknown.

Biotechnology: The species has been of considerable interest for its ability to produce lipases that have numerous applications in the biotransformation of various molecules in the food, pharmaceutical,

pesticide and other industries (Benjamin and Pandey 1998). Considerable confusion exists, however, in the relevant literature due to the renaming of the type strain from *C. cylindracea* to *C. rugosa* and back again. The biotechnological interest in the species has prompted a number of fundamental studies. For example, a transformation system was constructed (Tang et al. 2003) which takes advantage of the fact that *C. cylindracea* translates the codon CUG into serine instead of leucine. This example of non-universal codon usage is incidentally not as rare as previously thought, as shown by Sugita and Nakase (1999), who found that 69 of 78 *Candida* species that form CoQ-9 translated CUG into serine.

Agriculture and food: Unknown.

Clinical importance: It is likely that many reports of *C. rugosa* as an emerging pathogen or as a species found in food may be due to misidentification of *C. cylindracea*.

90.68. *Candida dajiensis* Lee & Liu (Liu et al. 2008)

Phylogenetic placement: *Wickerhamomyces* clade; see Systematics (Fig. 90.4).

(The description is based on Liu et al. 2008.)

Growth on YM agar: After 7 days at 25°C, the colony is cream to brownish, butyrous, smooth, glistening and with an entire margin.

Growth in YM broth: After 3 days at 25°C, the cells are globose or ovoid, 2.1–4.4 × 3.1–5.3 μm, occur singly or in pairs, and reproduce by multilateral budding.

Growth on the surface of YM broth: Sediment is present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and true hyphae are absent.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	d	Trehalose	–
Maltose	–	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	–
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	w/+
Lactose	–	Galactitol	–
Trehalose	w	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	–
D-Arabinose	–	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	+	Creatine	–
2-Keto-D-gluconate	–	L-Lysine	+
5-Keto-D-gluconate	–	Ethylamine	–
Arbutin	+	50% Glucose	–

D-Gluconate	–	10% NaCl/5% glucose	–
Propane 1,2 diol	+	Starch formation	–
Butane 2,3 diol	+	Urease	–
L-Arabinitol	w/+	Acetic acid production	–
D-Glucono-1,5-lactone	+	DBB	–
D-Galacturonate	–	Cycloheximide 0.01%	–
Nitrite	–	Growth at 30°C	+
Cadaverine	–	Growth at 35°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = EF460599.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 10590, isolated from forest soil in Dajiae, Taichung, Taiwan in 2006. The other isolates for this species were recovered from the same habitat at different locations: SU5S01 and SU16S03 in Renai, Nantou, Taiwan, and SC2S01 and SC9S01 in Dasi, Taoyuan, Taiwan (Liu et al. 2008).

Type strain: CBS 10590.

Systematics: *Candida dajiensis* (the original spelling, *dijiaensis*, is treated as an orthographic error) is part of the *Wickerhamomyces anomalus* clade. Within the clade, *C. dajiensis* clusters in a well-supported subclade with *C. yuanshanicus* and *W. onychis*. The last species is the closest relative and differs from *C. dajiensis* by 53 substitutions (Liu et al. 2008).

Ecology: All isolates were recovered from forest soil in Taiwan in 2006 (Liu et al. 2008).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Ascospores were not observed on YM agar, Fowell's acetate agar, corn meal agar or malt extract agar after incubation at 18 and 25°C for 1 month.

90.69. *Candida davenportii* Stratford, Bond, James, Roberts & Steels (2002)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

(The description is based on Stratford et al. 2002.)

Growth on morphology agar: After 2 days at 24°C, the cells are spherical to ovoid, 1–1.5 × 2–3 μm, and occur singly, in pairs or in groups, and budding is multilateral.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	n
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	–
Raffinose	+	Glycerol	–
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	–

Soluble starch	—	Succinate	—
Cellobiose	—	Citrate	—
Salicin	—	D-Gluconate	n
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	—	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	n	DBB	—
D-Glucuronate	n	Gelatin	n
Glucono-δ-lactone	—	Casein	n
Amino acid-free	n	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	—	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	—	1% Acetic acid	n
10% NaCl	+	Growth at 30°C	n
50% Glucose	+	Growth at 37°C	—

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AJ310447.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 9069 (NCYC 3013), isolated from a dead wasp (*Vespula vulgaris*, Hymenoptera: Vespidae) in a soft drink production facility, UK.

Type strain: CBS 9069.

Systematics: *Candida davenportii* was described from a strain isolated from a dead wasp found near some spilled syrup used in the manufacturing of soft drinks (Stratford et al. 2002). The species is similar in many ways to its sister species *C. stellata* and is typical of other species in the *Starmerella* clade. The growth characteristics of the two species are more or less identical. Species delineation was based on the approximately 6% divergence in the D1/D2 LSU rRNA gene sequences (Fig. 71.1). Separation from other similar species can be based on the utilization of L-lysine, which is positive for *C. davenportii*.

Ecology: The isolation of *C. davenportii* from a wasp is consistent with the habitat characteristics of other members of the *Starmerella* clade, which are frequently found in association with Hymenoptera.

Biotechnology: Unknown.

Agriculture and food: Stratford et al. (2002) examined the resistance of *C. davenportii* to various substances that serve as food preservatives in comparison with the resistance of well-known spoilage yeasts and found the levels afforded by *C. davenportii* comparable with those of others, with the exception of *Zygosaccharomyces bailii*. They inferred that the new species might have the potential to be a spoilage organism vectored to food and drink processing plants by wasps, which are particularly abundant in the warmer season.

Clinical importance: Unknown.

90.70. *Candida deformans* Langeron & Guerra (1938)

Phylogenetic placement: *Yarrowia* clade (Figs 82.1, 90.3).

Synonyms:

Pseudomonilia deformans Zach (Wolfram and Zach 1934b)

Candida lipolytica var. *deformans* (Zach) van Uden & H.R. Buckley (1970)

(The description is based on van Uden and Buckley 1970 and the CBS database.)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are short-ovoid to elongate and measure 3–5 × 5–11 μm, with elongate cells that reach up to 20 μm. A pellicle is formed.

Growth in glucose–yeast extract–peptone agar: After 1 month at 25°C the streak culture is cream colored. Some strains produced wrinkled colonies with a moist, mucoid appearance, and others are coarsely folded, hirsute and dull.

Dalmau plate culture on corn meal agar: Pseudohyphae and true hyphae with small numbers of blastoconidia are abundant.

Fermentation: Absent.

Growth (in Liquid Media)

Glucose	+	D-Ribose	s
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	—	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	+
Maltose	—	D-Glucitol	s
Melezitose	—	myo-Inositol	—
Methyl-α-D-glucoside	—	DL-Lactate	w/+
Soluble starch	—	Succinate	+/w
Cellobiose	s	Citrate	+
Salicin	s	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	n
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	—	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	n
Glucono-δ-lactone	+	Casein	n
Amino acid-free	n	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	w	Growth at 37°C	—

CoQ: 9 (Yamada and Kondo 1972b).

Mol% G + C: 46.1–48.2, (*T_m*: Knutsen et al. 2007).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AB197669.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 2076, isolated from human, Germany, F. Zach; CBS 2071, type strain of *Pseudomoniliella deformans*, from fingernail, Australia; CBS 10250, from preserved fish, Japan, M. Suzuki.

Type strain: CBS 2071.

Systematics: *Candida deformans* was described by Langeron and Guerra (1938), who borrowed the epithet from the illegitimate name

Pseudomonilia deformans (Wolfram and Zach 1934b). The species was considered a variety of *Candida* (*Yarrowia*) *lipolytica* by van Uden and Buckley (1970) and as a synonym by Meyer et al. (1998). Bigey et al. (2003) suggested that the D1/D2 LSU rRNA gene sequence of 14 substitutions is sufficiently divergent to recognize it as a separate species. This was further corroborated by Knutsen et al. (2007) through various observations that included DNA reassociation values of 17 to 30% with the neighboring species, *C. alimentaria*, *C. galli*, *C. hollandica*, *C. oslonensis* and *Y. lipolytica*. Of the four strains examined, one was found to mate with the mating type B of *C. galli*, even producing asci with ascospores at a “moderate to low” frequency.

Ecology: Unknown.

Biotechnology: Bigey et al. (2003) investigated the ability of *C. deformans* to excrete powerful lipolytic enzymes that are active in a mostly aqueous environment and characterized three genes that code for the enzymes.

Agriculture and food: Unknown.

Clinical importance: Although the species was recovered twice from clinical materials, the inability to grow at 37°C makes it unlikely to be an agent of systemic infection.

90.71. *Candida dendrica* (van der Walt, van der Klift & D.B. Scott) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Starmera* sister clade (Figs 70.1, 90.1).

Synonym:

Torulopsis dendrica van der Walt, van der Klift & D.B. Scott (van der Walt et al. 1971b)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to short-ovoid, some cylindrical, 2–5.5 × 3–6.5 μm, and occur singly, in pairs, short chains and clusters (Fig. 90.45).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present. Aerobic growth is smooth, shiny, cream colored and with an entire to somewhat irregular margin.

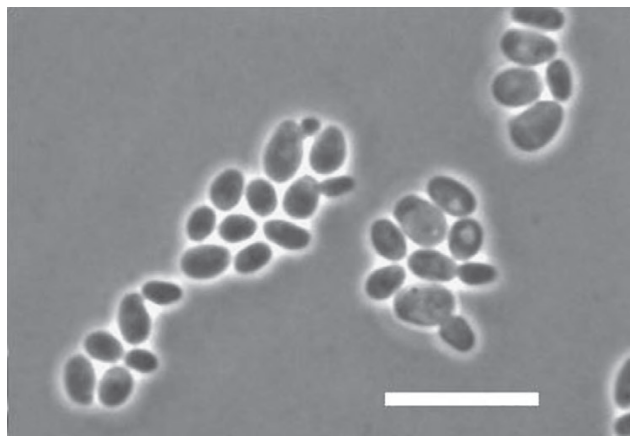


FIGURE 90.45 *Candida dendrica* CBS 6151. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Fermentation

Glucose	s	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	w
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	w	Cycloheximide 0.1%	+
Cadaverine	s	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: 42.0, CBS 6151 (T_m : Stenderup et al. 1972).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U62301.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6151, isolated from frass of cerambycid (Coleoptera) larvae infesting broad-leaved quince (*Cryptocarya latifolia*, Lauraceae), South Africa.

Type strain: CBS 6151.

Systematics: Van der Walt et al. (1971b) described *Torulopsis dendrica* from seven strains isolated from the habitats of various beetles. A similarity with *C. karawaiewi* was noted. *C. dendrica* is related to *C. berthetii* and these species have affinities for the genus *Starmera*, as evidenced by rRNA gene sequence analysis (Kurtzman and Robnett 1998a, Kurtzman et al. 2008, Suzuki and Nakase 2002, Yamada et al. 1999).

The species is physiologically specialized and is easily distinguished from any others. Separation from similar species can be obtained from the utilization of β-glucosides, ethanol, glycerol, resistance of 0.01% cycloheximide and absence of growth on β-fructosides

or nitrate. Previous reports of citrate utilization (Meyer et al. 1998, van der Walt et al. 1971b) were not confirmed by replica plating.

Ecology: Like the sister species *C. berthetii*, *C. dendrica* appears to be involved in a symbiotic association with tree-boring beetles. Other strains cited in the original description (van der Walt et al. 1971b) were recovered in South Africa from tunnels of the beetles *Philematium natalense* (Cerambycidae) infesting broad-leaved quince (*Cryptocarya latifolia*), *Xyleborus ferrugineus* (Scolytidae) infesting wild plum (*Harpephyllum caffrum*, Anacardiaceae), *Platypus sampsonii* (Platypodidae) infesting *Eucalyptus maculata* (Myrtaceae) and *Platypus* (syn. *Crossotarsus*) *externedentatus* in toad tree (*Tabernaemontana ventricosa*, Apocynaceae).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.72. *Candida dendronema* van der Walt, van der Klift & D.B. Scott (van der Walt et al. 1971a)

Phylogenetic placement: *Yamadazyma* clade (Figs 81.1, 90.2).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are of various shapes, namely globose, ovoid, elongate, teardrop and triangular to cylindrical, 2–5 × 4–6 µm, and occur

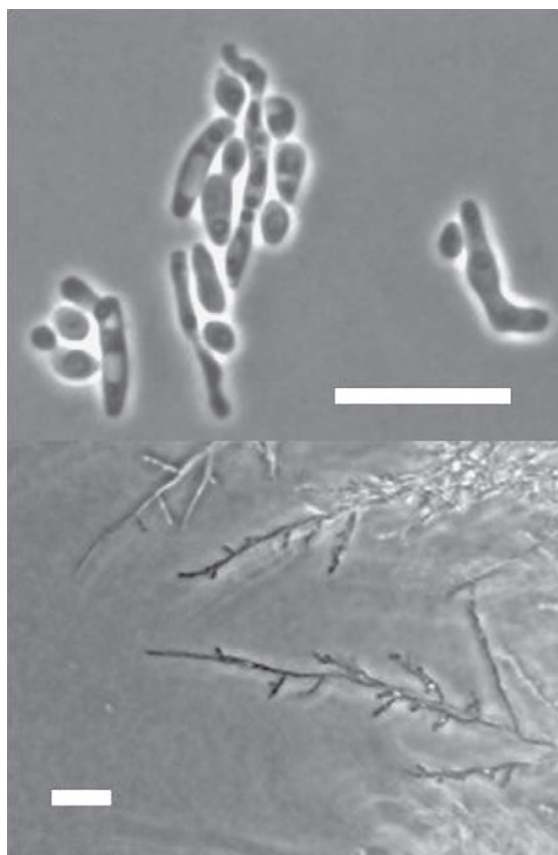


FIGURE 90.46 *Candida dendronema* CBS 6270. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, on YCBAS agar (bottom). Bars = 10 µm.

singly, in pairs and in small clusters and short chains (Fig. 90.46 top). Pseudohyphae are present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, well-developed pseudohyphae are present (Fig. 90.46 bottom). The blastoconidia are curved, globose, triangular or teardrop shaped and arranged in grape-like clusters. Aerobic growth is off-white, dry, raised, wrinkled and with a fringed border.

Fermentation

Glucose	+	Lactose	–
Galactose	s	Raffinose	–
Sucrose	–/s	Trehalose	s
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	+
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	s	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	s	D-Glucosamine	–
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Gluconate	–	Gelatin	v
Glucono-δ-lactone	–	Casein	v
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	v

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 38.9, CBS 6270 (T_m : Meyer et al. 1984); 38.5, CBS 6270; 38.0, CBS 6271 (HPLC: C.-F. Lee et al. 1993).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45751.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 6270 and CBS 6271, isolated from frass of cerambycid beetle larvae infesting an evergreen tree (*Diospyros inhacaensis*, Ebenaceae), South Africa.

Type strain: CBS 6270.

Systematics: van der Walt et al. (1971a) described *C. dendronema* from five strains isolated in frass of cerambycid larvae in two tree species. The species was thought to rank second in a phyletic series involving *C. hylophila*, *C. diddensiae*, *C. shehatae*, *C. silvanorum* and *C. entomophila*. Analysis of rRNA gene sequences (Kurtzman and Robnett 1998a, Sugita and Nakase 1999) supports this to the extent that *C. diddensiae* is closely related. An affinity to the *Yamadazyma* clade has been demonstrated from LSU and SSU rRNA gene sequence analysis (Kurtzman and Suzuki 2010). The physiological profile of this group of species is characterized by a broad utilization of pentoses and sugar-alcohols. Failure to utilize melezitose combined with the ability to assimilate galactitol together separate *C. dendronema* from similar species. The two strains received from CBS grew poorly, although the growth profiles were consistent with those given.

Ecology: *Candida dendronema* is one of many species recovered by van der Walt and colleagues that seem to be restricted in habitat to tree-boring beetles and their environment.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.73. *Candida derodonti* S.-O. Suh & M. Blackwell (2005)

Phylogenetic placement: *Kodamaea* clade (Fig. 36.1).

(The description is based on Suh and Blackwell 2005.)

Growth on YM agar: After 7 days at 25°C, colonies are white to cream, butyrous and with a smooth surface.

Growth in YM broth: After 7 days at 25°C, yeast cells are subglobose to ellipsoidal, 2.5–6 × 4–7.5 µm, occur singly, in pairs or in short chains and pseudohyphae may be present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, hyphae and pseudohyphae with blastoconidia are present. Aerobic growth is white, shiny and smooth.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	+/-
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+/-
Raffinose	–	Glycerol	+/-
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	+/-	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+/-
Salicin	+/-	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	–	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	50% Glucose	–
2-Keto-D-gluconate	+	10% NaCl/5% glucose	–
D-Gluconate	–	Starch formation	–
L-Arabinitol	–	Urease	–
Arbutin	+/-	DBB	–
Propane 1,2 diol	w	Cycloheximide 0.01%	–
Butane 2,3 diol	–	Cycloheximide 0.1%	–
Cadaverine	+	Growth at 25°C	+
Creatinine	–	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	–
Ethylamine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY242347, SSU rRNA = AY242235.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27711 (CBS 9882), isolated from the gut of tooth-necked fungus beetle (*Derodontus esotericus*, Derodontidae) on fruiting body of basidiomycete fungus (*Hericum* sp.), Athens, Georgia, USA.

Type strain: NRRL Y-27711.

Systematics: *Candida derodonti* forms a well-supported clade with *C. arcana*, within the *Kodamaea* clade (Fig. 36.1; Suh and Blackwell 2005).

Ecology: *Candida derodonti* is only known from one strain isolated from the gut of a tooth-necked fungus beetle that occurred on a fruiting body of *Hericum* sp., USA (Suh and Blackwell 2005).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.74. *Candida diddensiae* (Phaff, Mrak & Williams) Fell & S.A. Meyer ex S.A. Meyer & Ahearn (1983)

Phylogenetic placement: *Yamadazyma* clade (Figs 81.1, 90.2).

Synonyms:

Trichosporon diddensiae Phaff, Mrak & Williams (1952)

Torulopsis saccharini Santa María (1959b)

Candida diddensiae (Phaff, Mrak & Williams) Fell & S.A. Meyer (1967) nom. inval.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose, pear-shaped to cylindroid, 2–5 × 2.5–6 µm, and occur singly, in pairs, short chains and clusters (Fig. 90.47 top). After 1 month a thin filmy pellicle is present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of cylindroid cells with verticils of ovoid blastoconidia giving a wavy appearance (Fig. 90.47 bottom). Aerobic growth is off-white to cream colored, lacy to wrinkled with a mycelial border.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–/s	Trehalose	s
Maltose	–/s		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	v	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	v	DL-Lactate	—
Soluble starch	—	Succinate	v
Cellobiose	+	Citrate	v
Salicin	v	D-Gluconate	+
L-Sorbose	v	D-Glucosamine	v
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	w
L-Arabinose	v	Nitrate	—
D-Arabinose	v	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	—
2-Keto-D-gluconate	v	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	—
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	+

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 38.8; 38.3; 36.1, CBS 2214 (T_m : Meyer and Phaff 1972; T_m : Daniel 1983; HPLC: C.-F. Lee et al. 1993, respectively); 37.3, AJ 5108 (*T. saccharini*) (T_m : Nakase and Komagata 1971e).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45750.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 2214, isolated from shrimp in Texas, USA; UWOPS 79-202 and four other strains, from insect frass in black knots (*Dibotron morbosum*) of *Prunus* spp. (Rosaceae), Ontario, Canada; UWOPS 92-254.2, from tequila fermentation, Mexico.

Other strain available: CBS 4514, from damp sugar, Spain.

Type strain: CBS 2214.

Systematics: Phaff et al. (1952) isolated *Trichosporon diddensiae* from shrimp. The species was transferred to *Candida* by Fell and Meyer (1967) and the new combination was validated by Meyer and Ahearn (1983). *Torulopsis saccharini* was added to the species based on DNA reassociation (Meyer and Simone 1978). Other species (*C. atmosphaerica*, *C. polymorpha* and *Trichosporon atlanticum*) were once considered synonyms of *C. diddensiae* (van Uden and Buckley 1970), but were restored to species status (Meyer et al. 1984) due to low DNA reassociation values. C.-F. Lee et al. (1993) showed low DNA relatedness with *C. dendronema* and *C. terebra*. Analysis of rRNA gene sequences (Kurtzman and Robnett 1998a, Sugita and Nakase 1999) positions *C. diddensiae* near *Yamadazyma nakazawae* and other species that are often found in association with insects. Kurtzman and Robnett (1997) found the types of *C. diddensiae* and *C. naeodendra* to have identical sequences in the D1/D2 LSU rRNA gene, suggesting that

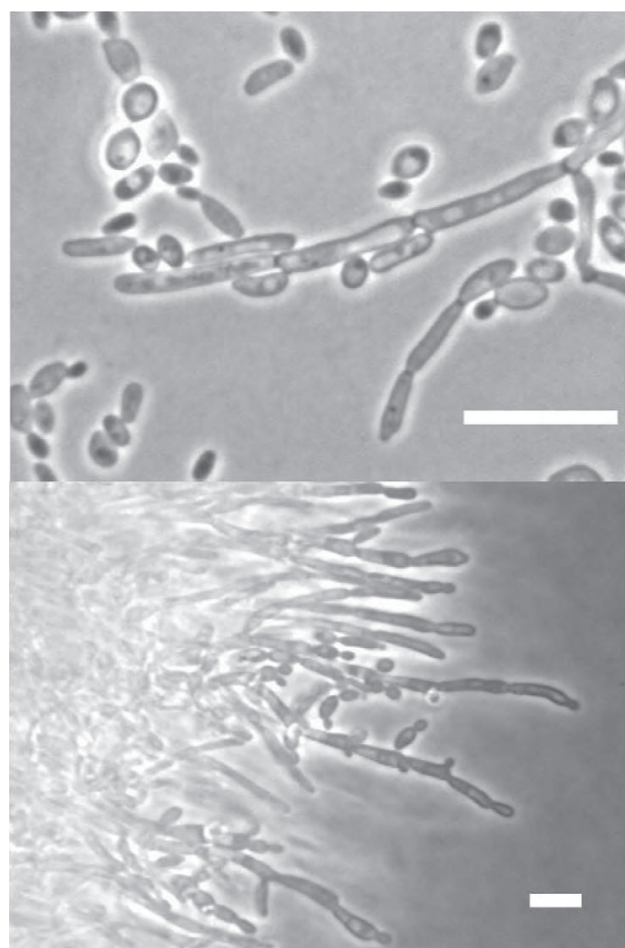


FIGURE 90.47 *Candida diddensiae* CBS 2214. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, on YCBAS agar (bottom). Bars = 10 µm.

the two taxa might be conspecific. The SSU rRNA genes (Sugita and Nakase 1999) differ by only four substitutions. However, the sequences of the ITS/5.8S rRNA genes (AY580315, AY580316) were determined for this study and found to differ by 34 substitutions and 17 gaps. The perfect identity of the D1/D2 regions was also confirmed. In view of the difference in ITS sequences, the two species are retained as separate. Identification of *C. diddensiae* on the basis of physiological traits is impractical due to the extensive variation present.

Ecology: An insect association is apparent and reinforced by the phylogenetic position of the species.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.75. *Candida digboiensis* G.S. Prasad, Mayilraj, Sood & Lal (Prasad et al. 2005)

Phylogenetic placement: unaffiliated clade (Fig. 90.3).

(The description is based on Prasad et al. 2005.)

Growth on malt agar: Colonies are low-convex, white to cream, butyrous and with an entire or fringed margin.

Growth in YM broth: After 3 days at 25°C, cells are ellipsoidal to short cylindrical, 2–3.5 × 3–9 µm, and occur singly, in pairs or in short chains. Some irregularly shaped and elongated cells, up to

15 µm, may be present. Pseudohyphae occur. Budding is sympodial, holoblastic and conidia are ovoid to obclavate, 2–4 µm and arise from pronounced protuberances.

Dalmau plate culture: After 1 week, pseudohyphae consist of branched chains of elongated cells; true hyphae are also present.

Fermentation: Absent.

Growth (Media Unknown)

Glucose	n	D-Ribose	+
Inulin	+	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	w
Melibiose	+	Erythritol	+
Galactose	+	Ribitol	+
Lactose	+	Galactitol	w
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	+
Methyl-α-D-glucoside	+	D,L-Lactate	n
Soluble starch	s	Succinate	–
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	+	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	50% Glucose	–
D-Glucuronate	+	Starch formation	–
Amino acid-free	+	Urease	–
Arbutin	+	DBB	–
Cadaverine	+	Cycloheximide 0.01%	–
L-Lysine	+	Growth at 19°C	+
Ethylamine	+	Growth at 42°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AJ549212, ITS = AJ697745.

Cell carbohydrates: Not determined.

Origin of the strains studied: TERI-6 (CBS 9800, JCM 12300, MTCC 4371), TERI-7 (CBS 9801, JCM 12301, MTCC 4372), both isolated from acid tar sludge-contaminated soil from Digboi oil refinery, Digboi, Assam, India.

Type strain: CBS 9800.

Systematics: *Candida digboiensis* is a sister species to *C. blankii* (Prasad et al. 2005). These two species form a sister clade to *C. auringiensis*, *C. tartarivorans* and *C. salmanticensis*, and both clades form a sister group to a clade that contains several teleomorphic and anamorphic species, e.g., *Blastobotrys* spp., *Trichomonascus farinosus*, *T. ciferrii*, *Zygoascus steatolyticus* and *Z. hellenicus*.

Ecology: *Candida digboiensis* was isolated from acid tar sludge-contaminated soil from Digboi oil refinery in India.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.76. *Candida diospyri* Bai & Lu (Lu et al. 2004c)

Phylogenetic placement: *Yamadazyma* clade (Fig. 90.2).

(The description is based on Lu et al. 2004a.)

Growth on YM agar: After 1 month at 25°C, the streak culture is white to cream, somewhat dull, smooth, butyrous and has an entire margin.

Growth in YM broth: After 3 days at 25°C, the cells are ellipsoidal to elongate, 1.8–5 × 2–5.5 µm, occur singly, in pairs or in groups, and reproduce by multilateral budding (Fig. 90.48). After 1 month at 25°C, sediment is present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae are absent. Chains of cylindrical cells are formed after 14 days on YCBAS agar (Fig. 90.48).

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	n
Maltose	–		

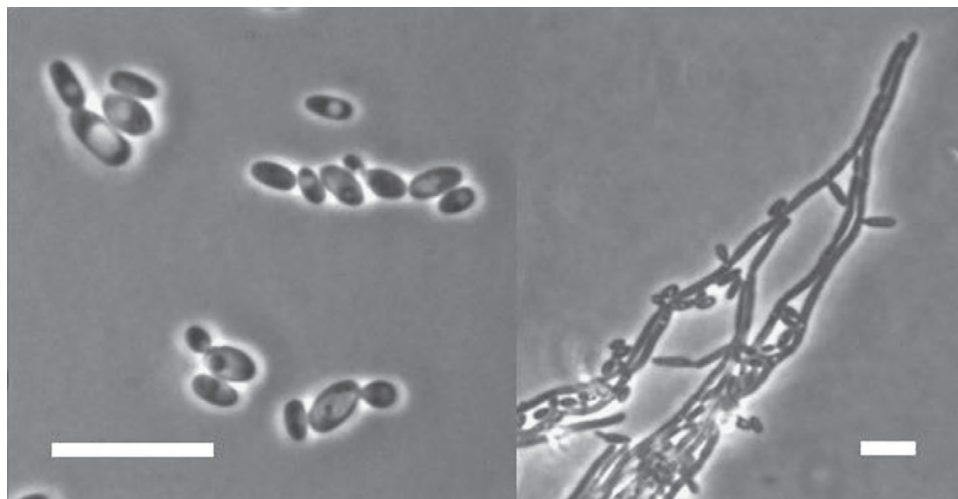


FIGURE 90.48 *Candida diospyri* CBS 9769. Budding cells after 3 days, 25°C, YM agar (left) and pseudohyphae after 14 days, 18°C, on YCBAS agar (right). Bars = 10 µm.

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	d
Salicin	+	D-Gluconate	n
L-Sorbose	+	D-Glucosamine	w
L-Rhamnose	+	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Nitrite	–	DBB	–
Cadaverine	+	Growth at 19°C	+
L-Lysine	+	Growth at 25°C	+
Ethylamine	+	Growth at 30°C	+
Starch formation	–	Growth at 35°C	+
Urease	–	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY450918, ITS = AY450919.

Cell carbohydrates: Not determined.

Origin of the strain studied: Strain QL 21-2 (AS 2,2525, CBS 9769), isolated from kaki fruit (*Diospyros kaki*, Ebencaea, Ericales) collected in Qinling, Shanxi Province, China, October 2002.

Type strain: CBS9769.

Systematics: D1/D2 LSU rRNA gene sequence analysis placed *C. diospyri* in a clade with *C. friedrichii*, *C. membranifaciens* and *C. buiensis*, and in which *C. tammaniensis* occupies a weakly supported basal position (Lu et al. 2004a). These species form a sister group to a clade comprising *C. caaseri*, *C. conglobata*, *C. trypodendroni* and *Yamadazyma mexicana*.

Ecology: *Candida diospyri* is only known from a kaki fruit collected in China.

Biotechnology: Unknown.

Agriculture and food: Unknown, but the only strain available was isolated from a kaki fruit.

Clinical importance: Unknown.

90.77. *Candida diversa* Y. Ohara, Nonomura & Yunome ex van Uden & H.R. Buckley (1970)

Phylogenetic placement: *Saturnispora* clade (Figs 64.1, 90.1).

Synonyms:¹

Candida fimetaria Soneda var. *diversa* Ohara, Nonomura & Yunome (1960b)

Torulopsis arnaudii Capriotti & Fatichenti (1969)

¹ Synonymy based on phenotypic similarities.

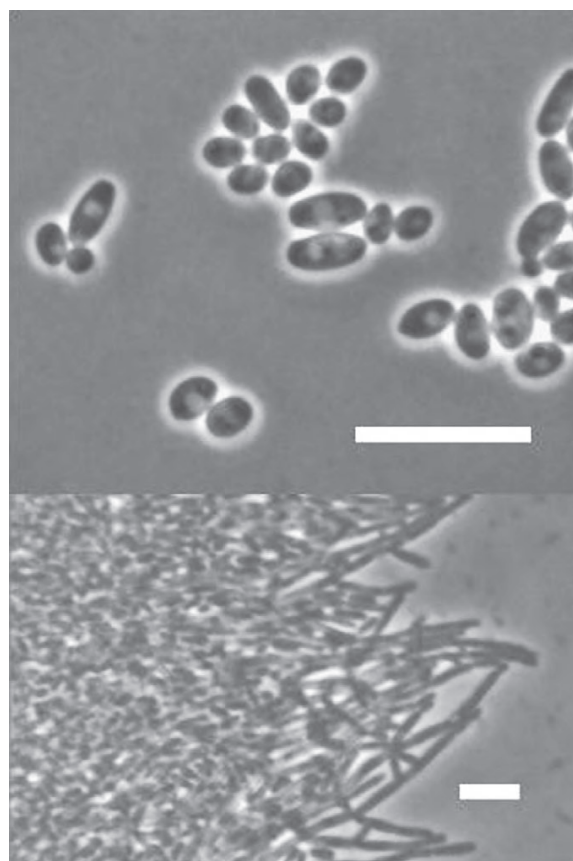


FIGURE 90.49 *Candida diversa* CBS 4074. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, on YCBAS agar (bottom). Bars = 10 µm.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to short cylindrical, 1.5–4.5 × 5–8 µm, and occur singly and in short chains (Fig. 90.64 top).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, poorly developed pseudohyphae consisting of branched chains of cylindrical cells with clusters of blastoconidia may be present (Fig. 90.49 bottom). Aerobic growth is white, smooth and creamy with an entire border.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	v
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	v
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+

Melezitose	–	<i>myo</i> -Inositol	–
Methyl- α -D-glucoside	–	D,L-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	v	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	n
Glucono- δ -lactone	v	Casein	n
Amino acid-free	+	Lipase	n
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	v

CoQ: 7 (Yamada and Kondo 1972a).

Mol% G + C: 34.4, AJ 4648; 34.9, AJ 5367 (T_m : Nakase and Komagata 1971f); 36.0, CBS 6102; 36.5, CBS 6103; 35.1, 36.6, CBS 4074 (T_m : Suzuki et al. 1994; BD: Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U71064.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 4074, isolated from grape must in Japan.

Other strains: CBS 6102, CBS 6103, from grape must, Italy.

Type strain: CBS 4074.

Systematics: Ohara et al. (1960b) described *C. fimetaria* var. *diversa* from a strain isolated from grape must. Van Uden and Buckley (1970) transferred *C. fimetaria* to *C. lambica* (teleomorph: *Pichia fermentans*) and elevated *C. diversa* to the rank of species based on physiological differences. *C. diversa* belongs to the *Saturnispora* clade (Kurtzman and Robnett 1998a, Suzuki and Nakase 2002), which also includes *C. silvae*. *C. diversa* and *C. silvae* are practically indistinguishable physiologically, sharing the inability to utilize most of the standard carbohydrates except for glucose. The profile resembles those of species in the *Saturnispora* clade as well as several unrelated species. The most useful characters for identification are the assimilation of D-mannitol and citric acid, the fermentation of glucose and the lack of growth on sucrose, trehalose and β -glucosides. Identification based on rRNA gene sequences is preferable.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Because of the ambiguity of identifications based on physiology, it is difficult to evaluate occasional reports of the occurrence of *C. diversa* in wines or grape musts. One such example is the isolation of the species in Arkansas-grown White Riesling grapes (Moore et al. 1988). However, in a recent study of yeasts found in orange juice, Arias et al. (2002) indicated that three of nine isolates of *Pichia kluyveri* were misidentified as *C. diversa* by the conventional method. The species was not present in 92 strains isolated from various citrus preparations.

Clinical importance: Unknown.

90.78. *Candida drosophilae* Lachance, Rosa, Starmer, Schlag-Edler, Barker & Bowles (1998c)

Phylogenetic placement: *Wickerhamiella* clade (Fig. 79.1).

Growth on malt extract agar: After 2 weeks at 17°C, colonies are convex, smooth, glossy, white and butyrous.

Growth in glucose–yeast extract broth: The cells are spherical to ovoid, 1–2 $\times$ 2–3 μ m, and occur singly or in parent-bud pairs.

Dalmay plate culture on corn meal agar: Hyphae and pseudohyphae are not formed.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	s
Melibiose	–	Erythritol	–
Galactose	–/s	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–/w
Maltose	–	D-Glucitol	w
Melezitose	–	<i>myo</i> -Inositol	–
Methyl- α -D-glucoside	–	D,L-Lactate	–
Soluble starch	–	Succinate	s
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–/s	Hexadecane	w
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	w
Glucono- δ -lactone	–	Casein	v
Amino acid-free	+	Lipase	v
Nitrite	–	Acid production	–
Ethylamine	–/w	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	–/s	1% Acetic acid	–
10% NaCl	s	Growth at 30°C	s
50% Glucose	–/s	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF046039.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 8459 (UWOPS 91-716.3) and others isolated from flowers of morning glory (*Ipomoea indica*, Convolvulaceae); UWOPS 91-751.3 and others from fruit fly (*Drosophila floricola*), unidentified dipter and a nitidulid beetle (*Prosopeus subaeneus*, Coleoptera: Nitidulidae) on morning glory (*Ipomoea indica* and *I. cairica*), Hawai'i; UWOPS 01-141b2 and others from dipters on *I. indica*, Costa Rica.

Type strain: CBS 8459.

Systematics: *Candida drosophilae* was described from five strains isolated in Hawaiian morning glories and associated drosophilids. The species is the nearest relative to certain *Wickerhamiella* species found in association with floricolous insects (Lachance et al. 1998c, 2000a). *C. drosophilae* exhibits a narrow range of growth responses, and gives variable results for many of the potentially positive tests. In particular, the hydrolysis of casein or lipids (Tween 80) is strong in some strains and negative in others. As more strains have accumulated, the distinction between *C. drosophilae* and *Wickerhamiella lipophila* based on the assimilation of xylitol, reported in the original description, is no longer possible, and identification requires sequence data.

Ecology: Like many close relatives, *C. drosophilae* is recovered from flowers and associated beetles and flies. Based on the frequency of isolation from different insects, it appears that a closer association exists with drosophilid flies. The species was presumed to be a Hawaiian endemic until the recent isolation of a few strains in Costa Rican insects.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.79. *Candida dubliniensis* Sullivan, Westerneng, Haynes, Bennett & Coleman (1995)

Phylogenetic placement: *Lodderomyces-Spathaspora* clade (Fig. 90.5).

Growth on yeast morphology agar: After 10 days at 25°C, the colony is flat to lowly button-like, 13 mm wide, cream, butyrous, shiny or dull, smooth, with an entire or extensively eroded margin. Cells are ellipsoid, $4\text{--}10 \times 3.8\text{--}6\text{ }\mu\text{m}$, and reproduce by multilateral

budding (Fig. 90.50 top). Extensive pseudohyphae may be formed. Filaments of cells measure $11\text{--}22 \times 2.5\text{--}3.5\text{ }\mu\text{m}$.

Growth in 3% glucose broth in yeast nitrogen base: After 10 days at 25°C, the cells are subglobose, globose to ovoid, $4\text{--}8.5 \times 3.5\text{--}7\text{ }\mu\text{m}$, reproduce by sympodial budding and occur singly, in pairs or in short chains. Pseudohyphae and hyphae are absent. A ring and sediment are formed.

Dalmat plate culture on PDA agar: After 10 days at 25°C, pseudohyphae are extensively formed (Fig. 90.50 bottom).

Dalmat plate culture on rice agar Tween (RAT, bioMérieux) or corn meal agar supplemented with 1% Tween 80: After 2–3 days at 25–27°C, abundant pseudohyphae and some true hyphae, both with extensive branching, are produced. Chlamydospores are often found in triplets or in pairs.

Fermentation

Glucose	+	Lactose	–
Galactose	+/s	Raffinose	–
Sucrose	–	Trehalose	n
Maltose	+		

Growth (on Agar and in Liquid Medium)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	w/s/+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	s/+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	w/+	myo-Inositol	–
Methyl- α -D-glucoside	s	DL-Lactate	+
Soluble starch	w/+	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	s/+	Hexadecane	s
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	s	10% NaCl	–
2-Keto-D-gluconate	+	50% Glucose	w
D-Glucuronate	–	Starch production	–
Glucono- δ -lactone	–	DBB	–
L-Arabinitol	–	Gelatin	–
Arbutin	–	Casein	w
Propane-1,2-diol	–	Lipase	s
Butane 2,3 diol	–	Acid production	–
Amino acid-free	+	Cycloheximide 0.01%	+
Nitrite	–	Cycloheximide 0.1%	s
Creatinine	–	1% Acetic acid	–
Ethylamine	+	Growth at 37°C	+
L-Lysine	+	Growth at 42°C	v
Cadaverine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

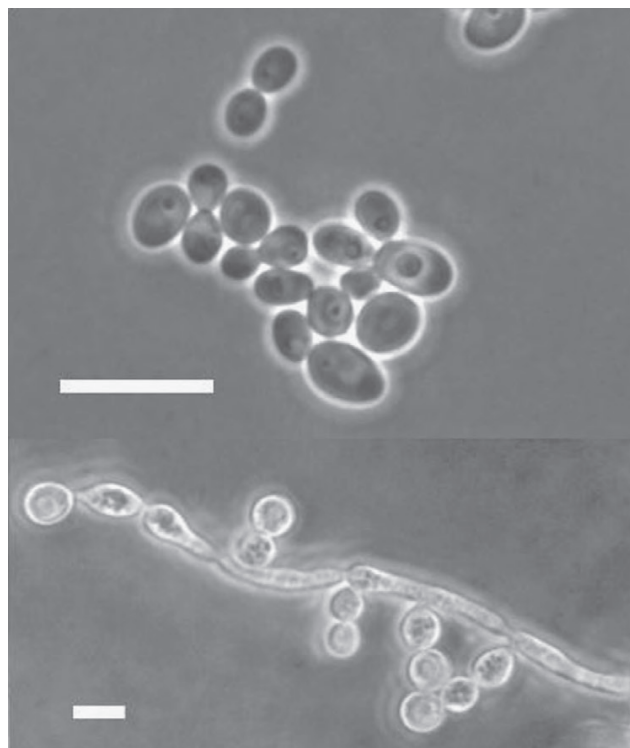


FIGURE 90.50 *Candida dubliniensis* CBS 7987. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, on YCBAS agar (bottom). Bars = 10 μm .

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U57685.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 2747, isolated from sputum, The Netherlands; CBS 7987, isolated from oral cavity of an HIV-infected patient, Ireland; CBS 7988, from oral cavity of an HIV-infected patient, Melbourne, Australia; CBS 8500, from blood of a patient with chronic myelogenous leukemia, The Netherlands; CBS 8501, from a neutropenic child, The Netherlands (Meis et al. 1999); CD33 and several others, from oral candidiasis in HIV-infected patients, Ireland; CM1 and several others, from oral candidiasis in HIV-infected patients, Austria; NCPF 3108, atypical strain of *C. stellatoidea*, HIV-infected patient.

Type strain: CBS 7987.

Systematics: Sullivan et al. (1995) described *C. dubliniensis* after studying several atypical *Candida* strains from HIV-infected patients with oral candidosis. Like *C. albicans*, the species produces germ tubes in horse serum at 37°C and chlamydospores on nitrogen-poor media. Serotypes of the two species overlap. However, strains assigned to *C. dubliniensis* were atypical in growth characteristics, DNA fingerprints obtained with microsatellite hybridization probes, RAPD PCR patterns and D1/D2 LSU rRNA gene sequences. The latter differed by 15 substitutions in the two species, and the SSU rRNA gene sequences (Gilfillan et al. 1998) differed by 14 substitutions and eight gaps. O'Neill and Meyer (2000) confirmed the distinct status of the two species by DNA reassociation, and Daniel (2002) showed divergence at the level of both amino acid and nucleotide sequences for actin. *C. dubliniensis* is a member of the *Lodderomyces* clade.

The original description (Sullivan et al. 1995) reported that growth on D-glucosamine and absence of growth on melezitose, glycerol and lactic acid could be used to separate *C. dubliniensis* from *C. albicans*. The results obtained by replica plating did not confirm these differences, but agreed with the data given in the CBS database, such that separation between *C. dubliniensis* and *C. albicans* on the basis of physiology is not as simple as previously thought. The reported lack of growth on D-xylose, methyl- α -D-glucoside, melezitose, glycerol and lactate (Sullivan et al. 1995) could not be confirmed by growth in culture tubes for up to 3 weeks. Sancak et al. (2003) found D-xylose utilization to vary among strains of *C. albicans* and suggested that this character should be used in combination with growth at 42°C and the utilization of methyl- α -D-glucoside. Many special identification techniques have been proposed to discriminate between *C. dubliniensis* and *C. albicans*. These include CHROMagar *Candida* (Odds and Bernaerts 1994), which reportedly causes the former to form light green colonies that are recognizable from the dark green colonies of *C. albicans*. Growth at different temperatures has been suggested to differ between *C. albicans* and *C. dubliniensis*, with the majority of investigated isolates of *C. albicans* able to grow at 45°C, while those of *C. dubliniensis* were not able to grow at this temperature (Pinjon et al. 1998). Species-specific antibodies have been raised and implemented in diagnostics kits (reviewed in Ells et al. 2009). Clear and rapid identification is best accomplished with PCR-based methods using species-specific primers (Joly et al. 1999, Kurzai et al. 1999), analysis of restriction fragments of ITS (McCullough et al. 1999), amplified fragment length polymorphism (Borst et al. 2003), and sequence analysis of the ITS 1 and 2 regions of the rDNA and the actin gene (Donnelly et al. 1999, Kurzai et al. 1999, see also reviews by Ells et al. 2009, Sullivan and Coleman 1998). Gee et al. (2002) successfully used a set of species-specific primers with target sequences in the ITS/5.8S rDNA to resolve four distinct genetic populations within the species. Multilocus sequence typing (MLST) demonstrated less genetic diversity in *C. dubliniensis* when compared to *C. albicans* (McManus et al. 2008).

Ecology: Most isolates are known from clinical samples. Recently, isolates of *C. dubliniensis* genotype 1 were found in ticks from an

Irish seabird colony (Nunn et al. 2007), which suggests a non-human habitat for *C. dubliniensis*.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: *Candida dubliniensis* is an opportunistic pathogen with a broad distribution. Abundant literature describes the worldwide isolation of the species in clinical specimens. *C. dubliniensis* is mainly isolated from oral candidiasis in HIV-infected patients, but is also isolated from healthy individuals, women suffering from vaginitis, systemic infections in immunocompetent and immunocompromised patients, dental stomatitis, diabetes, cystic fibrosis and neutropenia (Johnson 2009, Sebti et al. 2001, Sullivan and Coleman 1998, Sullivan et al. 2004). Montour et al. (2003) reported the isolation of four strains from two of 39 healthy individuals in an isolated aboriginal community in Canada.

Additional comment: The genome of *C. dubliniensis* was recently sequenced (EMBL FM992688-FM992695) and found to be highly similar to that of *C. albicans*, which shared a highly conserved syn-teny (Jackson et al. 2009).

90.80. *Candida easanensis* Jindamorakot, Thuy & Nakase (Jindamorakot et al. 2004)

Phylogenetic placement: *Wickerhamomyces* clade (Fig. 90.4).

(The description is based on Jindamorakot et al. 2004.)

Growth on YM agar: After 1 month at 20°C, the streak culture is grayish-white, smooth, shiny, soft and has an entire to eroded margin.

Growth in YM broth: After 3 days at 25°C, the cells are globose, short ovoid to ovoid, ellipsoidal or cylindrical, $2-4.5 \times 3-7.5 \mu\text{m}$, occur singly or in pairs and pseudohyphae are present. After 1 month, traces of a ring and sediment are present.

Dalmau plate culture on potato dextrose agar: Well-developed pseudohyphae bearing blastoconidia are abundantly produced.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	n
Maltose	—		

Growth (in Liquid Media)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	D-Lactate	+
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+/-w
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	+	N-Acetyl-D-glucosamine	—
D-Xylose	+	Hexadecane	—
L-Arabinose	w	Nitrate	—
D-Arabinose	w	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+/-	Pyridoxine and thiamin requirements	+
2-Keto-D-gluconate	—	Starch formation	—
5-Keto-D-gluconate	—	Urease	—
D-Glucuronate	—	DBB	—
Saccharate	—	Gelatin liquefaction	—
L-Arabinitol	v	Cycloheximide 0.1%	—
Propane 1,2 diol	+	Growth at 19°C	+
Butane 2,3 diol	—	Growth at 25°C	+
Nitrite	—	Growth at 30°C	+
Cadaverine	+	Growth at 35°C	+
L-Lysine	+	Growth at 37°C	+
Ethylamine	+	Growth at 40°C	+
10% NaCl/5% glucose	—		

CoQ: 7 (Jindamorakot et al. 2004).

Mol% G + C: 43.7–45.2 (HPLC: Jindamorakot et al. 2004).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY634570.

Cell carbohydrates: Not determined.

Origin of the strains studied: ST-225 (BCC 11760, JCM 12477, TISTR 5825), isolated from insect frass collected in February 1997, in Nong Laung, Amnat Charoen, north-eastern Thailand; ST-228 (BCC 11760, JCM 12477, TISTR 5825), ST-229 (BCC 11761), both isolated from insect frass, Nong Bo Mhu, Thailand.

Type strain: ST-225.

Systematics: *Candida easanensis* is closely related to *Lindnera japonica* (Jindamorakot et al. 2004).

Ecology: The species is known only from insect frass in Thailand.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.81. *Candida elateridarum* S.-O. Suh & M. Blackwell (2004)

Phylogenetic placement: *Meyerozyma* clade (Figs 47.1, 90.2). (Description based on Suh and Blackwell 2004.)

Growth on YM agar: After 7 days at 25°C on YM agar, colonies are white to cream colored, butyrous and smooth.

Growth in YM broth: After 5 days at 25°C, yeast cells are globose to subglobose, 2–4 × 2–4 µm, mostly globose, occur singly, in pairs or in short chains and pseudohyphae are present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae with blastoconidia and septate hyphae are present. Aerobic growth is white and smooth.

Fermentation

Glucose	d	Lactose	—
Galactose	d	Raffinose	—
Sucrose	d	Trehalose	d
Maltose	—		

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	+	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—

Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl-α-D-glucoside	+	D-Lactate	w
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	d
L-Sorbose	—	D-Glucosamine	+
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	w	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Ethylamine	+
2-Keto-D-gluconate	+	50% Glucose	w
D-Glucuronate	—	10% NaCl/5% glucose	w
Nitrite	—	Starch formation	—
L-Arabinitol	w	Urease	—
Arbutin	+	Cycloheximide 0.01%	+
Propane 1,2 diol	d	Cycloheximide 0.1%	—
Butane 2,3 diol	—	Growth at 30°C	+
Cadaverine	+	Growth at 35°C	+
Creatinine	—	Growth at 40°C	—
L-Lysine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY518530, SSU rRNA = AY518542, ITS and 5.8S rRNA = AY553849.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27647 (CBS 9842), isolated from the gut of an unidentified elaterid beetle in Barro Colorado Island, Panama.

Type strain: NRRL Y-27647.

Systematics: Sequence analysis of the SSU and D1/D2 LSU rRNA genes placed *C. elateridarum* as a basal lineage to the *Meyerozyma guilliermondii* clade, including *M. guilliermondii*, *C. xestobii*, *C. fermentati*, *C. smithsonii* and *C. athensensis* (Suh and Blackwell 2004).

Ecology: Only known from one strain isolated from an elaterid beetle, Panama.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.82. *Candida emberorum* S.-O. Suh & M. Blackwell (Suh et al. 2004b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5). (The description is based on Suh et al. 2004b.)

Growth on YM agar: After 7 days at 25°C, colonies are white to cream colored with a pale-pinkish perimeter, smooth and butyrous.

Growth in YM broth: After 7 days at 25°C, cells are globose to ellipsoidal, 1.3–5 × 2.5–6 µm, mostly globose or subglobose, occur singly, in pairs or in short chains and pseudohyphae may be present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae are present, but true hyphae are absent. Aerobic growth is white, dull, smooth and with a filamentous margin.

Fermentation

Glucose	+	Lactose	—
Galactose	+/d	Raffinose	—
Sucrose	—	Trehalose	+
Maltose	—		

Growth (in Liquid Media)

Glucose	n	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	d/w	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+/d
Salicin	+	D-Gluconate	d/w
L-Sorbose	+	D-Glucosamine	d/w
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	50% Glucose	+/w
2-Keto-D-gluconate	+	10% NaCl/5% glucose	v
D-Glucuronate	—	Starch formation	—
Arbutin	+	Urease	—
Propane 1,2 diol	—	DBB	—
Butane 2,3 diol	—	Cycloheximide 0.01%	—
Nitrite	—	Growth at 25°C	+
Cadaverine	+	Growth at 30°C	+
Creatinine	—	Growth at 35°C	+/w
L-Lysine	+	Growth at 40°C	—
Ethylamine	+		

CoQ: Not determined.**Mol% G + C:** Not determined.**Gene sequence accession numbers, type strain:** D1/D2 LSU = AY242277, SSU rRNA = AY242168.**Cell carbohydrates:** Not determined.

Origin of the strains studied: NRRL Y-27606 (CBS 9827), isolated from the digestive tract of a beetle (*Triplax alvarengai*, Erotylidae) on the basidiocarp of an oyster mushroom (*Pleurotus* sp.); Erot 24, from the digestive tract of a beetle (*Mycotretus scitulus*, Erotylidae) on the basidiocarp of *Pleurotus* spp.; Endo 2, from the digestive tract of an unidentified endomychid beetle on the basidiocarp of a mushroom *Ripartiella brasiliensis*, all from Barro Colorado Island, Panama.

Type strain: NRRL Y-27606.

Systematics: *Candida emberorum* belongs to the *C. tanzawaensis* clade (Suh et al. 2004b). The species belongs to a subclade with *C. chikasaworum*, *C. wounanorum*, *C. yuchorum* and with *C. terraborum* as a basal species.

Ecology: The three known strains of *C. emberorum* were isolated from the digestive tract of beetles occurring on fruiting bodies of basidiomycete mushrooms, Panama.

Biotechnology: Unknown.**Agriculture and food:** Unknown.**Clinical importance:** Unknown.

90.83. *Candida endomychidarum* S.-O. Suh, N.H. Nguyen & M. Blackwell (Suh et al. 2005b)

Phylogenetic placement: *Yamadazyma* clade (Fig. 90.2).

(The description is based on Suh et al. 2005b.)

Growth on YM agar: After 7 days at 25°C, the colonies are white, smooth and butyrous.**Growth in YM broth:** After 7 days at 25°C, the cells are globose to fusiform, but mostly subglobose, 2–5 $\times$ 3–6 μ m, and occur singly, in pairs or in short chains. Some cells form clusters and pseudohyphae are not present.**Dalmau plate culture on corn meal agar:** After 10 days at 25°C, pseudohyphae are present, but true hyphae are absent. Aerobic growth is white and smooth.**Fermentation**

Glucose	+	Lactose	—
Galactose	+	Raffinose	—
Sucrose	—	Trehalose	d
Maltose	—		

Growth (in Liquid Media)

Glucose	+	D-Ribose	d
Inulin	—	Methanol	w
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	d
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	+	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	—
D-Arabinose	+	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Ethylamine	+
2-Keto-D-gluconate	—	50% Glucose	+
D-Glucuronate	—	10% NaCl/5% glucose	+
Arbutin	d	Starch formation	—
Propane 1,2 diol	d	Urease	—
Butane 2,3 diol	—	DBB	—
Nitrite	—	Cycloheximide 0.01%	—
Cadaverine	+	Growth at 30°C	+
Creatinine	—	Growth at 35°C	—
L-Lysine	+		

CoQ: Not determined.**Mol% G + C:** Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY520330, SSU rRNA = AY520200, ITS and 5.8S rRNA = AY964672.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27708 (CBS 9881), isolated from the gut of an unidentified endomychid beetle (Endomychidae), Barro Colorado Island, Panama.

Type strain: NRRL Y-27708.

Systematics: *Candida endomychidarum* is a member of the *Yamadazyma* clade where it belongs to a subclade comprising *C. cerambycidarum*, *C. gorgasii*, *C. michaelii* and *C. lessepsii* (Suh et al. 2005b).

Ecology: The species is known only from the gut of an unidentified endomychid beetle (Endomychidae), Barro Colorado Island, Panama.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.84. *Candida entomophila* D.B. Scott, van der Walt & van der Klift (van der Walt et al. 1971a)

Phylogenetic placement: unaffiliated clade (Fig. 90.1).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are spherical, ovoid, long ovoid, cylindrical, teardrop to somewhat triangular and occur singly, with buds and in chains (Fig. 90.51 top). The cell size differs in the two strains, which measure $3\text{--}4 \times 7\text{--}8\text{ }\mu\text{m}$ and $6\text{--}7 \times 14\text{--}21\text{ }\mu\text{m}$. Spherical to ellipsoidal asexual endospores are formed in hyphal strands.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae are abundant and consist of long straight chains of cylindrical cells with little branching and often without blastoconidia (Fig. 90.51 bottom). When blastoconidia are present, they are ovoid to triangular and occur singly, in small clusters and short chains. Septate hyphae are also present. Aerobic growth is white to cream colored, semi-shiny to dull and smooth with wrinkled areas. The margin is fringed.

Fermentation

Glucose	+	Lactose	–
Galactose	s	Raffinose	s
Sucrose	+	Trehalose	+
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	s	Glycerol	+
Melibiose	+	Erythritol	s
Galactose	+	Ribitol	+
Lactose	+	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	–
L-Sorbose	w	D-Glucosamine	w
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	w
L-Arabinose	s	Nitrate	–
D-Arabinose	–	Vitamin-free	–

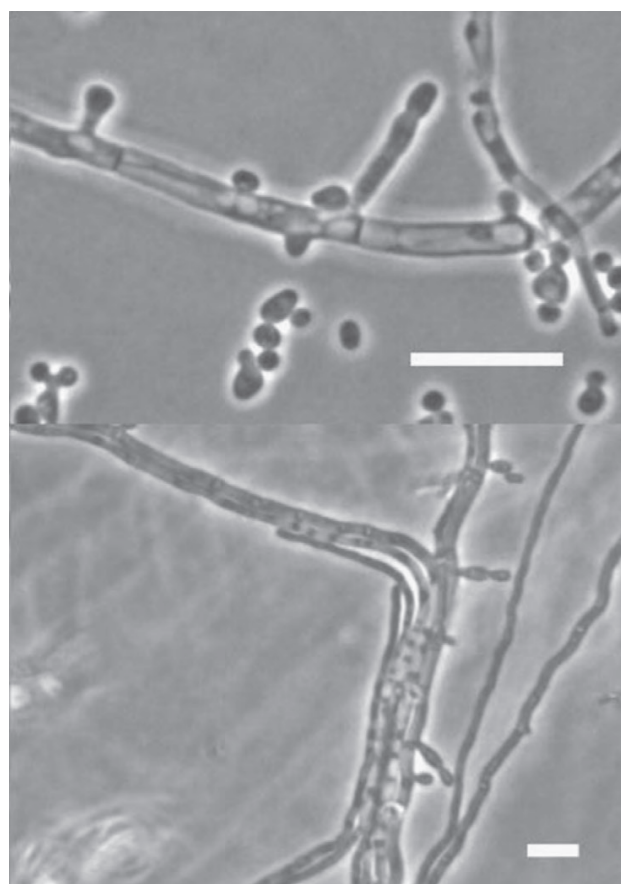


FIGURE 90.51 *Candida entomophila* CBS 6160. Budding cells and septate hyphae after 3 days, 25°C, YM agar (top) and hyphae after 14 days, 18°C, on YCBAS agar (bottom). Bars = 10 μm .

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	–	Casein	w
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	s	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: 8 (Suzuki and Nakase 1998).

Mol% G + C: 56.3, CBS 6160 (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U62302.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6160, isolated from tunnels of a platypodid beetle (*Platypus* [*Crossotarsus*] *externedentatus*, Coleoptera: Platypodidae) in *Ficus sycomorus* (Moraceae), South Africa.

Type strain: CBS 6160.

Systematics: Van der Walt et al. (1971a) reported the isolation of several new *Candida* species from frass and other materials associated with bark beetles. *C. entomophila* was thought to represent a derived form in a series consisting of *C. hylophila* (now included in *Rhodotorula*), *C. dendronema*, *C. silvanorum*, *C. diddensiae* and *C. shehatae* based on the occasional formation of triangular blastospores and well-developed pseudohyphae, as well as similarities at the level of growth reactions and habitats. The formation of true hyphae with endospores was also noted in *C. entomophila*. These affinities are supported in part by sequence analyses. Although a clear placement of the species using the highly divergent D1/D2 LSU rRNA gene was not obtained by Kurtzman and Robnett (1998a), an analysis conducted in this study indicated a weak connection with *C. silvanorum*. Suzuki and Nakase (1999), on the basis of SSU sequences, also suggested a relationship with *C. silvanorum* and a number of other *Candida* species.

Physiologically, *C. entomophila* resembles *C. insectorum* enough to make the separation of the two species problematic. The results obtained by replica plating, which differed slightly from those in previous descriptions, indicated that the two species differ in the assimilation of L-rhamnose (negative in *C. entomophila*) and growth at 37°C (positive). Separation from other species can be based on the assimilation of melibiose and erythritol and resistance to 0.01% cycloheximide, combined with the absence of growth on L-rhamnose or in the presence of 50% glucose.

Ecology: In the original description, van der Walt et al. (1971a) also reported the isolation of a strain from tunnels of *Platypus* (*Crossotarsus*) *externedentatus*, a platypodid beetle, in a toad tree, *Tabernaemontana ventricosa* (Apocynaceae).

Biotechnology: Unknown.

Agriculture and food: Gueguen et al. (1997) purified a β-glucosidase from a strain of *C. entomophila* isolated from fermenting agave juice for eventual use in flavor enhancement in wines and fruit juices.

Clinical importance: Unknown.

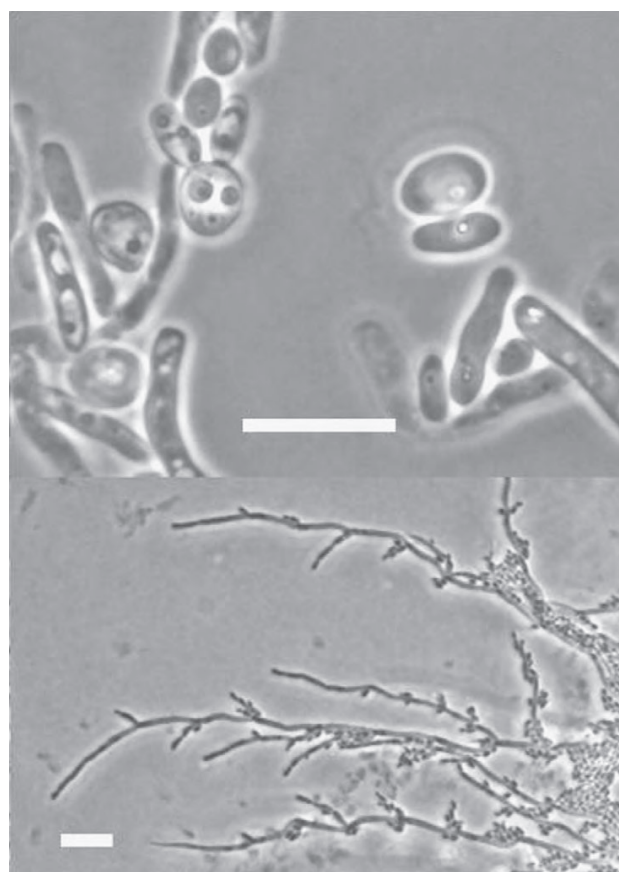


FIGURE 90.52 *Candida ergatensis* CBS 6248. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, on YCBAS agar (bottom). Bars = 10 µm.

90.85. *Candida ergatensis* Santa María (1971)

Phylogenetic placement: *Scheffersomyces* clade (Figs 65.1, 90.2).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to elongate and cylindroid, 2–4 × 4.5–15 µm, and occur singly or in chains (Fig. 90.52 top).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae are abundant and consist of chains of cylindroid cells, often long and slender, with ovoid blastoconidia (Fig. 90.52 bottom). Septate hyphae may also be present. Aerobic growth is white to cream colored, somewhat shiny and folded with a fringed margin.

Fermentation

Glucose	+	Lactose	–
Galactose	s	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	+	Ethanol	s
Raffinose	–	Glycerol	s
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	v	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+

Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	+	D,L-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	v
Salicin	s	D-Gluconate	–
L-Sorbose	s	D-Glucosamine	w
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	w
L-Arabinose	–	Nitrate	–
D-Arabinose	s	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	s	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	w	Casein	w
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	–
50% Glucose	–	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: 36.5, CBS 6248 (BD: Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45746.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 6248, isolated from larvae of a cerambycid beetle (*Ergates faber*, Coleoptera: Cerambycidae) in stump of a pine tree (*Pinus* sp., Pinaceae), Spain; CBS 4238 from cerambycid beetle (*Leptura rubra*, Coleoptera: Cerambycidae).

Type strain: CBS 6248.

Systematics: Santa María (1971) described *C. ergatensis* from an isolate collected in a cerambycid larva. The species was named after the beetle genus *Ergates*, and, accordingly, the spelling of the epithet *ergatensis* used by Meyer et al. (1998), by Barnett et al. (1983, 1990) and in a number of other publications is treated as an orthographic error. *C. ergatensis* is related to other species found in association with wood decay beetles, including *Scheffersomyces* (*Pichia*) *stipitis* and *C. shehatae* (Kurtzman and Robnett 1998a, Sugita and Nakase 1999). The next nearest relative as determined by phenetic sequence comparison appears to be *C. coipomoensis*. Strain CBS 4238, received as *C. ergatensis*, was originally identified as *C. butyri* and was listed in GenBank as *C. tenuis* in reference to an SSU rRNA gene sequence deposited by K.G. Jones et al. (1999). An analysis of the sequence with the current database showed a higher similarity, but not perfect identity with *C. ergatensis*. However, the D1/D2 sequence was determined and found to match that of the type perfectly.

The growth responses obtained for both strains differed from previous descriptions with respect to the assimilation of L-arabinose and erythritol as well as cycloheximide resistance, all of which were negative. Strain CBS 4238 differed by the absence of growth on lactose and citric acid. This notwithstanding, the physiological profile of the species is sufficiently unique to allow identification.

Ecology: An association with wood decay beetles is evident.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.86. *Candida etchellsii* (Lodder & Kreger-van Rij) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

Synonyms:

Brettanomyces sphaericus Etchells & T.A. Bell (1950b)

Torulopsis citrus Recca & Mrak (1952)

Torulopsis etchellsii Lodder & Kreger-van Rij (1952)

Torulopsis nodaensis Onishi (1957) nom. nud.

Candida nodaensis Yarrow & S.A. Meyer (1978)

Torulopsis halonitratophila Onishi ex van Uden & Vidal-Leiria (1970)

Candida halonitratophila (Onishi ex van Uden & Vidal-Leiria) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 2–4 × 3–5 µm, and occur singly or in pairs (Fig. 90.53).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present. Aerobic growth is off-white to cream colored, shiny or somewhat dull and smooth with an entire margin.

Fermentation

Glucose	v	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	v		

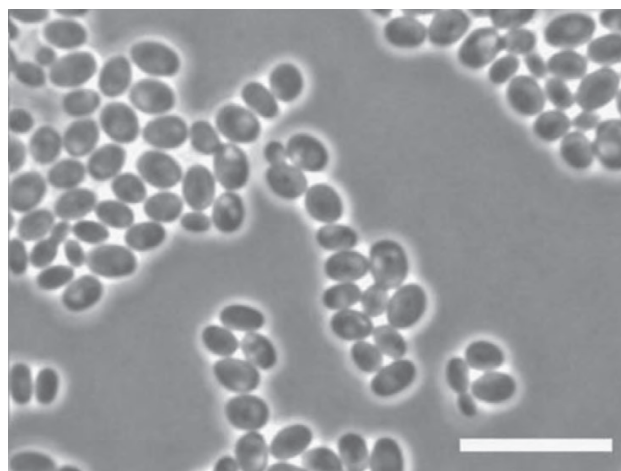


FIGURE 90.53 *Candida etchellsii* CBS 1750. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	—	Ethanol	v
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	v	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	v
Maltose	v	D-Glucitol	v
Melezitose	—	myo-Inositol	—
Methyl-α-D-glucoside	—	DL-Lactate	v
Soluble starch	—	Succinate	v
Cellobiose	—	Citrate	v
Salicin	—	D-Gluconate	v
L-Sorbose	v	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	+
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	—
2-Keto-D-gluconate	v	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono-δ-lactone	v	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	+	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	n
10% NaCl	+	Growth at 30°C	v
50% Glucose	+	Growth at 37°C	—

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 52.0–52.7, four strains (T_m : Nakase and Komagata 1971d); 52.4, CBS 6268 (T_m : Meyer et al. 1984); 53.0, CBS 3094 (T_m : Yarrow and Meyer 1978); 52.0, CBS 1750; 52.4, JCM 5956; 51.4, CBS 5240; 52.0, CBS 3094 (T_m : Suzuki et al. 1992).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45723.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 1750, isolated from fermenting cucumber brine, USA; CBS 3094, type strain of *C. nodaensis*, from soy mash, Japan; CBS 5240, type strain of *C. halonitratophila*, from soy mash, Japan; UWOPS00-153a2, from beetle *Diabrotica* sp. (Coleoptera: Chrysomelidae) on a flower of woodrose (*Merremia tuberosa*, Convolvulaceae); UWOPS01-168.1 and UWOPS01-168.3, from a stingless bee (*Trigona*, Hymenoptera: Apidae); UWOPS 99-338.4, bee from a flower of Costa Rica night-blooming cactus (*Hylocereus costaricensis*, Cactaceae), Costa Rica.

Other strains available: CBS 1751, from fermenting cucumber brine, USA; CBS 2853, from sputum, The Netherlands; CBS 2854, origin unknown, but probably of human origin; CBS 2987, type strain of *Torulopsis citrui*, from concentrated lemon juice; CBS 4852, from sputum; CBS 5008, from sugar, Mauritius; CBS 6268, from soy mash, Japan; CBS 8147, from sausages, The Netherlands.

Type strain: CBS 1750.

Systematics: Lodder and Kreger-van Rij (1952) described *Torulopsis etchellsii* to accommodate cucumber brine isolates originally named *Brettanomyces sphaericus* (Etchells and Bell 1950b). *C. halonitratophila* and *C. nodaensis*, which were also isolated from high salt substrates, were found to be conspecific with *C. etchellsii* by DNA reassociation (Suzuki et al. 1992, F.-L. Lee et al. 1992). The species belongs to the *Starmerella* clade (Fig. 71.1, Rosa et al. 2003, Texeira et al. 2003).

Although *C. etchellsii* is nutritionally specialized, the growth characteristics exhibit substantial variation. The assimilation of galactose, maltose, L-sorbose, ethanol, D-glucitol, succinic acid, gluconic acid and L-lysine (nitrogen) differs from strain to strain. The former species *C. halonitratophila* is truly osmophilic, growing only in media containing higher than normal concentrations of solutes (e.g., glucose or NaCl). Strains UWOPS 01-168.1 and UWOPS 01-168.3 were isolated from the same individual bee, but differ from one another in the assimilation of maltose. Both strains failed to assimilate L-lysine as nitrogen source. Separation from several similar species can take advantage of the fact that all strains utilize nitrate, but the distinction from *C. magnoliae* and the unrelated species *C. versatilis* is problematic.

Ecology: The known strains of *C. etchellsii* are sporadic isolates from a broad variety of sources. An association with floricolous insects is suspected.

Biotechnology: Unknown.

Agriculture and food: *Candida etchellsii* has been regularly isolated from salty foods and can be regarded as a spoilage organism.

Clinical importance: Unknown.

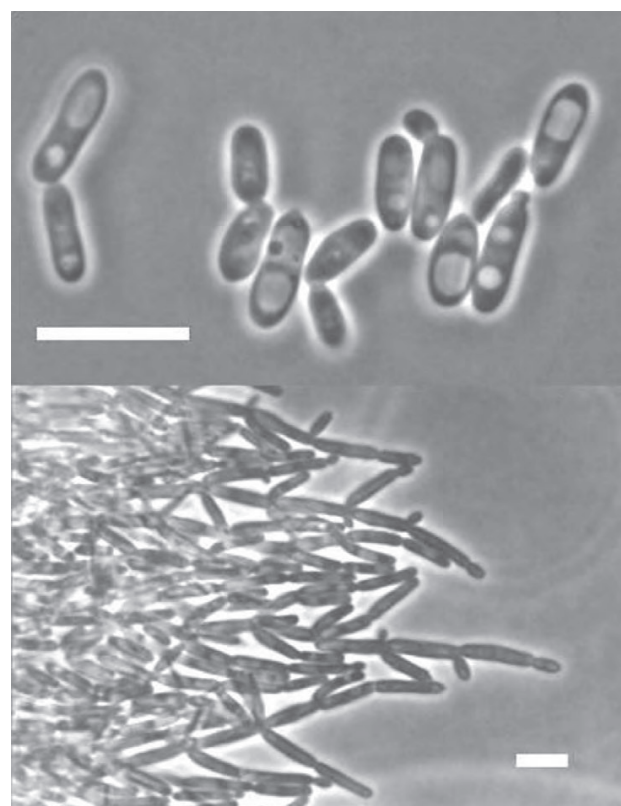


FIGURE 90.54 *Candida ethanolica* CBS 8041. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, on YCBAS agar (bottom). Bars = 10 µm.

Fermentation

Glucose	s/–	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	v
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D-Lactate	v
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	+

90.87. *Candida ethanolica* Rybářová, Štros & Kocková-Kratochvílová (1980)

Phylogenetic placement: *Pichia* clade (Figs 57.1, 90.1).

Synonyms:

Torulopsis ethanolitolerans Rybářová, Štros & Kocková-Kratochvílová (1981)

Torulopsis ethanolitolerans Rybářová, Štros & Kocková-Kratochvílová var. *minor* Rybářová, Štros & Kocková-Kratochvílová (1981)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, 5–7 × 6–10 µm, and occur singly and in pairs (Fig. 90.54 top). After 1 month, a thin pellicle is present and growth is evident on the glass surface.

Dalmai plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of elongate cells (Fig. 90.54 bottom). Aerobic growth is white to cream colored, smooth to delicately wrinkled and with a lobed but entire margin.

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono-δ-lactone	v	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	+

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: 29.3, CBS 6753 (T_m : S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U71073.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 6753 (ATCC 14927), source unknown; CBS 8041, isolated from industrial fodder yeast; CBS 8084, type of *Torulopsis ethanolitolerans*, isolated from industrial fodder yeast, both from former Czechoslovakia.

Type strain: CBS 8041.

Systematics: Strains assigned to *C. ethanolica* were isolated from fodder yeast grown on synthetic ethanol (Rybářová et al. 1980). The species was reported to differ from other *Candida* species by the inability to assimilating nitrate or to ferment sugars. Kurtzman and Robnett (1998a) found *C. ethanolica* and *Pichia deserticola* to differ by only two nucleotides in the D1/D2 LSU rRNA gene, showing that the two taxa are closely related members of the *Pichia* clade (Fig. 90.1). The phylogenetic placement is supported by analysis of SSU rRNA gene sequences (Suzuki and Nakase 2002). The newly described species *C. thaimueangensis* (Limtong et al. 2007a) is a close relative.

Candida ethanolica is nutritionally specialized. The species differs from *Pichia deserticola* by the ability to grow in the absence of vitamins. Furthermore, the two differ in the assimilation of ethyl acetate (negative in the species). Growth at 37°C, the absence of growth on D-ribose and the weak or absent fermentative ability are useful in separating *C. ethanolica* from other similar species, but not entirely. Distinction from *Pichia membranifaciens* remains a problem due to the high heterogeneity of that species.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.88. *Candida fennica* (Sonck & Yarrow) S.A. Meyer & Ahearn (1983)

Phylogenetic placement: Clade *Hyphopichia* (Figs 33.1, 90.5).

Synonyms:

Trichosporon fennicum Sonck & Yarrow (1969)

Trichosporon melibiosaceum D.B. Scott & van der Walt (1970b)¹

¹ Synonymy based on rRNA gene sequence analyses (Kurtzman and Robnett 1998a, Suzuki and Nakase 1999).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, cells are globose or ovoid to elongate, 2–6.5 × 3–6.5 μm (Fig. 90.55 top). Pseudohyphae and true hyphae are also present. After 1 month the broth appears viscous.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae and true hyphae are present (Fig. 90.55 bottom). Long

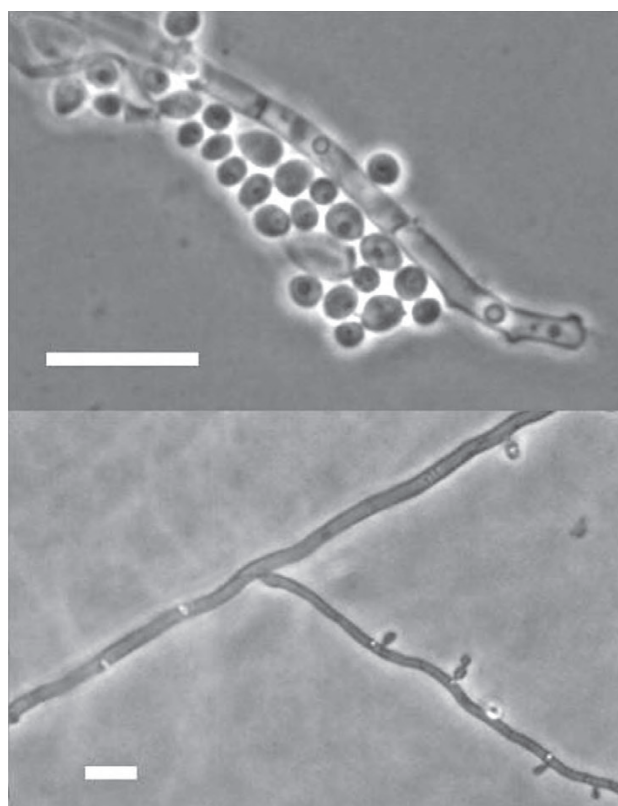


FIGURE 90.55 *Candida fennica* CBS 5928. Budding cells and septate hyphae after 3 days, 25°C, YM agar (top) and true hyphae after 14 days, 18°C, on YCBAS agar (bottom). Bars = 10 μm.

wavy, branched chains of cells with globose to ovoid blastoconidia are abundant as well as true hyphae, which have knobby protuberances along the hyphal strands. Aerobic growth is white to off-white, folded, wrinkled, dull, dry to powdery, with a mycelial border.

Fermentation

Glucose	+	Lactose	s/—
Galactose	s	Raffinose	s/—
Sucrose	s	Trehalose	+
Maltose	+		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	v	Glycerol	+
Melibiose	v	Erythritol	+
Galactose	+	Ribitol	+
Lactose	v	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	v	myo-Inositol	—
Methyl-α-D-glucoside	v	DL-Lactate	—
Soluble starch	+	Succinate	+
Cellobiose	v	Citrate	+
Salicin	v	D-Gluconate	s
L-Sorbose	v	D-Glucosamine	v
L-Rhamnose	—	N-Acetyl-D-glucosamine	+

D-Xylose	v	Hexadecane	v
L-Arabinose	v	Nitrate	—
D-Arabinose	—	Vitamin-free	v

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	+
Glucono-δ-lactone	v	Casein	+
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	—

CoQ: 8 (Suzuki and Nakase 1998).

Mol% G + C: 34.7, CBS 5928; 37.9, CBS 5999 (T_m : Guého et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45715.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5928, isolated from the anus of a cat, Finland; CBS 6087, type of *Trichosporon melibiosaceum*, from frass of horned shot-hole borer (*Bostrichoplites cornutus*, Coleoptera: Bostrichidae) in a moribund sweet thorn tree (*Acacia karoo*, Fabaceae), South Africa.

Other available strains: CBS 5999, from frass of *Bostrichoplites cornutus* (Coleoptera: Bostrichidae) in moribund sweet thorn tree, South Africa; CBS 6027, from poultry, CBS 6028, from birch tree (*Betula* sp., Betulaceae), Finland.

Type strain: CBS 5928.

Systematics: *Trichosporon fennicum* was described by Sonck and Yarrow (1969) to accommodate a strain from an anal infection in a domestic cat. In view of the phenotypic similarity with *Hyphopichia* (*Pichia*) *burtonii*, then designated as *Endomycopsis chodatii*, the strain was mixed with the mating types of that species, but no conjugation was observed. The species was transferred to *Candida* by Meyer and Ahearn (1983) due to its ascomycetous nature and the absence of arthroconidia. The suspected close relationship with *Hyphopichia burtonii* was confirmed by rRNA gene sequence analyses (Fig. 33.1) (Kurtzman and Robnett 1998a, Suzuki and Nakase 1999).

Assimilation of lactose by the type strain was reported as positive in the original description and variable by Meyer et al. (1998). However, neither strain utilized lactose as assessed by replica plating. *C. fennica* is physiologically indistinguishable from *Hyphopichia burtonii*, but the combination of starch and erythritol utilization, growth on nitrate and the formation of extensive true hyphae is sufficient to distinguish it from any other species.

Ecology: Like many related species, *C. fennica* appears to be associated with tree-inhabiting beetles, although it is not confined to that habitat.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.89. *Candida fermenticarens* van der Walt & P.B. Baker (1978)

Phylogenetic placement: *Priceomyces* clade (Figs 59.1, 90.2).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, $2.54 \times 3\text{--}5\text{ }\mu\text{m}$, and occur singly or in pairs (Fig. 90.56).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of elongated cells, sometimes with verticils of ovoid blastoconidia. Aerobic growth is white to cream colored, smooth and with an entire margin.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	s	Ribitol	+
Lactose	—	Galactitol	s
Trehalose	—	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl-α-D-glucoside	—	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	+
Salicin	—	D-Gluconate	+
L-Sorbose	s	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono-δ-lactone	+	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	—

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: Not determined.

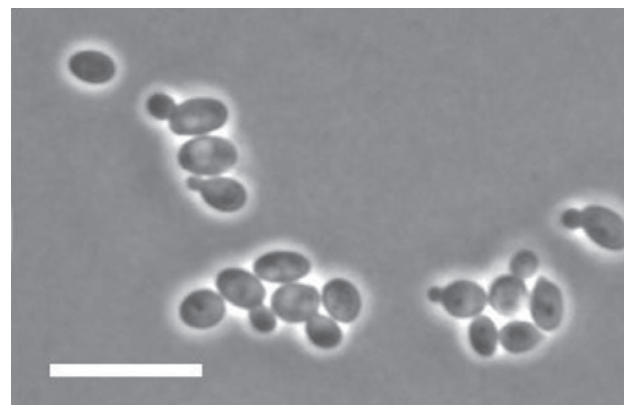


FIGURE 90.56 *Candida fermenticarens* CBS 7040. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm .

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45756.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 7040, isolated from lichen on a tree, South Africa.

Type strain: CBS 7040.

Systematics: *Candida fermenticorens* is a close relative of *Priceomyces* (*Debaryomyces*) *melissophilus*, as evidenced by analysis of rRNA gene sequences (Kurtzman and Robnett 1998a, Kurtzman and Suzuki 2010, Sugita and Nakase 1999).

The ability to grow in the presence of 0.1% cycloheximide, as reported by Meyer et al. (1998), was not confirmed. Good growth was observed, however, on 0.01% cycloheximide. The utilization of galactitol separates *C. fermenticorens* from similar species.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.90. *Candida floccosa* Péter, Dlačny & Tornai-Lehoczki (Péter et al. 2006)

Phylogenetic placement: Basal to the *Ogataea* clade (Fig. 90.4). (The description is based on Péter et al. 2006.)

Growth on 5% malt extract agar: After 3 days at 25°C, the streak culture is butyrous or membranous, slightly raised or more or less convex, cream colored, smooth or rough and folded, slightly glistening or dull and with an entire or slightly undulating margin.

Growth in 5% malt extract broth: After 3 days at 25°C, the cells are subglobose, and ellipsoid or elongated, but a small portion of them are more or less lemon-shaped, 1.8–5–6 × 2.3–6.8–10 µm, and occur singly, in pairs, in short chains and in clusters. Asexual reproduction is by multi-lateral budding. An incomplete pellicle or ring and sediment are present.

Growth on corn meal agar: On corn meal agar after 10 days at 25°C, pseudohyphae occur, but true hyphae are absent.

Fermentation

Glucose	w/s	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

Growth (in Liquid Media)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	+
Sucrose	v	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	v	myo-Inositol	—
Methyl-α-D-glucoside	—	DL-Lactate	+
Soluble starch	—	Succinate	v
Cellobiose	—	Citrate	+
Salicin	—	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	v	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	v	L-Lysine	+
2-Keto-D-gluconate	—	Ethylamine	+
D-Glucuronate	—	50% Glucose	—
L-Arabinitol	—	10% NaCl/5% glucose	—
Propane 1,2 diol	+	Urease	—
Butane 2,3 diol	+	DBB	—
Nitrite	—	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 30°C	s
Creatinine	—	Growth at 37°C	—

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY069955.

Cell carbohydrates: Not determined.

Origin of the strains studied: NCAIM Y.01581 (CBS 10307, NRRL Y-27951) and NCAIM Y.01579 were isolated from flux of an oak (*Quercus petraea*, Fagaceae) collected from Pilis Mountain, Hungary; UWOPS 03-345y3, isolated from flux of a red oak (*Quercus rubra*), collected from Long Point, Ontario, Canada.

Type strain: NCAIM Y.01581.

Systematics: *Candida floccosa* seems loosely related to *C. hungarica* based on a sequence analysis of the D1/D2 domains of the LSU rRNA gene (Péter et al. 2006) and more closely related to *C. cidri* (Fig. 90.4).

Ecology: The species is known from fluxes of oaks in Hungary and Canada.

Biotechnology: The species is methylotrophic.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.91. *Candida floricola* Tokuoka, Ishitani, S. Goto & Komagata (1987)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 2–3 × 3–4.5 µm, and occur singly or in pairs (Fig. 90.57).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae are not present. Aerobic growth is white, smooth, butyrous and with an entire margin.

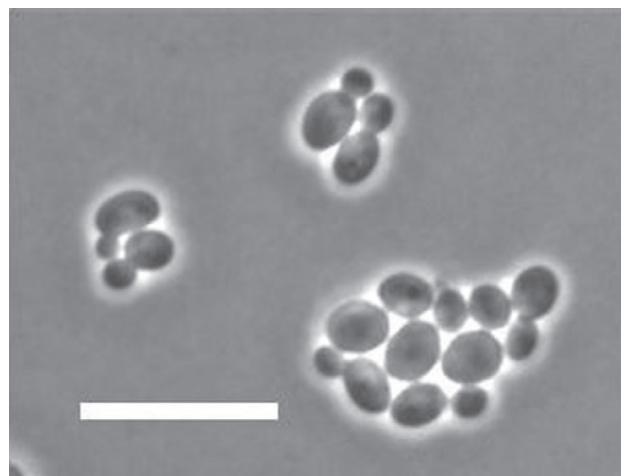


FIGURE 90.57 *Candida floricola* CBS 7289. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	+
Sucrose	+	Trehalose	–
Maltose	+/s		

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	–	Methanol	–
Sucrose	+	Ethanol	v
Raffinose	+	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	D,L-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	v
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	v	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	s	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	w
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	–

CoQ: 9 (Tokuoka et al. 1987).

Mol% G + C: 51.7, CBS 7289 (T_m : Tokuoka et al. 1987); 51.7, CBS 7289 (T_m : S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45710.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 7289, isolated from a dandelion flower (*Taraxacum platycarpum*, Asteraceae), Japan.

Other strain: CBS 7290, isolated from a dandelion flower, Japan.

Type strain: CBS 7289.

Systematics: *Candida floricola* is known from two isolates from dandelion (Tokuoka et al. 1987). Analysis of D1/D2 LSU rRNA gene sequences places the species in proximity of *C. powellii* in the *Starmerella* clade (Fig. 71.1).

The species is physiologically similar to *Zygosaccharomyces rouxii*, but the two differ in the utilization of succinic acid. Weak growth was observed in the presence of 1% acetic acid.

Ecology: Like many other members of the *Starmerella* clade, an association with floricolous insects is to be suspected.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.92. *Candida floridensis* Kurtzman (2007a)

Phylogenetic placement: *Sugiyamaella* clade (Figs 72.1, 90.3). (The description is based on Kurtzman 2007a.)

Growth on 5% malt extract agar: After 3 days' growth at 25°C, yeast cells are spherical, 2.5–5 μ m, to ellipsoidal, 1.8–4 $\times$ 2.4–5.5 μ m, reproduce by multilateral budding, and occur singly or in pairs (Fig. 90.58A). Growth is tannish-white, semi-glistening and butyrous.

Growth on the surface of assimilation media: Thin, climbing films were formed on stationary liquid media, but pellicles were absent.

Dalmau plate culture on yeast morphology agar: Growth after 7 days at 25°C showed no true hyphae and only infrequent pseudo-hyphae (Fig. 90.58B). Aerobic growth is white, glistening, butyrous and with an entire margin.

Fermentation: Absent.

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	v
Melibiose	+	Erythritol	–
Galactose	+	Ribitol	–
Lactose	v	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	+
Methyl- α -D-glucoside	+	D,L-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	v
Salicin	+	D-Gluconate	v
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	+
D-Arabinose	v	Vitamin-free	–

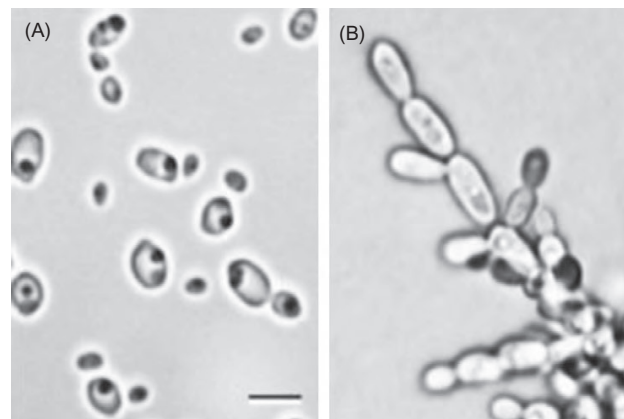


FIGURE 90.58 *Candida floridensis* NRRL YB-3827. Budding cells after 3 days, 25°C, 5% malt extract agar (A) and pseudohyphae after 7 days, 25°C, yeast morphology agar (B). Bar = 5 μ m.

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	–	Starch formation	–
5-Keto-D-gluconate	+	Gelatin liquefaction	w
Saccharate	–	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 37°C	+
10% NaCl/5% glucose	–		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ438222, ITS = DQ911442, mitochondrial SSU rRNA = DQ442738, COXII = DQ443066.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL YB-3827 (CBS 10350), isolated in 1954 from insect frass on a pine tree (*Pinus* sp.), Gainesville, Florida, USA.

Type strain: NRRL YB-3827.

Systematics: *Candida floridensis* forms, with *C. valdiviana* and *C. boreocaroliniensis*, a well-supported clade that occurs as a basal lineage to the *Sugiyamaella* clade (Kurtzman 2007a).

Ecology: The species is known from insect frass on a pine tree in Florida, USA.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.93. *Candida floris* Rosa, Pagnocca & Lachance (Rosa et al. 2007b)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

(The description is based on Rosa et al. 2007b.)

Growth on YM agar: After 2 days at room temperature, colonies are white, convex, smooth and opalescent.

Growth in 0.5% yeast extract–2% glucose broth: After 3 days at 25°C, the cells are ovoid to ellipsoidal, 2–3 × 2–4 µm, and reproduce by multilateral budding. Sediment is formed after a month, but a pellicle is not present.

Dalmau plate culture on corn meal agar: After 2 weeks, pseudohyphae and true hyphae are not formed.

Fermentation

Glucose	v	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	–
Raffinose	–	Glycerol	+/w
Melibiose	–	Erythritol	–
Galactose	v	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	+

L-Sorbose	v	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch formation	–
Nitrite	–	Urease	–
Cadaverine	+	DBB	–
L-Lysine	+	Cycloheximide 0.01%	+
Ethylamine	+	Growth at 37°C	+
10% NaCl/5% glucose	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF313353.

Cell carbohydrates: Not determined.

Origin of the strains studied: UFMG-C16, UFMG-C37, UFMG-C139, UFMG-C141, UFMG-C144, UFMG-C151, all isolated from flowers of morning glory (*Ipomoea* sp., Convolvulaceae) in the pantanal ecosystem, Paraguai River, Mato Grosso, Brazil; UWOPS 00-226.2 (CBS 10593, NRRL Y-48255), isolated from an adult of a stingless bee (*Trigona* sp.) on a rock rosemary (*Merremia quinquefolia*, Convolvulaceae) flower in Santa Rosa National Park, Guanacaste, Costa Rica; UWOPS 01-159.2, from a flower of a wood rose (*Merremia quinquefolia*, Convolvulaceae), Santa Rosa National Park, Guanacaste, Costa Rica.

Type strain: CBS 10593.

Systematics: *Candida floris* is related to *C. etchellsii*, *C. cellae* and a number of undescribed *Candida* spp. in the *Starmerella* clade (Rosa et al. 2007b).

Ecology: The species is known from flowers of morning glory (*Ipomoea* sp.) and rock rosemary (*Merremia quinquefolia*) that both belong to Convolvulaceae, and an adult stingless bee on wood rose, from Brazil and Costa Rica.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.94. *Candida floscolorum* Rosa, Pagnocca, Lachance, Ruivo & Medeiros (Rosa et al. 2007b)

Phylogenetic placement: *Metschnikowia* clade (Fig. 90.1).

(The description is based on Rosa et al. 2007b.)

Growth on YM agar: After 2 days at room temperature, colonies are white, convex, smooth and opalescent.

Growth in 0.5% yeast extract–2% glucose broth: After 3 days at 25°C, the cells are ovoid to ellipsoidal, 2–3 × 2–5 µm, and reproduce by multilateral budding. After a month sediment is formed, but a pellicle is not present.

Dalmau plate culture on corn meal agar: After 2 weeks, pseudohyphae or true hyphae are not formed.

Fermentation

Glucose	+	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (Media not Specified)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	—
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	—
Maltose	+	D-Glucitol	—
Melezitose	s	myo-Inositol	—
Methyl- α -D-glucoside	—	D,L-Lactate	—
Soluble starch	—	Succinate	—
Cellobiose	+	Citrate	—
Salicin	+	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	+	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	10% NaCl/5% glucose	—
Amino acid-free	+	Starch formation	—
Nitrite	—	Urease	—
Cadaverine	+	DBB	—
L-Lysine	+	Cycloheximide 0.01%	—
Ethylamine	+	Growth at 37°C	+

CoQ: Not determined.**Mol% G + C:** Not determined.**Gene sequence accession number, type strain:** D1/D2 LSU rRNA = EF137918.**Cell carbohydrates:** Not determined.

Origin of the strains studied: UFMG-JL11, UFMG-JL13 (CBS 10566, NRRL Y-48258), UFMG-JL36, UFMG-JL45, UFMG-JL52, all isolated from a flower bract of *Heliconia episcopalis* (Heliconiaceae), Parque Estadual do Rio Doce Atlantic rainforest, Minas Gerais, Brazil; UNESP-00-91, UNESP-00-92, both from flower bract of *Heliconia velloziana*, Pinguaba Atlantic rainforest, Parque Estadual da Serra do Mar, State of São Paulo, Brazil.

Type strain: CBS 10566.

Systematics: *Candida flosculorum* belongs to the *Metschnikowia* clade. The exact placement is uncertain. Rosa et al. (2007b) suggested a relationship with an undescribed *Candida* species from Thailand. The analysis in Fig. 90.1 suggests a link to *C. akabanensis*.

Ecology: *Candida flosculorum* occurs in flowers of *Heliconia* spp. in Brazil.

Biotechnology: Unknown.**Agriculture and food:** Unknown.**Clinical importance:** Unknown.**90.95. *Candida fluvialis* Hedrick (1976)****Phylogenetic placement:** *Candida glabrosa* clade (Fig. 90.2).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 1.5–4 $\times$ 3–5 μ m, and occur singly or in pairs (Fig. 90.59).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent or primitive, consisting of short branched chains of ovoid cells. Aerobic growth is white to cream colored, smooth, glossy to dull and entire.

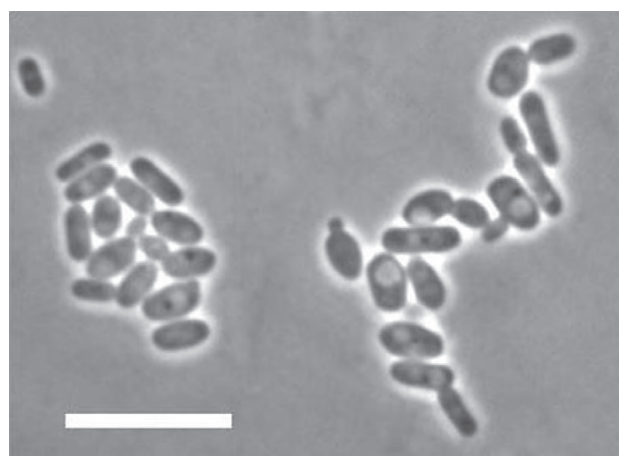


FIGURE 90.59 *Candida fluvialis* CBS 6776. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

Fermentation

Glucose	s	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	s
Maltose	—/s		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	+	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	D,L-Lactate	v
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	v
L-Sorbose	—	D-Glucosamine	+
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	s	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Gluconate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	+
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	+

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 39.8, CBS 6776; 40.0, CBS 6775 (T_m : S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45717.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6776, isolated from polluted river water in Indiana, USA.

Type strain: CBS 6776.

Systematics: Hedrick (1976) described *C. fluvitilis* to accommodate five strains recovered from polluted water. The author noted a similarity with *C. shehatae*. The spelling of the epithet was changed to *fluvitilis* by Meyer et al. (1984). The possible relationship inferred in the original description was confirmed to some degree by rRNA gene sequence analysis (Kurtzman and Robnett 1998a, Sugita and Nakase 1999). The species belongs to a subclade of closely related *Candida* species with affinities for the genus *Debaryomyces*. *C. palmioleophila* is the closest relative and *C. shehatae* belongs to a sister subclade.

The original description reported vitamin independence, but this was not confirmed in later publications or in the present study. Distinction from *Schwanniomyces occidentalis* is made difficult by the variability of the latter species. Growth at 37°C, the assimilation of lactose, and the absence of growth on L-sorbose and D-ribose are useful in separation from similar species.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.96. *Candida fragi* M. Suzuki, Nakase & Fukazawa (1991)

Phylogenetic placement: *Kurtzmaniella* clade (Figs 40.1, 90.2).

(Some of the morphological characteristics are based on Suzuki et al. 1991.)

Growth on YM agar: After 1 month at 17°C, the streak culture is cream colored, butyrous, dull, raised and rugose.

Growth in YM broth: After 3 days at 25°C, the cells are spherical, ovoid or elongate, 2–5 × 4–11 µm, and occur singly, in pairs or in simple or branched chains (Fig. 90.60 top). A dull creeping pellicle is formed.

Dalman plate culture on corn meal agar: After 2 weeks at 18°C, well-developed pseudohyphae are formed (Fig. 90.60 bottom).

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	w	Trehalose	–
Maltose	w		

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	–	Methanol	–
Sucrose	+	Ethanol	s
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	s
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	+	D-Glucitol	s
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	+

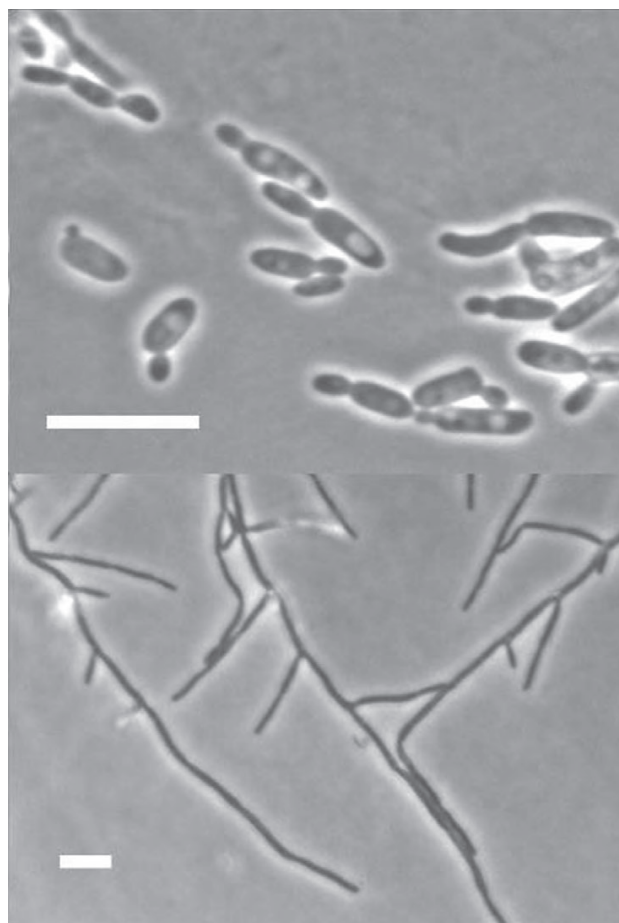


FIGURE 90.60 *Candida fragi* NRRL Y-17910. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, on YCBAS agar (bottom). Bars = 10 µm.

Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	s
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	s	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	w	Casein	–
Amino acid-free	+	Lipase	s
Nitrite	–	Acid production	w
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	s
50% Glucose	–	Growth at 37°C	–

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 37.1, type strain (T_m : Suzuki et al. 1991).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U71071.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 7702 (NRRL Y-17910, JCM 1791), isolated from a fermenting strawberry (*Fragaria chiloensis* var. *anassa*), Japan.

Type strain: CBS 7702.

Systematics: Suzuki et al. (1991) examined in detail an isolate that exhibited similarities with *C. sake* and *C. natalensis*. DNA reassociation demonstrated that the strain was genetically distinct from these species as well as from *C. oleophila* and *C. parapsilosis*, which led them to describe *C. fragi* as a separate species. This conclusion is borne out by sequence comparisons (Kurtzman and Robnett 1998a, Sugita and Nakase 1999), which further position the species near the *Debaryomyces* clade. The nearest relative is *Kurtzmaniella cleridarum*. The two species differ by only five substitutions in each of the D1/D2 LSU rRNA gene region (Lachance et al. 2001a) and the ITS/5.8S regions (AY344065, AY344066). Attempts to observe mating reactions between these sister species were not successful (Lachance and Starmer 2008).

The growth characteristics of *C. fragi* resemble those of many species, related or unrelated. However, the vast majority, including the highly variable *C. sake*, assimilate trehalose, whereas *C. fragi* does not. Other diagnostic responses include the utilization of galactose, glycerol and citric acid and the absence of growth at 37°C or in the presence of 10% NaCl.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.97. *Candida freyschussii* H.R. Buckley & van Uden (1968)

Phylogenetic placement: Unaffiliated clade near *Starmera* (Fig. 90.1).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, 3–5 × 5–13 μm, and occur singly or in pairs (Fig. 90.61). On YM agar, buds are occasionally formed at the end of a peduncle, reminiscent of conjugation figures.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of somewhat elongated cells, sometimes with ovoid blastoconidia. Aerobic growth is whitish to cream colored, soft, smooth and glistening.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	s/–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	s	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D-Lactate	+

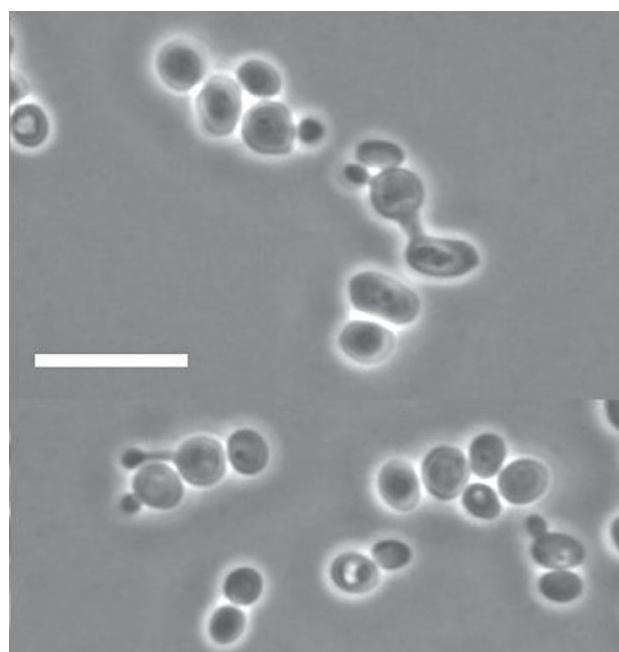


FIGURE 90.61 *Candida freyschussii* CBS 2162. Budding cells after 3 days, 25°C, YM. Bar = 10 μm.

Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	+	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: 45.3, type strain (BD: Meyer et al. 1984); 43.8, two strains (BD: Holzschu et al. 1979).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF017242.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 2161, isolated from wood pulp, Sweden.

Other strains: CBS 2162, from wood pulp, Sweden; CBS 7845, from fermented vegetable, Mongolia.

Type strain: CBS 2162.

Systematics: Buckley and van Uden (1968) described *C. freyschussii* to accommodate two strains isolated from wet wood pulp. The type strain of *C. freyschussii* produces inviable, hat-shaped ascospores on 5% Difco malt agar (Meyer et al. 1998, C.P. Kurtzman, personal communication), and consequently transfer to a teleomorphic genus could be considered, provided that an ascosporic relative could be identified. Unfortunately, the D1/D2 LSU rRNA gene sequence is too divergent to place the species unambiguously in proximity to such a genus (Kurtzman and Robnett 1998a), although the SSU sequence suggests a weak connection to some former *Williopsis* species (Suzuki and Nakase 2002). A multigene study places the species in a basal position with respect to the *Lindnera* clade, but with little statistical support (Kurtzman et al. 2008).

The growth characteristics are similar to those of *Lindnera* (*Pichia euphorbiae*, *L. rhodanensis* and *L. veronae*, making it impractical to identify the species physiologically. Separation from other similar species can be based on the assimilation of melezitose, L-rhamnose and D-gluconate, growth at 37°C and the lack of growth on raffinose, starch, L-arabinose, D-arabinose and N-acetyl-D-glucosamine. The utilization of citric acid was not observed by replica plating.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Dorko et al. (2002) identified a single strain of *C. freyschussii* in a collection of 191 strains isolated from patients with respiratory tract diseases.

90.98. *Candida friedrichii* van Uden & Windisch (1968)

Phylogenetic placement: *Yamadazyma* clade (Figs 81.1, 90.2).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to cylindroid, $1.5\text{--}2.5 \times 5\text{--}12\text{ }\mu\text{m}$, and occur singly and in short chains (Fig. 90.62 top). A thin pellicle is present.

Dalmat plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of chains of cylindroid cells, sometimes bearing short chains of ovoid blastoconidia (Fig. 90.62 bottom). Some pseudohyphae bear many blastoconidia whereas others have few. Aerobic growth is white to cream colored, soft, wrinkled with a frosted appearance and with a fringed border.

Fermentation

Glucose	+	Lactose	–
Galactose	s/–	Raffinose	–
Sucrose	–	Trehalose	s
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	+	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	+
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+

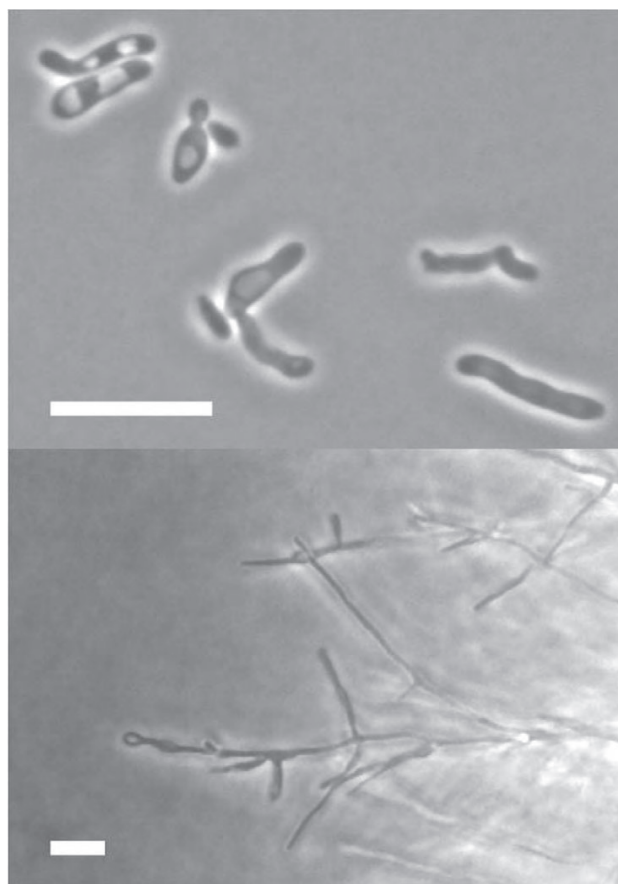


FIGURE 90.62 *Candida friedrichii* CBS 4114. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, on YCBAS agar (bottom). Bars = 10 μm .

L-Sorbose	+	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	–
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	v
50% Glucose	+	Growth at 37°C	–

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 32.9–33.7, 2 strains (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45781.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 4114, isolated from a D-glucitol solution, Germany.

Type strain: CBS 4114.

Systematics: van Uden and Windisch (1968) described *C. friedrichii* to accommodate two melibiose-fermenting strains. The strains were categorized as belonging to group III in terms of raffinose fermentation, meaning that they are unable to ferment the sucrose portion of the hydrolyzed trisaccharide. *C. friedrichii* is a sister species to *C. membranifaciens* (Kurtzman and Robnett 1998a, Sugita and Nakase 1999). These and other *Candida* species exhibit an affinity to the *Yamadazyma* clade.

At variance from previous descriptions, replica plating indicated that *N*-acetyl-D-glucosamine was assimilated, but not hexadecane. The species is polyphagic and similar to several *Debaryomyces* species. The utilization of β -glucosides, galactitol and fermentative ability separate *C. friedrichii* from most other species, but the high variability encountered in *Debaryomyces hansenii* is problematic in this case.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.99. *Candida frijolesensis* S.-O. Suh, N.H. Nguyen & M. Blackwell (Suh et al. 2008)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Fig. 90.5). (The description is based on Suh et al. 2008.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, butyrous and smooth.

Growth in YM broth: After 7 days at 25°C, cells are globose to ellipsoidal, 4–12 $\times$ 4–12 μ m, mostly globose and occur singly, in pairs, in short chains and in clusters.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae may be present. Aerobic growth is white and smooth, and the margin is undulate.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	+	Trehalose	d
Maltose	+		

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	–
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	D,L-Lactate	+/d
Soluble starch	–	Succinate	–
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	50% Glucose	+/w
2-Keto-D-gluconate	+	10% NaCl/5% glucose	w
L-Arabinitol	–	Starch formation	–
Arbutin	+	Urease	–
Propane 1,2 diol	–	DBB	–
Butane 2,3 diol	–	Cycloheximide 0.01%	+
Nitrite	–	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 25°C	+
Creatinine	–	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	+
Ethylamine	+	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = EF120596, SSU rRNA = EF120581.

Cell carbohydrates: Not determined.

Origin of the strains studied: NRRL Y-48060 (CBS 10377), isolated from the gut of an unidentified endomychid beetle (Coleoptera, Endomychidae); NRRL Y-48062, isolated from the gut of elephant beetle (*Megasoma elephas*, Scarabae), both from Barro Colorado Island, Panama.

Type strain: NRRL Y-48060.

Systematics: From LSU and SSU rRNA gene sequence analysis, *C. frijolesensis* belongs to a clade with *C. neerlandica* and *C. labiduridarum* within the *Lodderomyces elongisporus* clade (Suh et al. 2008).

Ecology: The species is known only from the gut of an endomychid beetle at Barro Colorado Island, Panama.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.100. *Candida fructus* (Nakase) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Metschnikowia* clade (Fig. 90.1).

Synonym:

Torulopsis fructus Nakase (1971a)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 3–6 $\times$ 3–7 μ m, and occur singly and in pairs (Fig. 90.63).

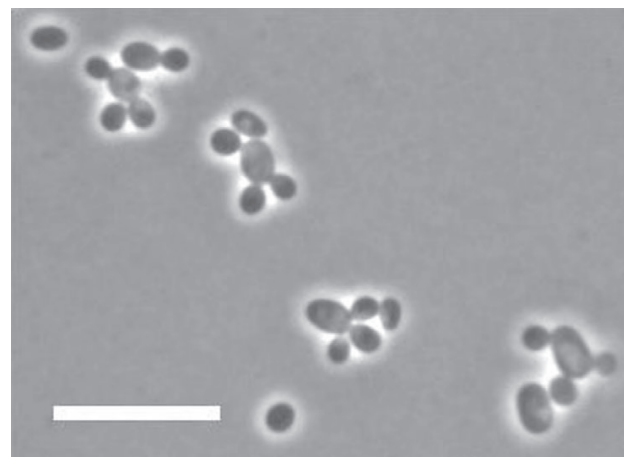


FIGURE 90.63 *Candida fructus* CBS 6380. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, primitive pseudohyphae of short chains of ovoid cells are sparsely formed. Aerobic growth is off-white, shiny, smooth and entire.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	s
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	s
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	s
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: 8 (Suzuki and Nakase 1998).

Mol% G + C: 48.8, CBS 6380 (T_m : Nakase 1971b).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U44814.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6380, isolated from a banana (*Musa* sp., Musaceae), Japan.

Type strain: CBS 6380.

Systematics: Nakase (1971a) described *Torulopsis fructus* to accommodate two strains isolated from bananas in a food market. The author noted a similarity with *C. castellii* and *C. glabrata*, but with a number of important differences. Kurtzman and Robnett (1997) found *C. fructus* and *C. musae* to have identical sequences in the D1/D2 LSU rRNA gene suggesting that the two taxa might be conspecific. Lu et al. (2004a) found the two species also to have identical ITS/5.8S rRNA gene regions, and viewed this result as a confirmation

of conspecificity. However, the two were reported to differ by 14 substitutions and seven gaps in the SSU rRNA gene (Suzuki and Nakase 1999), calling for caution before placing them into synonymy. These species are members of a heterogeneous clade associated with the Metschnikowiaceae.

The growth characteristics given in the original description agree well with the results obtained by replica plating except for growth on D-ribose, which was found positive. *C. fructus* differs from *C. musae* by the absence of growth on sucrose, maltose, melibiose and methyl- α -D-glucoside.

Ecology: Morais et al. (1995b) reported the presence of *C. fructus* as a major component of the yeast community of the Amazonian amapa fruit (*Parahancornia amapa*, Apocynaceae). The species appeared fairly early during the succession of typical fruit yeast species vectored to the fermenting amapa fruit by various species of *Drosophila*. A relative of *C. fructus* (and *C. musae*), strain UWOPS91-639.1, was recovered from a *Drosophila* sp. collected on a *Sapindus* berry on the island of Hawai'i. These observations suggest that the species is associated with fructicolous drosophilids.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.101. *Candida fukazawae* Nakase, M. Suzuki, Sugita, S.-O. Suh & Komagata (1999)

Phylogenetic placement: *Kodamaea* clade (Fig. 36.1).

(Some of the morphological characteristics are based on Nakase et al. 1999.)

Growth on YM agar: After 1 day at 17°C, the streak culture is white to yellowish, delicately wrinkled, butyrous to tough, with a ciliate margin.

Growth in YM broth: After 3 days at 25°C, the cells are long ovoid to ellipsoidal, 4–7 $\times$ 8–15 μ m, or elongate to cylindrical, 2.5–8 $\times$ 7–25 μ m (Fig. 90.64 left). A thick, wrinkled pellicle is produced.

Slide culture on potato dextrose agar: Well-developed pseudohyphae are formed. Ovoid to elongate blastoconidia are formed in chains or verticils (Fig. 90.64 right).

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

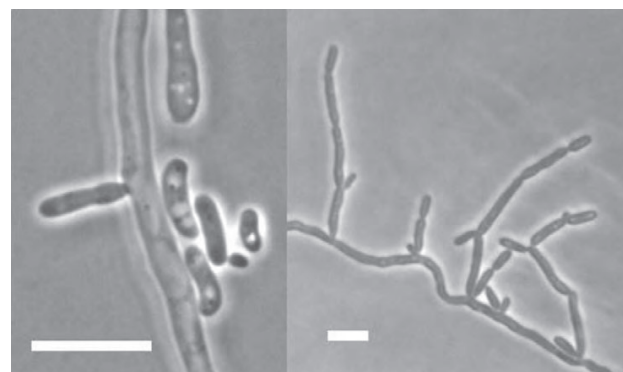


FIGURE 90.64 *Candida fukazawae* JCM 1641. Budding cells and pseudohypha after 3 days, 25°C, YM agar (left) and pseudohyphae after 14 days, 18°C, on YCBAS agar (right). Bars = 10 μ m.

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	–	Methanol	–
Sucrose	+	Ethanol	s
Raffinose	–	Glycerol	s
Melibiose	–	Erythritol	+
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	w
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	s
Salicin	+	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	s	Hexadecane	s
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	w	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	w
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: 9 (Nakase et al. 1999).**Mol% G + C:** 45.1, type (HPLC: Nakase et al. 1999).**Gene sequence accession number, type strain:** D1/D2 LSU rRNA = AY313957.**Cell carbohydrates:** Not determined.**Origin of the strain studied:** CBS 9137 (JCM 1641), isolated from the fruiting body of an unidentified mushroom, Japan.**Type strain:** CBS 9137.

Systematics: Nakase et al. (1999) examined four isolates from mushrooms. Analysis of SSU rRNA gene sequences showed that the strains were related to *C. mesenterica* and *C. suecica*, and could be divided into three species by DNA reassociation and ITS/5.8S rRNA gene sequences. The strain assigned to *C. fukazawae* occupied a basal position with respect to *C. fungicola* and *C. sagamina*. Analysis of the D1/D2 LSU rRNA gene (AY313957) confirmed these relationships and further demonstrated a relationship to the genus *Kodamaea* and related *Candida* species (Fig. 36.1).

Physiologically, *C. fukazawae* superficially resembles *C. mesenterica*, but, unlike the latter, it utilizes D-gluconic acid, but not L-sorbose, and grows at 30°C. A similarity with *C. oregonensis* and *C. lyxosophila* is also evident, but the utilization of erythritol by *C. fukazawae* separates the species well. The growth characteristics determined by replica plating agreed well with the description, with the exception of the utilization of ribose (negative). Although the description reported a negative response for lipolytic activity, Tween 80 was hydrolyzed.

Ecology: Unknown.**Biotechnology:** Unknown.**Agriculture and food:** Unknown.**Clinical importance:** Unknown.**90.102. *Candida fungicola* Nakase, M. Suzuki, Sugita, S.-O. Suh & Komagata (1999)****Phylogenetic placement:** *Kodamaea* clade (Fig. 36.1).

(Some of the morphological characteristics are taken from Nakase et al. 1999.)

Growth in YM broth: After 3 days at 25°C, the cells are ellipsoidal, cylindrical, elongate and slender, $2\text{--}3.5 \times 4.5\text{--}25\text{ }\mu\text{m}$, and occur singly, in pairs or in chains (Fig. 90.65 top). A pellicle is formed.**Slide culture on potato dextrose agar:** Abundant branching pseudohyphae without blastoconidia are formed (Fig. 90.65 bottom).**Fermentation:** Absent.**Growth (on Agar)**

Glucose	+	D-Ribose	s
Inulin	–	Methanol	–
Sucrose	+	Ethanol	–
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	–
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	–	Hexadecane	s
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	w	Casein	–
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	w
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	w
50% Glucose	–	Growth at 37°C	–

CoQ: 9 (Nakase et al. 1999).**Mol% G + C:** 38.5–39.4, two strains, including the type (HPLC: Nakase et al. 1999).**Gene sequence accession number, type strain:** D1/D2 LSU rRNA = AY313958.**Cell carbohydrates:** Not determined.**Origin of the strain studied:** CBS 9138 (JCM 10142), isolated from the fruiting body of an unidentified mushroom, Japan.**Type strain:** CBS 9138.

Systematics: Nakase et al. (1999) described *C. fungicola* based on two strains recovered from mushrooms. Analysis of SSU rRNA gene sequences placed *C. fungicola* with *C. fukazawae* and *C. sagamina*, but DNA reassociation and the ITS/5.8S rRNA gene sequences demonstrated that they are distinct species. A relationship with *C. mesenterica*

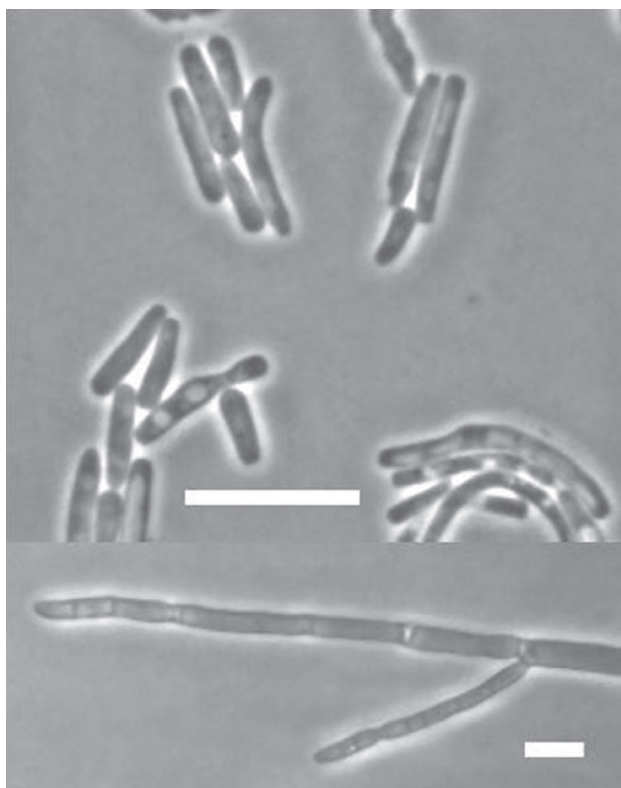


FIGURE 90.65 *Candida fungicola* JCM 10142. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, on YCBAS agar (bottom). Bars = 10 μm.

and *C. suecica* was also demonstrated. Analysis of the D1/D2 LSU rRNA gene (AY313958) further demonstrated membership in the *Kodamaea* clade (Fig. 36.1).

Physiologically, *C. fungicola* resembles *C. mesenterica* and *C. sagamina*, but the lack of growth on L-sorbose, D-xylose and ethanol, as well as in the presence of 0.01% cycloheximide, can be used for identification. The description reported a negative response for lipolytic activity, but hydrolysis of Tween 80 was observed by replica plating.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.103. *Candida galacta* (Golubev & Bab'eva) F.-L. Lee, C.-F. Lee, Okada, Komagata & Kozaki (1993)

Phylogenetic placement: *Wickerhamiella* clade (Fig. 79.1).

Synonym:

Torulopsis apis var. *galacta* Golubev & Bab'eva (1977)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are spherical, 1.5–3.5 μm, and occur singly, in pairs, in small chains and in clusters (Fig. 90.66).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present. Aerobic growth is white to light beige in color, smooth, creamy and soft with an entire margin.

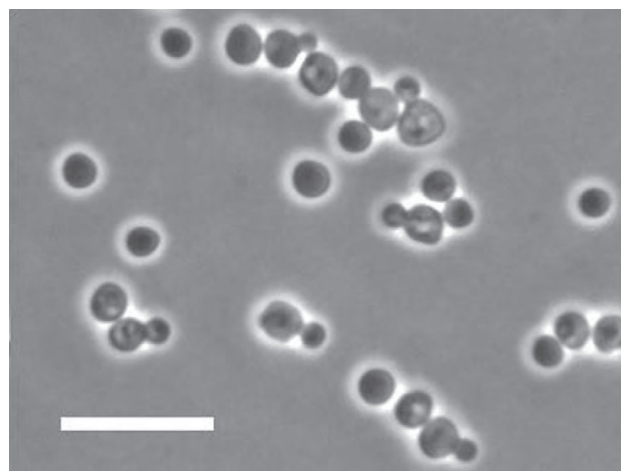


FIGURE 90.66 *Candida galacta* CBS 6939. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	w
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	s
50% Glucose	+	Growth at 37°C	–

CoQ: 8 (F.-L. Lee et al. 1993).

Mol% G + C: 50.2, CBS 6939 (HPLC: F.-L. Lee et al. 1993); 49.8, CBS 6939 (T_m : S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45820.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6939, isolated from cocoons of red wood ant (*Formica rufa*, Hymenoptera: Formicidae).

Type strain: CBS 6939.

Systematics: Golubev and Bab'eva (1977) described *Torulopsis apis* var. *galacta* to accommodate 14 strains isolated from various ant-associated substrates, including cocoons, the intestines of females and the inner cones of anthills. The variety differed by a weak or negative response on raffinose and a requirement for vitamins. The cell shape was dramatically different. F.-L. Lee et al. (1993) found *C. galacta* and *C. apis* to be unrelated by DNA reassociation. Both the D1/D2 LSU and the SSU rRNA gene sequences place *C. galacta* in the *Wickerhamiella* clade, in contrast to *C. apis*, which is a member of the *Starmerella* clade. In the first instance (Kurtzman and Robnett 1998a, Lachance et al. 1998c), the species occupies a basal position with respect to *Wickerhamiella occidentalis* and relatives such as *C. azyma*. In the second case (Suzuki et al. 1999), a closer relationship with *C. sorbophila* and *C. spandovensis* is suggested. The analysis presented in Fig. 79.1 based on D1/D2 LSU sequences suggests yet another branching order, and so does the multi-gene analysis of Kurtzman and Robnett (2007).

The growth characteristics determined by replica plating match well those in previous descriptions, but most responses were weak. Separation from similar species can be based on the assimilation of galactose and citric acid combined with the lack of growth on sucrose or fermentation.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.104. *Candida galis* Lachance (2001)

Phylogenetic placement: Near the *Barnettozyma* clade (Fig. 90.1).

Growth on malt agar: After 2 weeks at 17°C, colonies are low convex, semi-glossy, smooth, white and butyrous.

Growth in glucose–yeast extract broth: After 3 days at 25°C, the cells are ovoid to bacilliform, slightly curved or compressed, 1–2 × 4–6 µm, and occur singly or in parent–bud pairs. A thin ring is formed.

Dalmau plate culture on corn meal agar: After 2 weeks at 18°C, pseudohyphae or true hyphae are absent.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	D-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	s/–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Gluconate	–	Gelatin	–
Glucono- δ -lactone	–	Casein	w/–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	w
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	s/–	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF322055.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 8842 (UWOPS 00-159.2) and eight other strains were isolated from exudates of *Maclura tinctoria* (Moraceae) in two Costa Rican localities.

Type strain: CBS 8842.

Systematics: *Candida galis* was the dominant species recovered from exudates of the moraceous tree *Maclura tinctoria* in Costa Rica (Lachance et al. 2001d). Sequencing of the D1/D2 LSU rRNA gene demonstrates an affinity for species distributed in clades designated as *Barnettozyma*, *Wickerhamomyces*, *Lindnera* and *Starmera* (Kurtzman et al. 2008). The exact phylogenetic placement remains uncertain.

Candida galis is nutritionally specialized. The growth profile is typical of *Pichia deserticola* or *P. membranifaciens*, although some strains utilize xylitol. The formation of compressed or curved bacilli-form cells is unusual and may help in identification. The absence of growth on salicin, D-mannitol, D-glucitol or N-acetyl-D-glucosamine and the failure to grow at 37°C are useful to separate *C. galis* from similar species.

Ecology: *Maclura tinctoria*, a common tree in the tropical forests of Central and South America, produces bleeding wounds that are slow to heal, but resistant to fungal decay (Lachance et al. 2001d). The isolation of *C. galis* from that tree and not others suggests a specific interaction, possibly linked to the utilization of few organic compounds, which could serve to protect the yeast from toxic substances present in the habitat.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.105. *Candida galli* Péter, Dlačhy, Vasdinyei, Tornai-Lehoczki & Deák (Péter et al. 2004)

Phylogenetic placement: *Yarrowia* clade (Figs 82.1, 90.3).

(The description is based on Péter et al. 2004.)

Growth on malt agar: After 3 days at 25°C, the streak culture is butyrous, cream colored, hirsute, moderately raised and with the margin fringed with filaments.

Growth in malt extract broth: After 3 days at 25°C, the cells are ellipsoid to elongated, 2.3–6 × 3–13 µm, occur singly, in pairs and in small clusters, and reproduce by multilateral budding. Septate hyphae occur. A creeping pellicle and sediment are present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae are formed. Sparse formation of arthroconidia occurs.

Fermentation: Absent.

Growth (in Liquid Media)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	w/s	Ribitol	v
Lactose	—	Galactitol	—
Trehalose	v	D-Mannitol	+/1
Maltose	—	D-Glucitol	+/s
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	+
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	+
Salicin	v	D-Gluconate	+/s/1
L-Sorbose	v	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	—	Hexadecane	+
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	+

Additional Growth Tests and Other Characteristics

Xylitol	v	L-Lysine	+
2-Keto-D-gluconate	s/1	Ethylamine	+
D-Glucuronate	—	50% Glucose	—
L-Arabinitol	—	10% NaCl/5% glucose	+
Arbutin	v	Urease	—
Propane 1,2 diol	+/s	DBB	—
Butane 2,3 diol	v	Gelatin liquefaction	+
Nitrite	—	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 30°C	+
Creatinine	—	Growth at 35°C	—

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY116080.

Cell carbohydrates: Not determined.

Origin of the strains studied: NCAIM Y.01482 (CBS 9722), NCAIM Y.01483, NCAIM Y.01484, NCAIM Y.01486 (CBS 9723), NCAIM Y.01488, NCAIM Y.014889, all isolated in 1998 from chicken breast and chicken liver, Griffin, Georgia, USA.

Type strain: NCAIM Y.01482.

Systematics: *Candida galli* is a close relative of *Yarrowia lipolytica* (Péter et al. 2004). Asci with hat-shaped ascospores were observed after mating *C. deformans* CBS 2076 with *C. galli* CBS 9722 (Knutsen et al. 2007). Although the viability of these ascospores was not tested, the DNAs of two species exhibit only 30% reassociation, indicating that they are genetically distinct. As the significance of epitypification (McNeil 2006) becomes clearer, transfer of the species to *Yarrowia* will be desirable.

Ecology: The species is known only from chicken liver and breast from Georgia, USA (Ismail et al. 2000, Péter et al. 2004).

Biotechnology: Unknown.

Agriculture and food: *Candida galli* may occur as a spoilage organism on non-processed chicken and processed chicken meat because of lipolytic and proteolytic activities (Péter et al. 2004).

Clinical importance: Unknown.

Additional comments: The hyphal septum of the type strain has a single narrow central pore (Péter et al. 2004).

90.106. *Candida gatunensis* S.-O. Suh, N.H. Nguyen & M. Blackwell (Suh et al. 2006a)

Phylogenetic placement: *Candida kruisii* clade (Fig. 90.5).

(The description is based on Suh et al. 2006a.)

Growth on YM agar: After 7 days on YM agar at 25°C, colonies are off-white, butyrous, smooth and have a filamentous margin.

Growth in YM broth: After 7 days at 25°C, cells are ellipsoidal to fusiform, 1–3 $\times$ 2–9 μ m, but mostly fusiform, and occur singly or in pairs, or occasionally form clusters. Pseudohyphae and true hyphae are present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae are present. Aerobic growth is off-white, smooth and with a filamentous margin.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	+
Maltose	—		

Growth (in Liquid Media)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	d
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	d
L-Sorbose	—	D-Glucosamine	w
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	w	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	d	Ethylamine	+
2-Keto-D-gluconate	+	50% Glucose	—
D-Glucuronate	—	10% NaCl/5% glucose	—
L-Arabinitol	—	Starch formation	—
Arbutin	+	Urease	—
Propane 1,2 diol	—	DBB	—
Butane 2,3 diol	—	Cycloheximide 0.01%	+
Nitrite	—	Cycloheximide 0.1%	—
Cadaverine	+	Growth at 30°C	+
Creatinine	—	Growth at 35°C	w
L-Lysine	+	Growth at 40°C	—

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = DQ647643, SSU rRNA = DQ647642, ITS and 5.8S rRNA = DQ647644.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-48064 (CBS 10379), isolated from the gut of a sap-feeding beetle (*Pallodes* sp.) on the fruiting body of a mushroom (*Hydropus* sp.), Barro Colorado Island, Panama.

Type strain: NRRL Y-48064.

Systematics: *Candida gatunensis* belongs to the *C. kruisii* clade based on a combined analysis of SSU and D1/D2 LSU rRNA gene sequences. The species forms a subclade with *C. barrocoloradensis* and *C. stri*, and with *C. aglyptinia* as a basal species (Suh et al. 2006a).

Ecology: The species is known only from the gut of a sap-feeding beetle (*Pallodes* sp.) occurring on a mushroom, Panama.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.107. *Candida gelsemii* Lachance (Manson et al. 2007)

Phylogenetic placement: *Metschnikowia* clade (Figs 46.1, 90.1).

Growth on agar: Colonies are low-convex, slightly umbonate, glabrous, may be papillate or pitted and have an entire margin.

Growth in 2% glucose–0.5% yeast extract broth: After 3 days, the cells are ovoid, $3\text{--}7 \times 5\text{--}10\text{ }\mu\text{m}$, and occur singly or in bud–parent cell pairs. A ring and pellicle are not formed.

Dalmau plate culture on YCB agar supplemented with 0.01% ammonium sulfate: After 2 weeks, a few chains of undifferentiated cells may be formed.

Fermentation

Glucose	w	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	n
Raffinose	–	Glycerol	w
Melibiose	–	Erythritol	–
Galactose	v	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	v	D-Mannitol	–
Maltose	+	D-Glucitol	w
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	–
Soluble starch	n	Succinate	v
Cellobiose	v	Citrate	–
Salicin	v	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	–	Hexadecane	w
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	10% NaCl/5% glucose	+/s
2-Keto-D-gluconate	–	Starch formation	–
Amino acid-free	+	DBB	–
Nitrite	–	Gelatin liquefaction	w
Cadaverine	+	Cycloheximide 0.1%	–
L-Lysine	+	Growth at 24°C	+
Ethylamine	+	Growth at 30°C	v
50% Glucose	–		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = DQ988046.

Cell carbohydrates: Not determined.

Origin of the strains studied: UWOPS 06-24.1 (CBS 10509, NRRL Y-48212), UWOPS 06-11.1, UWOPS 06-17.1, all isolated from nectar of yellow jessamine (*Gelsemium sempervirens*, Gelsemiaceae), near Georgia Southern University, Statesboro, Georgia, USA.

Type strain: CBS 10509.

Systematics: Based on sequence analysis of the D1/D2 domains of the LSU rRNA gene, *C. gelsemii* belongs to the Metschnikowiaceae (Manson et al. 2007).

Ecology: The species is known only from nectar of yellow jessamine, USA.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Chlamydospores similar to those of *Metschnikowia pulcherrima* may be formed on dilute V8 medium (Manson et al. 2007).

90.108. *Candida geochares* (van der Walt, E. Johannsen & Yarrow) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

Synonym:

Torulopsis geochares van der Walt, E. Johannsen & Yarrow (1978)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to subglobose, $3\text{--}5\text{ }\mu\text{m}$, and occur singly or in pairs (Fig. 90.67).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present. Aerobic growth is white, butyrous, smooth and with an entire margin.

Fermentation

Glucose	s	Lactose	–
Galactose	–	Raffinose	–
Sucrose	s	Trehalose	–
Maltose	–		

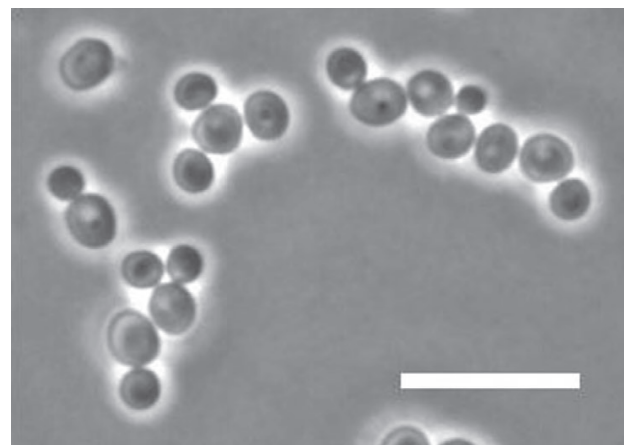


FIGURE 90.67 *Candida geochares* CBS 6870. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm .

Growth (on Agar)

Glucose	+	D-Ribose	w
Inulin	—	Methanol	—
Sucrose	—	Ethanol	w
Raffinose	—	Glycerol	s
Melibiose	—	Erythritol	—
Galactose	s	Ribitol	s
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	—
Soluble starch	—	Succinate	s
Cellobiose	s	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	—	Hexadecane	w
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Gluconate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	w

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 54.1, CBS 6870 (T_m : van der Walt et al. 1978).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U48591.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6870, isolated from soil, South Africa.

Type strain: CBS 6870.

Systematics: van der Walt et al. (1978) described *Torulopsis geochares* from a strain isolated from grassland soil. *C. geochares* is a member of the *Starmerella sensu lato* clade (Fig. 71.1) and is most closely related to *C. sorbosivorans* and *C. magnoliae* based on D1/D2 LSU rRNA gene sequences (James et al. 2001b, Rosa et al. 2003). Analysis of the 18S rRNA gene (Suzuki et al. 1999) places the species in a more basal position in the clade, along with other species that stand out from the rest by the absence of galactose in cell extracts.

The physiology is specialized as is typical of the *Starmerella* clade. The type strain exhibited a number of small differences from previous descriptions. Growth of the type strain on agar media was not as vigorous as reported in liquid media and the strain did not assimilate sucrose as evaluated by replica plating. *C. geochares* can be separated from similar species by growth on salicin and the absence of growth on raffinose, sorbose and nitrate.

Ecology: In view of the recovery of *C. geochares* from the soil and the existence of only one known isolate, van der Walt et al. (1978) suggested that the species is uncommon and free-living. No new isolates have since been reported, confirming the rare nature of the species. However, the closest relative of the species, *C. sorbosivorans*, occurs more frequently than originally thought and the apparent rarity derived from the difficulty of correct identification by the physiological

method. As a strong association exists between many species in the *Starmerella* clade and hymenopteran insects, one may safely predict that examination of bees and their nests in the area where the type was isolated could yield a quantity of additional strains.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.109. *Candida germanica* Kurtzman, Robnett & Yarrow (2001b)

Phylogenetic placement: *Yamadazyma* clade (Fig. 90.2).

(Some of the morphological characteristics are based on Kurtzman et al. 2001b.)

Growth on 5% malt agar: After 3 days at 25°C, the cells are spherical, 2.2–5 μ m, to ellipsoidal 1–4 $\times$ 2–7 μ m, sometimes tapered, occur singly or in pairs, and reproduce by multilateral budding (Fig. 90.68A). Occasionally cells form a rachis-like extension that seems to exhibit sympodial blastoconidiogenesis (Fig. 90.68B). Growth is tannish-white, glistening and butyrous.

Dalmat plate culture on corn meal agar: After 7 days at 25°C, neither pseudohyphae nor true hyphae were formed under the coverglass. Aerobic growth is white to tannish-white, glistening, butyrous and with a margin that is glabrous to finely denticulate to broadly lobed.

Fermentation

Glucose	+	Lactose	—
Galactose	+	Raffinose	—
Sucrose	—	Trehalose	v
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	—
Salicin	+	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	s
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	+	Nitrate	—
D-Arabinose	+	Vitamin-free	w

Additional Growth Tests and Other Characteristics

Xylitol	w	Starch production	—
2-Keto-D-gluconate	w	DBB	—
D-Gluconate	—	Gelatin	—
Glucono- δ -lactone	—	Casein	—
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	w

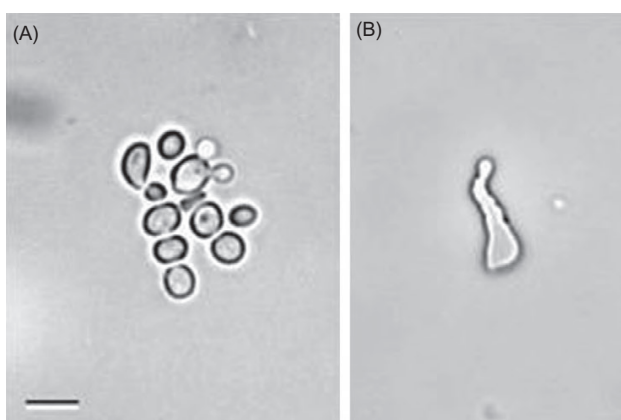


FIGURE 90.68 *Candida germanica* NRRL Y-27064. Budding cells (A) and cell with rachis-like extension (B), after 3 days, 25°C, 5% malt extract agar. Bar = 5 μm.

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF245401.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 4105 (NRRL Y-27064), isolated from atmosphere in Germany.

Type strain: CBS 4105.

Systematics: *Candida germanica* was described to accommodate an isolate from the atmosphere, on the basis of a difference of 11 substitutions in the D1/D2 LSU rRNA gene from the nearest relative, *C. diddensiae* (Kurtzman et al. 2001b). The species has affinities for members of the genus *Yamadazyma*.

Some minor differences in growth characteristics have been observed from the published description. Separation from similar species can rely on the utilization of sucrose, L-arabinose, D-arabinose and 2-keto-D-gluconate, combined with the lack of growth on starch, galactitol and glucono-δ-lactone.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.110. *Candida ghanaensis* Kurtzman (2001a)

Phylogenetic placement: unaffiliated clade (Fig. 90.3).

(Some of the morphological characteristics are based on Kurtzman 2001a.)

Growth on 5% malt agar: After 3 days at 25°C, budding yeast cells are infrequent and may be spherical, 2–3 μm, or ellipsoidal, 2–2.5 × 2.5–3 μm, and occur singly or in pairs (Fig. 90.69A). Much of the growth consists of pseudohyphae and true hyphae, both of which form inflated spherical cells that may be terminal or intercalary (Fig. 90.69B). Spherical to ovoid blastoconidia develop on sterigma and are produced on the inflated cells as well as on hyphae. Growth is tannish-white, thin, dull and mycelial.

Dalmau plate culture on morphology agar: After 7 days at 25°C, growth under the coverglass is mycelial with hyphae showing abundant blastoconidia similar to those seen on 5% malt extract agar (Fig. 90.69C). Aerobic growth is tannish-white, low convex with a glistening butyrous center, a smooth mycelial fringe and a broadly lobed margin.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	–
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	+
Salicin	+	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	w
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	w	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	s
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF271083.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 8798 (NRRL Y-1486), isolated from soil in Ghana.

Type strain: CBS 8798.

Systematics: *Candida ghanaensis* is known from a single isolate from Tafo, Ghana (Kurtzman 2001a). An analysis of the D1/D2 LSU rRNA gene given in the original description did not establish a clear link with any clade in particular, and neither did a BLAST search of the sequence against the GenBank database. An analysis of the SSU rRNA gene sequence determined for this study (AY618510) suggested a weak and probably insignificant affinity with *C. incommunis*, and the highest matches in the GenBank database were with members of the *Dipodascus/Geotrichum* clade.

The physiological profile of *C. ghanaensis* is unique. A moderate number of carbon compounds are utilized, but the pattern does not resemble that of any other yeast. The growth characteristics evaluated by replica plating exhibited some differences from the published description. The type culture received from CBS did not assimilate trehalose, cellobiose, L-arabinose or glycerol, nor did it grow in the presence of 10% NaCl, but citric acid was utilized. Even after taking these differences into account, the utilization of galactose and erythritol, growth at 37°C, resistance to 0.01% cycloheximide and the absence of



FIGURE 90.69 *Candida ghanaensis* NRRL YB-1486. Budding cells, after 1 day, 25°C, 5% malt extract agar (A). Hyphae with inflated terminal and intercalary cells and blastoconidia, after 1 day, 25°C, YM agar (B). True hypha with blastoconidia borne on short sterigmata after 7 days, 25°C, yeast morphology agar (C). Bar = 5 μm.

growth on lactose are sufficient to separate *C. ghanaensis* from any remotely similar species.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.111. *Candida gigantensis* S.-O. Suh, N.H. Nguyen & M. Blackwell (2008)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Fig. 90.5). (The description is based on Suh et al. 2008.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white with membranous and filamentous margins.

Growth in YM broth: After 7 days at 25°C, cells are globose to subglobose, 5–9 × 5–9 μm, occur singly, in pairs, in short chains or in clusters, and pseudohyphae are present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, septate hyphae are present. Aerobic growth is white and fuzzy.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	d	Trehalose	d
Maltose	d		

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	d	Ethylamine	+
2-Keto-D-gluconate	+	50% Glucose	+
D-Glucuronate	–	10% NaCl/5% glucose	w
L-Arabinitol	–	Starch formation	–
Arbutin	–	Urease	–
Propane 1,2 diol	–	DBB	–
Butane 2,3 diol	–	Cycloheximide 0.01%	–
Nitrate	–	Growth at 25°C	+
Cadaverine	+	Growth at 30°C	+
Creatinine	–	Growth at 35°C	–
L-Lysine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY520316, SSU rRNA = AY520186.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27736 (CBS 9896), isolated from the gut of an elaterid beetle (Coleoptera, Elateridae), Barro Colorado Island, Panama.

Type strain: NRRL Y-27736.

Systematics: Based on combined SSU and D1/D2 LSU rRNA gene sequences, *C. gigantensis* belongs to the *Lodderomyces elongisporus* clade, where it forms a basal lineage to *C. buenasvistaensis*, *C. dublinensis* and *C. albicans* (Suh et al. 2008).

Ecology: The species is known only from the gut of an elaterid beetle, Panama.

Biotechnology: Unknown.**Agriculture and food:** Unknown.**Clinical importance:** Unknown.

90.112. *Candida glabrata* (Anderson) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Nakaseomyces* clade (Figs 50.1, 90.1).**Synonyms:***Cryptococcus glabratus* Anderson (1917)*Torulopsis glabrata* (Anderson) Lodder & de Vries (1938)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 2.5–4 × 3–6 μm, and occur singly or in pairs (Fig. 90.70).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent or consist of a few short chains of ovoid cells. Aerobic growth is white, smooth, butyrous and entire.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	–
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D,L-Lactate	+
Soluble starch	–	Succinate	–
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

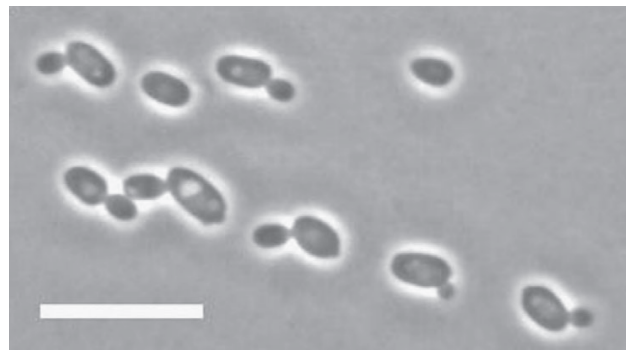


FIGURE 90.70 *Candida glabrata* CBS 138. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	–	Cycloheximide 0.01%	–
L-Lysine	–	Cycloheximide 0.1%	–
Cadaverine	–	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	+

CoQ: 6 (Yamada and Kondo 1972a).**Mol% G + C:** 39.6–40.2, five strains (Mendonça-Hagler and Phaff 1975); 38.5–39.5, two strains (T_m : Nakase and Komagata 1971d).**Gene sequence accession numbers, type strain:** D1/D2 LSU rRNA = U44808, SSU rRNA = AY046237, ITS = AY046165.**Cell carbohydrates:** Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).**Origin of the strain studied:** CBS 138, isolated from human feces.

Other available strains: CBS 858, CBS 859, origin unknown, but probably human; CBS 861, CBS 862, from mouth; CBS 863, from urine; CBS 1518, from baker's yeast; CBS 2192, from sorghum malt; CBS 2498, from culture medium with pH 2; CBS 2661, from calf fetus; CBS 4331, from fermenting passion-fruit juice; CBS 5278 (IGC 2990), origin unknown; CBS 6144, from vagina; CBS 7307, from sputum, New Zealand.

Type strain: CBS 138.

Systematics: Like *C. castellii*, *C. glabrata* is a close relative of species assigned to the new genus *Nakaseomyces* (formerly part of *Kluyveromyces*), as evidenced by multi-gene sequence analysis (Kurtzman 2003). *C. bracarensis* (Correia et al. 2006) and *C. nivariensis* (Alcoba-Flórez et al. 2005) are recently added sister species.

Candida glabrata is physiologically specialized and in this respect bears considerable resemblance to many other oligophagic species with affinities to *Saccharomyces sensu lato*. Separation is difficult as most potentially positive growth responses are variable. However, the utilization of D-gluconic acid, resistance to 10% NaCl, absence of growth on galactose, nitrate and L-lysine, the lack of extracellular protease activity and the fermentative ability appear sufficient to distinguish *C. glabrata* from most similar species.

Ecology: Much of the work on ecological aspects of *C. glabrata* is clinically oriented. Biogeographical and epidemiological studies are facilitated by a multilocus sequence typing initiative (<http://cglabrata.mlst.net/>). A few strains recovered from floricolous insects in Australia keyed perfectly to *C. glabrata* based on growth tests, but differed by 4.1% substitutions in the D1/D2 LSU rRNA gene (AF313362, Lachance et al. 2001d). They have now been reassigned to *C. nivariensis*.

Biotechnology: Unknown.**Agriculture and food:** Unknown.

Clinical importance: *Candida glabrata* is of mounting importance in clinical microbiology. A comprehensive review by Fidel et al. (1999) concludes that the species is emerging as a major pathogen that accounts for an increasingly large proportion of nosocomial fungal infections. Whereas *C. albicans* is considered a primary pathogen because it will infect normal individuals, *C. glabrata* is regarded as a secondary agent, as it is more frequently found in immunocompromised patients, those who have undergone prolonged antimycotic treatment or those who are already victims of a primary infection by *C. albicans*. The infection sites are the same as for *C. albicans*, namely the oral cavity, the urogenital tract and the bloodstream. The yeast is particularly problematic because of an innate resistance to the azole antimycotics, including fluconazole, although systemic treatment can

be effective. Flucytosine, which is not used as widely as the azole drugs, is apparently quite effective. Medical research on *C. glabrata* is hampered by the fact that its pathogenicity for laboratory animals is less than in humans. The fact that *C. glabrata* occurs in the haploid state is thought to be important in the behavior of the microorganism with respect to its lower inherent pathogenicity and higher resistance to therapeutic drugs. Boldo et al. (2003) performed a detailed analysis of 47 isolates from four clinical laboratories in Mexico and found a strikingly low amount of genetic diversity among them. This finding was in disagreement with some previous studies that reported a higher degree of variance and a geographical structuring of the variation. Poláková et al. (2009) suggested that chromosome rearrangements constitute an important factor in the evolution of antifungal drug resistance in the species.

90.113. *Candida glaeobosa* Komagata & Nakase (1965)

Phylogenetic placement: *Candida glaeobosa* clade (Fig. 90.2).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, 2–3 × 3–6 μm, and occur singly, in pairs and dense clusters (Fig. 90.71 top).

Dalmau plate culture on corn meal agar: After 4 days at 25°C, pseudohyphae consist of dense chains of elongated cells (Fig. 90.71 bottom). Aerobic growth is white, smooth, butyrous and entire.

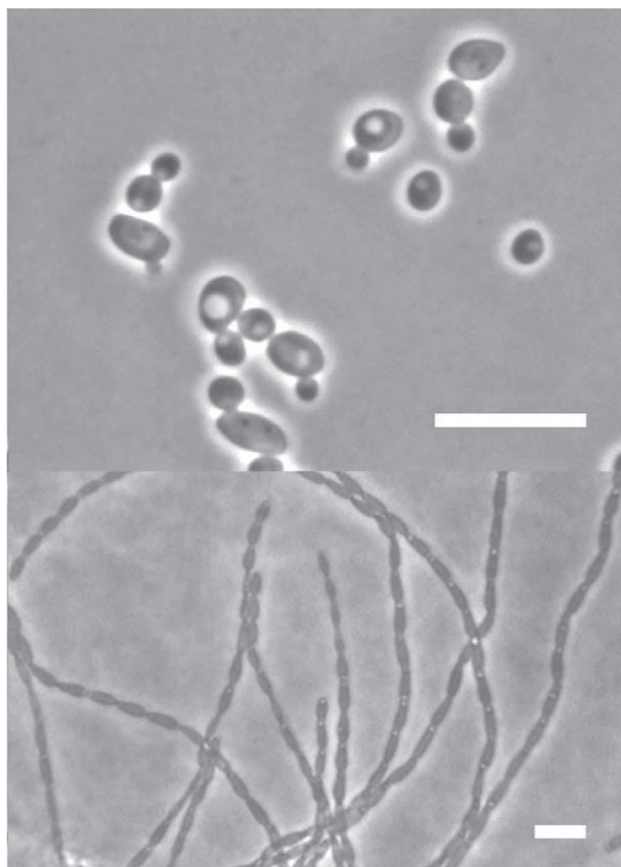


FIGURE 90.71 *Candida glaeobosa* CBS 5691. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μm.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	+	Erythritol	–
Galactose	+	Ribitol	+
Lactose	+	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	v	Citrate	+
Salicin	+	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	v
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	–	Casein	w
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	v
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	–
50% Glucose	–	Growth at 37°C	–

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 42.9, 42.4, CBS 5691 (T_m : Nakase and Komagata 1971f; BD: Meyer et al. 1984, respectively); 41.2–43.1, five strains; 42.5 CBS 5691 (T_m : Suzuki and Nakase 1993).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45757.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 5691, isolated from frozen cuttlefish in Japan.

Type strain: CBS 5691.

Systematics: *Candida glaeobosa* was described on the basis of an isolate from frozen cuttlefish (Komagata and Nakase 1965). The authors reported a similarity with some *Candida* species that have since been removed from the genus as they were of basidiomycetous affinity. The species is a close relative to *C. pseudoglaebosa* and *C. saitoana* as evidenced by rRNA gene sequencing, which places them near the genus *Debaryomyces* (Kurtzman and Robnett 1998a, Sugita and Nakase 1999). The three species were delimited on the basis of DNA reassociation and isoenzyme patterns by Suzuki and Nakase (1993).

Separation of *C. glaeobosa* from *C. pseudoglaebosa* and *C. saitoana* using traditional physiological tests was reported to be difficult (Suzuki and Nakase 1993), and the assimilation of non-standard compounds such as DL-glyceraldehyde and dihydroxyacetone was considered useful for physiological identification. However, it would seem that *C. glaeobosa* can be distinguished from *C. pseudoglaebosa* by

the absence of growth on melezitose and L-sorbose, and from *C. saitoana* by the absence of growth on inulin or at 30°C.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.114. *Candida glucosophila* Tokuoka, Ishitani, S. Goto & Komagata (1987)

Phylogenetic placement: *Meyerozyma* clade (Figs 47.1, 90.2).

Growth in 25% (w/w) glucose–YM broth: After 3 days at 25°C, growth is poor. After 7 days, the cells are globose to subglobose, 4–7 × 4–7 μm, and occur singly, in pairs, in short chains and in clusters.

Growth on 25% (w/w) glucose–YM agar: After 1 month at 25°C, the growth is cream colored, dull, dry, smooth and with an entire margin.

Slide culture on 25% glucose–corn meal agar: Pseudohyphae are not formed.

Fermentation (in Media Containing 10% w/v NaCl)

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	n
Maltose	–		

Growth (in Media Containing 10% w/v NaCl)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	–
Raffinose	–	Glycerol	w
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	n
L-Sorbose	–	D-Glucosamine	n
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	w	Hexadecane	n
L-Arabinose	–	Nitrate	+
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	n	Starch production	–
2-Keto-D-gluconate	n	DBB	–
D-Glucuronate	n	Gelatin	n
Glucono-δ-lactone	n	Casein	n
Amino acid-free	+	Lipase	n
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	–	Cycloheximide 0.1%	–
Cadaverine	–	1% Acetic acid	–
10% NaCl	n	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	+

CoQ: 9 (Tokuoka et al. 1987).

Mol% G + C: 36.6, type strain (*T_m*: Tokuoka et al. 1987).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45849.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 7349, isolated from brown sugar made in Taiwan.

Type strain: CBS 7349.

Systematics: Tokuoka et al. (1987) described *C. glucosophila* based on an isolate from brown sugar. The authors noted a similarity with *C. halonitratophila* (syn. *C. etchellsii*), although the latter differed significantly in DNA base composition. The species is moderately related to *Meyerozyma* (*Pichia*) *guilliermondii* (Kurtzman and Robnett 1998a; Nakase and Suzuki 1999) but bears little phenotypic resemblance to its phylogenetic relatives.

Candida glucosophila is an osmophilic yeast, with optimum growth on medium supplemented with 25% glucose. Assimilation tests can be conducted in media supplemented with 10% NaCl. Few carbon sources are utilized even under those conditions. Separation from the various physiotypes of *C. etchellsii* can be based on growth at 37°C, positive in *C. glucosophila*.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Braendlin (1996) examined the difficulties associated with the enumeration of xerophilic yeasts in foods. In a multi-laboratory study, four complex media were evaluated for their ability to detect *C. glucosophila* and three other species. Media DG18 (containing dichloran and 18% glycerol as selective agents) and MY50G (containing 50% glucose) were the only two media that allowed any growth at all for the species. The media OGYE and DRBC, which contain 20 and 10% glucose, respectively, did not allow detection of the species.

Clinical importance: Unknown.

90.115. *Candida gorgasii* S.-O. Suh, N.H. Nguyen & M. Blackwell (Suh et al. 2005b)

Phylogenetic placement: *Yamadazyma* clade (Fig. 90.2).

(The description is based on Suh et al. 2005b.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, smooth and butyrous.

Growth in YM broth: After 7 days at 25°C, cells are globose to subglobose, 3–5 × 3–5 μm, occur singly, in pairs, in short chains or in clusters, and pseudohyphae are present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae are present. Aerobic growth is white and slightly fuzzy.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	d
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	d
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	+	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+

Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	w
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	d
L-Rhamnose	+	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	—
D-Arabinose	d	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	+	Ethylamine	+
2-Keto-D-gluconate	w	50% Glucose	—
D-Glucuronate	—	10% NaCl/5% glucose	+
Arbutin	+	Starch formation	—
Propane 1,2 diol	d	Urease	—
Butane 2,3 diol	—	DBB	—
Nitrite	—	Cycloheximide 0.01%	—
Cadaverine	+	Growth at 30°C	+
Creatinine	—	Growth at 35°C	+
L-Lysine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU = AY964670, SSU rRNA = AY520170, ITS and 5.8S rRNA = AY520300.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27707 (CBS 9880), isolated from the gut of an unidentified cerambycid beetle (Cerambycidae), Barro Colorado Island, Panama.

Type strain: NRRL Y-27707.

Systematics: Based on a combined analysis of SSU and D1/D2 LSU rRNA gene sequences, *C. gorgasii* forms a well-supported clade with *C. amphixiae*, *C. cerambycidarum*, *C. michaelii*, *C. endomychidarum* and *C. lessepsii*. *C. membranifaciens*, *C. friedrichii*, *C. blattariae* and *C. buinensis* form a sister clade to the above-listed species (Suh et al. 2005b).

Ecology: The single strain originated from the gut of an unidentified cerambycid beetle, Panama.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

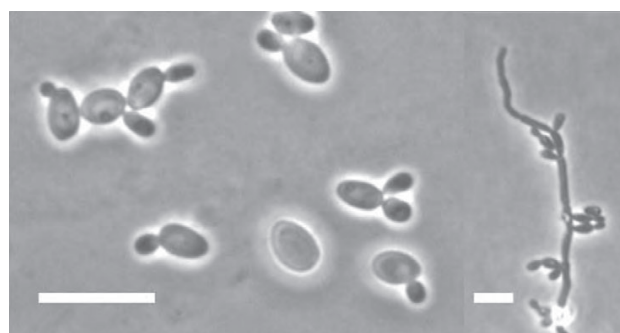


FIGURE 90.72 *Candida gotoi* CBS 8521. Budding cells after 3 days, 25°C, YM agar (left) and pseudohyphae after 14 days, 18°C, YCBAS agar (right). Bars = 10 μ m.

Fermentation

Glucose	+	Lactose	—
Galactose	s	Raffinose	—
Sucrose	+	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	+
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	w
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	—
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	+	Nitrate	—
D-Arabinose	—	Vitamin-free	+

90.116. *Candida gotoi* Nakase & Suzuki (1997)

Phylogenetic placement: *Hyphopichia* clade (Figs 33.1, 90.1).

(Some of the morphological characteristics are based on Nakase and Suzuki 1997.)

Growth on YM agar: After 1 month at 17°C, the streak culture is grayish-white, smooth, dull to shiny, soft to butyrous and the margin is entire or partly fringed with pseudohyphae.

Growth in YM broth: After 3 days at 25°C, the cells are spherical, ovoid, to elongate, $3.5\text{--}6.5 \times 3.5\text{--}7 \mu\text{m}$, and occur singly, in pairs, in chains or as pseudohyphae (Fig. 90.72 left). The pseudohyphal cells are $2\text{--}3 \mu\text{m}$ in diameter and up to $12 \mu\text{m}$ long. After a month, islets are present.

Dalmau plate culture on potato dextrose agar: Well-developed pseudohyphae are abundantly produced (Fig. 90.72 right).

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	w
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	w

CoQ: 8 (Nakase and Suzuki 1997).

Mol% G + C: 41.6, type strain (HPLC: Nakase and Suzuki 1997).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY489112.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 8531 (JCM 10145), isolated from insect frass in Japanese maple (*Acer palmatum*, Aceraceae).

Type strain: CBS 8531.

Systematics: *Candida gotoi* was described on the basis of a strain from maple frass by Nakase and Suzuki (1997). DNA base composition and DNA reassociation separated the species from others that were reported to be similar in nutritional characteristics, namely *C. homilentoma*, *C. silvarorum* and *Hyphopichia (Pichia) burtonii*. Suzuki and Nakase (1999) later demonstrated a relationship with those species and a few others, the closest being *C. rhagii* and *C. sequanensis*. *C. rhagii* differs by 13 substitutions in the SSU rRNA gene, suggesting a close relationship. As the D1/D2 LSU rRNA gene sequence was not available in GenBank, it was determined (AY489112) for this study and found to differ from that of *Pichia heimii* by 24 substitutions and that of *C. rhagii* by 26 substitutions, which identified these species as distinct but related members of a small, isolated clade. The relationship of the clade to *Hyphopichia burtonii* and relatives is better supported in the phylogeny based on the SSU rRNA gene (Suzuki and Nakase 1999).

Candida gotoi is physiologically similar to related species in the *Hyphopichia heimii* clade. The most useful growth characteristics for separation are the utilization of raffinose, and L-rhamnose, combined with the absence of growth on melibiose, lactose, starch, L-sorbose and galactitol.

Ecology: Although *C. gotoi* is known from only a single isolate, its isolation from insect frass in a tree is consistent with the isolation of *Hyphopichia heimii* from insect-infested decaying wood (Pignal 1970) and *C. rhagii* from cerambycid beetles and their larvae (Jursitz et al. 1960), and suggests a possible association with wood-boring insects.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.117. *Candida grinbergii* Kurtzman (2007a)

Phylogenetic placement: *Sugiyamaella* clade (Figs 72.1, 90.3).

(The description is based on Kurtzman 2007a.)

Growth on 5% malt extract agar: After 3 days at 25°C, yeast cells are spherical, 3–5.5 µm, to ellipsoidal, 1.5–4 × 2.5–8 µm, occur singly or in pairs and reproduce by multilateral budding (Fig. 90.73A). Growth is tannish-white, dull and butyrous.

Growth on the surface of assimilation media: Pellicles are formed on stationary liquid media by NRRL Y-27115, but not by NRRL Y-27117.

Dalmau plate culture on morphology agar: After 7 days at 25°C, a few pseudohyphae occur, but true hyphae are absent (Fig. 90.73B). Occasionally true hyphae are formed in 3-day-old cultures on 5% ME. Aerobic growth on morphology agar is tannish-white, smooth, dull-glistening and butyrous.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	+	Trehalose	+
Maltose	–		

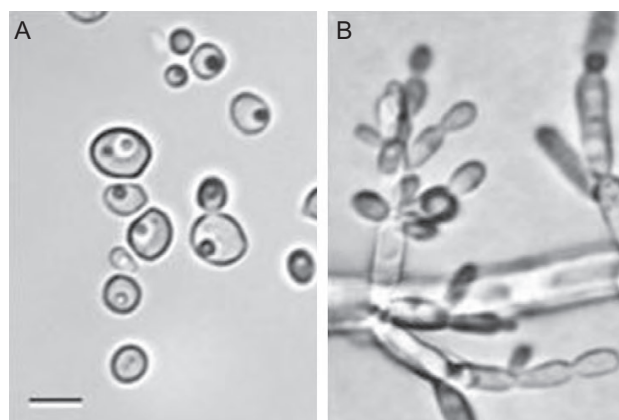


FIGURE 90.73 *Candida grinbergii* NRRL Y-27117. Budding cells after 3 days, 25°C, 5% malt extract agar (A) and pseudohyphae after 7 days, 25°C, yeast morphology agar (B). Bar = 5 µm.

Growth (in Liquid Media)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	w	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D,L-Lactate	+
Soluble starch	–	Succinate	w
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	v

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	+	Starch formation	–
5-Keto-D-gluconate	+	Gelatin liquefaction	–
Saccharate	–	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 37°C	–
10% NaCl/5% glucose	–		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA = DQ438199, ITS = DQ911443, mitochondrial SSU rRNA = DQ442729, COXII = DQ443056.

Cell carbohydrates: Not determined.

Origin of the strains studied: NRRL Y-27117 (CBS 5924), NRRL Y-27115 (CBS 5113), isolated from a bark beetle (*Hylurgonotus*

brunneus, Coleoptera: Scolytidae) in rotted stems of monkey puzzle (*Araucaria* sp., Araucariaceae), Chile.

Type strain: NRRL Y-27117.

Systematics: A combined analysis of the LSU rRNA gene, the mitochondrial SSU rRNA gene and the COXII gene revealed that *C. grinsbergii* belongs to the *Sugiyamaella* clade, where it forms a weak basal lineage with *C. pinicola*, *C. neomexicana* and *Sugiyamaella japonica* (Kurtzman 2007a).

Ecology: Known only from a bark beetle (*Hylurgonotus brunneus*) in rotted *Araucaria* stems, Chile (Kurtzman 2007a).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.118. *Candida gropengiesseri* (Harrison) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

Synonyms:

Torula gropengiesseri Harrison (1928)

Torulopsis gropengiesseri (Harrison) Lodder (1934)

Cryptococcus gropengiesseri (Harrison) Skinner (1950)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are long-ovoid, 1.5–2 × 3–7 µm, and occur singly or in pairs (Fig. 90.74).

Dalman plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present. Aerobic growth is off-white to cream colored, glistening, soft, butyrous and with an entire margin.

Fermentation

Glucose	s	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

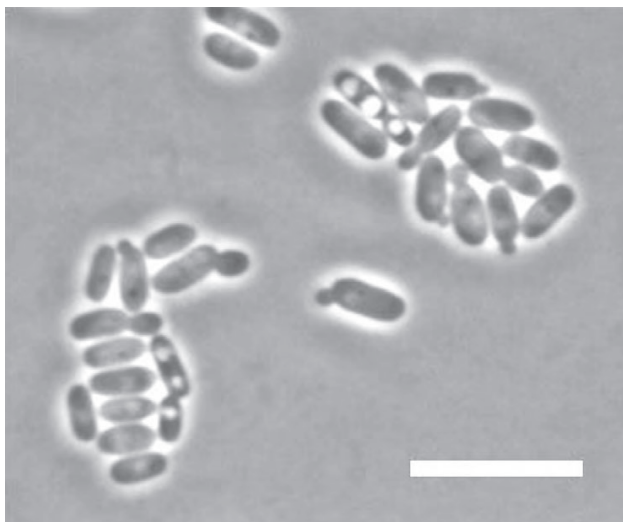


FIGURE 90.74 *Candida gropengiesseri* CBS 156. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	+	Ethanol	v
Raffinose	+	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	v	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D-Lactate	–
Soluble starch	–	Succinate	v
Cellobiose	v	Citrate	+
Salicin	v	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	v	Hexadecane	+
L-Arabinose	–	Nitrate	–
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	v	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	v	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	v
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	v

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 55.7, CBS 156 (BD: Meyer et al. 1984); 57.1, CBS 156 (T_m : Nakase and Komagata 1971d).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45721.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 156, isolated from the cocoon of cockroach (*Periplaneta orientalis*, Blattidae).

Other strains: CBS 6387, human toe, Denmark; CBS 7074, from a citrus product, Israel.

Type strain: CBS 156.

Systematics: *Candida gropengiesseri* is a well-resolved member of the *Starmerella sensu lato* clade (Fig. 71.1) as indicated by analysis of D1/D2 LSU (Kurtzman and Robnett 1998a) and SSU (Suzuki et al. 1999) rRNA gene sequences.

Identification by physiology is impractical, if not impossible, due to the variability reported in characteristics that might have diagnostic value, such as the utilization of galactose, β-glucosides, L-sorbose and others. Replica plating gave a negative response for L-sorbose utilization by the type strain, in contrast to previous reports.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.119. *Candida guaymorum* S.-O. Suh & M. Blackwell (Suh et al. 2004b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5). (The description is based on Suh et al. 2004b.)

Growth on YM agar: After 7 days at 25°C, colonies are white to cream colored with a pale-pinkish perimeter on some old colonies, smooth, shiny, flat and with a filamentous margin.

Growth in YM broth: After 7 days at 25°C, cells are globose to ellipsoidal, $1.3-6 \times 7-13 \mu\text{m}$, occur singly, in pairs or in short chains, and pseudohyphae are present.

Dalmeu plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae are present, but septate hyphae are absent. Aerobic growth is white, shiny, smooth and with a filamentous margin.

Fermentation

Glucose	+	Lactose	—
Galactose	d	Raffinose	—
Sucrose	v	Trehalose	+
Maltose	v		

Growth (in Liquid Media)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+/w
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	D-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	d/w
D-Sorbose	—	D-Glucosamine	+/w
D-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	50% Glucose	+
2-Keto-D-gluconate	+	10% NaCl/5% glucose	+
D-Glucuronate	—	Starch formation	—
Arbutin	+	Urease	—
Propane 1,2 diol	—	DBB	—
Butane 2,3 diol	—	Cycloheximide 0.01%	—
Nitrite	—	Growth at 25°C	+
Cadaverine	+	Growth at 30°C	+
Creatinine	—	Growth at 35°C	v
L-Lysine	+	Growth at 40°C	—
Ethylamine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY242350, SSU rRNA = AY242238.

Cell carbohydrates: Not determined.

Origin of the strains studied: BG 01-7-26-006A-2-1 isolated from gut of an erotyloid beetle (*Iphichus* (*Habrodactylus*) *conspicillatus*, Erotylidae) on an imbricate mushroom; BG 02-7-16-022A-1-1, from gut of skink (*Cyclomorphus* sp., Erotylidae) on a polypore; BG 02-7-20-020A-1-1, from gut of erotyloid beetle (*Iphichus* sp., Erotylidae) on a corticioid fungus; BG 02-7-2-020B-1-1, from gut of skink (*Cyclomorphus* sp., Erotylidae) on a corticioid fungus; NRRL Y-27568 (CBS 9823), isolated from gut of erotyloid beetle (*Mycotretus interstitialis*, Erotylidae), on an imbricate mushroom; NRRL Y-27581 (BG 01-7-21-003A-1-1), from gut of scarab beetle (*Onthophagus* sp., Scarabidae) on a polypore mushroom (*Polyporus* sp.), all from Barro Colorado Island, Panama (Suh et al. 2004b).

Type strain: NRRL Y-27568.

Systematics: Based on phylogenetic analysis of SSU and D1/D2 LSU rRNA gene sequences, *C. guaymorum* belongs to the *C. tanzawaensis* clade, where it forms a cluster with *C. bokatorum* and *C. kunorum* (Suh et al. 2004b).

Ecology: All isolates were obtained from the gut of various beetles in Panama.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.120. *Candida haemulonii* (van Uden & Kolipinski) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Metschnikowia* clade (Fig. 90.1).

Synonym:

Torulopsis haemulonii van Uden & Kolipinski (1962)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose, ovoid and ellipsoidal, $2-7 \times 2-7 \mu\text{m}$, and occur singly or in pairs (Fig. 90.75). A ring or a thin pellicle may be present.

Dalmeu plate culture on corn meal agar: After 14 days at 25°C, poorly developed pseudohyphae are sometimes present. Aerobic growth is off-white to light beige, smooth and butyrous, and with an entire border.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	+	Trehalose	+/s
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	—
Raffinose	s	Glycerol	w
Melibiose	—	Erythritol	—
Galactose	w	Ribitol	s
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	w	myo-Inositol	—
Methyl- α -D-glucoside	—	D-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	w
Salicin	—	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	s
L-Rhamnose	w	N-Acetyl-D-glucosamine	+
D-Xylose	—	Hexadecane	s
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	w

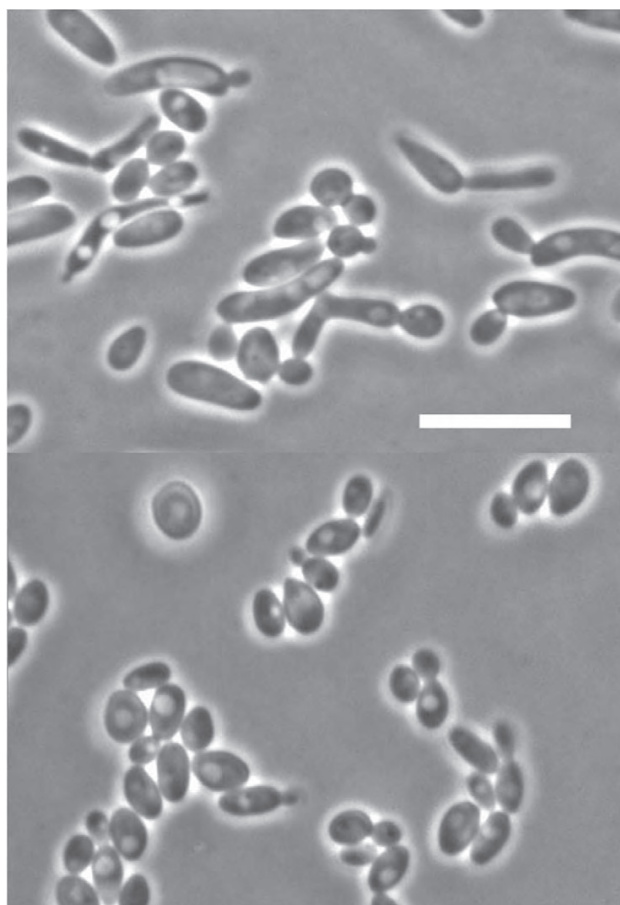


FIGURE 90.75 *Candida haemulonii*. Budding cells after 3 days, 25°C, YM agar. Type I strain CBS 5149 (top) and Type II strain CBS 6915 (bottom). Bar = 10 μ m.

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	s
Glucono- δ -lactone	w	Casein	+
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	–

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 45.9–46.1, two strains (T_m : Nakase and Komagata 1971d); 47.8, CBS 5149 (T_m : Meyer et al. 1984); 45.4, CDC 86-041135; 46.3, CBS 5149; 47.9, CBS 7801 (T_m : Gargeya et al. 1991); 45.6–46.3, eight strains including the type strain, 46.1 (T_m : Ribeiro 1995).

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = U44812. Strain NRRL Y-17801 (type II) D1/D2 LSU rRNA = U44819.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5149, isolated from the gut of fish (bluestriped grunt, *Haemulon sciurus*); CBS 6915 (DBVPG 6960), origin unknown. Other available strains: CBS 5150, isolated from seawater, Portugal; CBS 5468, from seawater in Biscayne Bay, Florida, USA; CBS 6332, from skin of dolphin, Suriname; CBS 6590, CBS 7801 and CBS 7802, from clinical specimens; CBS 8125, from furniture polish.

Type strain: CBS 5149.

Systematics: Van Uden and Kolipinski (1962) described *Torulopsis haemulonii* to accommodate strains isolated from the gut of a fish as well as seawater samples from Florida and Portugal. Lehmann et al. (1993) studied 25 clinical isolates identified as *C. haemulonii*. Examination of electrophoretic isoenzyme profiles, DNA base composition, DNA reassociation, morphology and physiology suggested the existence of two distinct groups. The DNA reassociation between members of the two groups was less than 28%, indicating the existence of two different species. The type strain and 11 isolates were designated as group I (type I) and the remaining 14 isolates made up group II (type II). Group I strains gave negative or latent reactions on galactose, L-sorbose, melezitose, L-arabinose, galactitol and methyl- α -D-glucoside, whereas group II strains gave positive responses. Ribeiro (1995) examined strains available in the CBS to determine if they could be assigned to these groups. DNA reassociation and restriction fragment length polymorphisms showed that most of the strains belonged to group I and were considered valid members of *C. haemulonii*. One strain demonstrated significant DNA reassociation with members of group II. The D1/D2 LSU rRNA gene sequences (Kurtzman and Robnett 1998a) of the two groups differ by 74 substitutions and 20 gaps, but nonetheless confirm that they represent closely related species in the Metschnikowiaceae clade. Analysis of the SSU sequence of the type (Sugita and Nakase 1999) with all other available sequences confirms this placement and further localizes the species in a basal position with respect to a number of *Candida* species that have an affinity to the genus *Clavispora*.

Growth responses are variable within groups and of little utility in identification. Characterization of the type strain (group I) and strain CBS 6915 (group II) by replica plating revealed much similarity between the two. The rapid utilization of galactitol by group II strains and the ability to grow in the presence of 10% NaCl appear to be the most reliable criteria for separation. The reported ability to grow in the presence of 0.1% cycloheximide was not confirmed.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Although group I strains deposited in the CBS are from diverse origins, including marine sources, the majority of known isolates in both groups are of clinical origin and in particular from thickened toenails and skin ulcers of feet and legs (Lehmann et al. 1993). Strains of *C. haemulonii* and undescribed related species exhibited fairly strong reactions for hydrolysis of casein and Tween 80, two properties that are often associated with yeasts that have a potential for infection. However, the inability of group I strains to grow well at 37°C would seem to preclude deep mycoses.

Additional comments: Group II strains should be recognized as a new species. These include strains CBS 6915, received from S. Windish, and strains CBS 7798, CBS 7799 and CBS 7800, which are clinical specimens.

90.121. *Candida hawaiiiana* Lachance, Bowles & Starmer (Lachance et al. 2003b)

Phylogenetic placement: *Metschnikowia* clade (Figs 46.1, 90.1). (The description is based on Lachance et al. 2003b.)

Growth on malt agar: After 2 weeks at 17°C, colonies are low convex to convex, glossy, smooth, white and butyrous.

Growth in 0.5% yeast extract–2% glucose broth: After 3 days at 25°C, the cells are spherical to ovoid, 3–4 × 4–6 μm, and occur singly or in parent–bud pairs. Transversely compressed buds may be formed.

Dalmau plate culture on glucose yeast extract agar: After 2 weeks, pseudohyphae and true hyphae are absent.

Fermentation

Glucose	+	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (in Liquid Media)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	+	Ethanol	v
Raffinose	–	Glycerol	+/s
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	s/w
Lactose	–	Galactitol	–
Trehalose	s/w	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+/s
Salicin	+	D-Gluconate	s/w
L-Sorbose	+	D-Glucosamine	s
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	–	Nitrate	–
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	50% Glucose	+
2-Keto-D-gluconate	+	10% NaCl/5% glucose	+
Amino acid-free	+	Gelatin liquefaction	–
Nitrite	–	Cycloheximide 0.1%	–
Cadaverine	+	Growth at 30°C	+
L-Lysine	+	Growth at 37°C	–
Ethylamine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF514293.

Cell carbohydrates: Not determined.

Origin of the strains studied: UWOPS91-698.3 (CBS 9146, NRRL Y-27473), isolated from the flower of morning glory (*Ipomoea indica*, Convolvulaceae) on a roadside, Manuka Natural Reserve, Hawai'i; UWOPS 02-183.3, isolated from sap beetle (*Conotelus* sp.) on morning glory (*I. indica*), Kipuka Puau, Hawai'i; UWOPS 01-677b1, from *Conotelus* sp. on woodrose (*Merremia tuberosa*, Convolvulaceae), Dos Rios, Costa Rica.

Type strain: CBS 9146.

Systematics: Sequence analysis of the D1/D2 domains of the LSU rRNA gene placed *C. hawaiiiana* in the *Metschnikowia* clade, where it seems related to *M. agaves* and an unidentified *Candida* sp. (Lachance et al. 2003b). A close link was later identified with *M. orientalis* (Lachance et al. 2006b).

Ecology: The habitat of *C. hawaiiiana* is in flowers of Convolvulaceae and associated insects in Hawai'i and Costa Rica.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.122. *Candida heliconiae* Ruivo, Pagnocca, Lachance & Rosa (Ruivo et al. 2006)

Phylogenetic placement: *Nakazawaea* clade (Fig. 90.4).

(The description is based on Ruivo et al. 2006.)

Growth on YM agar: After 4 days at 25°C, colonies are cream colored or white, low-convex, smooth and butyrous.

Growth in 0.5% yeast extract–2% glucose broth: After 3 days at 25°C, cells are spherical to ovoid, 3–5 × 3–5 μm, occur singly or in budding pairs and reproduce by multilateral budding.

Dalmau plate culture on corn meal agar: After 2 weeks, pseudohyphae and true hyphae are absent.

Fermentation

Glucose	+	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	+	Citrate	–
Salicin	w	D-Gluconate	s
L-Sorbose	+	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	v	Nitrate	–
D-Arabinose	+	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	–	10% NaCl/5% glucose	–
2-Keto-D-gluconate	–	Urease	–
5-Keto-D-gluconate	–	DBB	–
Nitrite	–	Cycloheximide 0.01%	+
Cadaverine	+	Cycloheximide 0.1%	+
L-Lysine	+	Growth at 35°C	+
Ethylamine	+	Growth at 37°C	–
50% Glucose	–		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY566406.

Cell carbohydrates: Not determined.

Origin of the strain studied: UNESP 00-91C1 (CBS 10000, NRRL Y-27813), isolated from water accumulated in flower bracts of *Heliconia velloziana* (Heliconiaceae, Zingiberales) in Brazil.

Type strain: CBS 10000.

Systematics: The phylogenetic position of *C. heliconiae* is not yet settled. Based on an analysis of the D1/D2 domains of the LSU rRNA gene, the species shows a weak relationship with *Yamadazyma mexicana* and *C. sinolaborantium* (Ruivo et al. 2006).

Ecology: The species is known only from water accumulated in flower bracts of *Heliconia* in Brazil.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.123. *Candida hispaniensis* Kurtzman (2005b)

Phylogenetic placement: *Yarrowia* clade (Figs 82.1, 90.3). (The description is based on Kurtzman 2005b.)

Growth on 5% malt extract agar: After 3 days at 25°C, yeast cells are spherical, 3–6 µm, to elongate, 2–4 × 4–9 µm, occur singly or in pairs and reproduce by multilateral budding (Fig. 90.76A–C). Additionally, some of the cells show tapered outgrowths that form blastoconidia and these outgrowths may become quite long. The ends of the outgrowths are often denticulate and bear blastoconidia on the denticles. Growth is white, semi-glistening and butyrous.

Dalmat plate culture on yeast morphology agar: After 7 days at 25°C, growth under the coverglass is sparse with “tree-like” outgrowths of undifferentiated cells (Fig. 90.76D). Pseudohyphae and true hyphae are not present. However, some pseudohyphal outgrowths were detected on YM agar after 3 months at 25°C. Aerobic growth is white with a dull surface, low convex, butyrous and with a finely lobate margin.

Fermentation: Absent.

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	v
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	w	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	+
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	–	Starch formation	–
5-Keto-D-gluconate	–	Gelatin liquefaction	+
Saccharate	–	Cycloheximide 0.01%	+
Cadaverine	+	Cycloheximide 0.1%	+
10% NaCl/5% glucose	–	Growth at 37°C	v



FIGURE 90.76 *Candida hispaniensis* NRRL Y-5580. Budding cells (A) and cell with conidiogenous protuberance (B) after 1 day, YM agar; cells with denticles after 3 days, 5% malt extract agar (C); chain of cells after 7 days, yeast morphology agar (D); all at 25°C. Bar = 5 µm.

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY789654.

Cell carbohydrates: Not determined.

Origin of the strains studied: NRRL Y-5580 (CBS 9996), NRRL Y-5579 (CBS 9995), both isolated from a larva of longhorn beetle (*Spondylus buprestoides*) collected in a conifer forest near El Ventorrillo, Spain, April 1960, by J. Santa María and sent to L.J. Wickerham, NCAUR, Peoria, Illinois, USA.

Type strain: NRRL Y-5580.

Systematics: D1/D2 LSU rRNA gene sequence analysis placed *C. hispaniensis* in the *Yarrowia* clade, closely related to *Y. lipolytica*, *C. galli* and *C. bentonensis* (Kurtzman 2005b).

Ecology: The species is known only from a larva of longhorn beetle in Spain.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.124. *Candida hollandica* Knutsen, V. Robert & M.Th. Smith (Knutsen et al. 2007)

Phylogenetic placement: *Yarrowia* clade (Figs 82.1, 90.3).

(The description is based on Knutsen et al. 2007.)

Growth in YM broth: After 3 days at 25°C, cells are ovoid to globose, 3–5 × 5–9 μm, occur singly, in pairs and in small clusters, and reproduction is by multilateral budding.

Dalmau plate culture on YM agar: After 3 days at 25°C, pseudohyphae and true hyphae are present.

Fermentation: Absent.

Growth (in Microplates)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	n
Sucrose	–	Ethanol	n
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	w
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	w
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D-Lactate	+
Soluble starch	–	Succinate	+
Cellulobiose	–	Citrate	+
Salicin	–	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	–	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	L-Lysine	+
5-Keto-D-gluconate	–	Ethylamine	–
D-Glucuronate	–	Starch formation	–
L-Arabinitol	–	10% NaCl/5% glucose	+
Propane 1,2 diol	w	Cycloheximide 0.1%	+
Butane 2,3 diol	–	Growth at 27°C	+
Cadaverine	+	Growth at 30°C	+
Creatinine	–	Growth at 35°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AM268482, ITS = AM279270.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 4855 (NRRL Y-48254), isolated from the back of a cow, The Netherlands.

Type strain: CBS 4855.

Systematics: Sequence analysis of the combined D1/D2 LSU rRNA gene and ITS regions showed that *C. hollandica* belongs to the *Yarrowia lipolytica* clade, in which it forms a basal lineage with *C. alimentaria* (Knutsen et al. 2007).

Ecology: Known from the back of a cow.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.125. *Candida homilentoma* van der Walt & Nakase (1973)

Phylogenetic placement: *Hyphopichia* clade (Figs 33.1, 90.1).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to elongate, 2.5–3.5 × 3–4.5 μm, and occur singly or in pairs (Fig. 90.77 top).

Dalmau plate culture on corn meal agar: After 3 days at 25°C, pseudohyphae of long cylindrical cells and septate hyphae with few blastoconidia are present (Fig. 90.77 bottom). Aerobic growth is off-white, dull and wrinkled with a mycelial border.

Fermentation

Glucose	+	Lactose	–
Galactose	s	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	s		

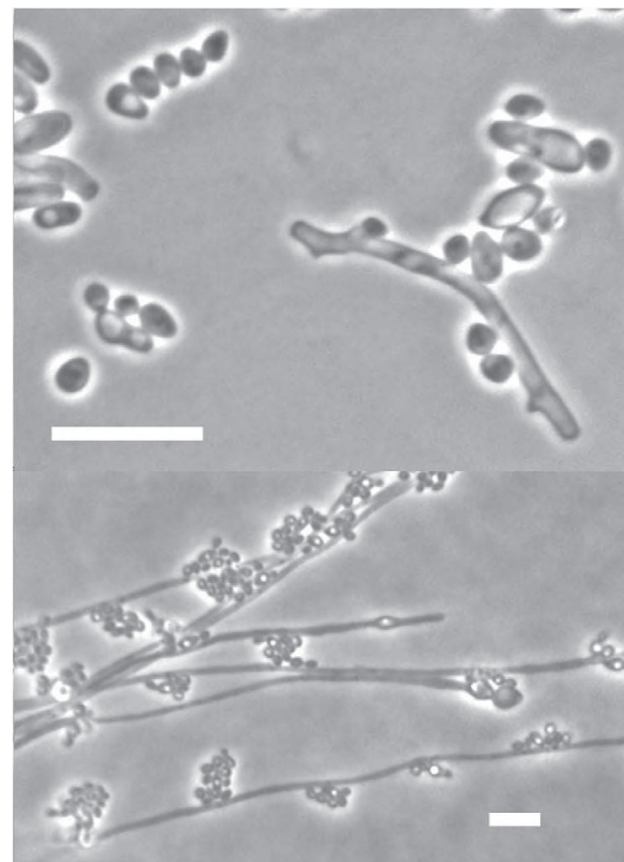


FIGURE 90.77 *Candida homilentoma* CBS 6312. Budding cells and hyphal fragment after 3 days, 25°C, YM agar (top) and true/pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μm.

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	v
L-Sorbose	—	D-Glucosamine	s
L-Rhamnose	+	N-Acetyl-D-glucosamine	—
D-Xylose	+	Hexadecane	—
L-Arabinose	s	Nitrate	—
D-Arabinose	—	Vitamin-free	v

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	s	Casein	+
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	v

CoQ: 8 (Suzuki and Nakase 1998).

Mol% G + C: 48.3, CBS 6099; 49.0, CBS 6312 (T_m : van der Walt and Nakase 1973).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45716.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6312, isolated from frass of auger beetle (*Sinoxylon ruficorne*, Coleoptera: Bostrichiae) infesting red bushwillow (*Combretum apiculatum*, Combretaceae), South Africa.

Other strain available: CBS 6099, tunnel of auger beetle (*Xylion adustus*, Coleoptera: Bostrichiae) infesting sycamore fig (*Ficus sycomorus*, Moraceae), South Africa.

Type strain: CBS 6312.

Systematics: The two strains described as *C. homilentoma* were initially thought to be starch-assimilating, vitamin-independent variants of *C. diddensiae* by van der Walt and Nakase (1973). However, significant differences in DNA base composition indicated that they represented a separate species. Analysis of D1/D2 LSU rRNA gene sequences (Kurtzman and Robnett 1998a) and SSU sequences (Suzuki and Nakase 1999) suggests a relationship with the genus *Hyphopichia*. A close relationship to *C. diddensiae* can be ruled out.

The species is polyphagic and consequently can be mistaken for certain members of the *Debaryomyces* clade. The utilization of L-rhamnose or the absence of growth on L-rhamnose or D-arabinose is useful for separation from most similar species. Replica plating indicated that the type strain assimilates N-acetyl-D-glucosamine as sole carbon source.

Ecology: Like related species, *C. homilentoma* appears to be associated with tree-inhabiting beetles.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.126. *Candida humilis* (E.E. Nel & van der Walt) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: Saccharomycetaceae (Fig. 90.1), *Kazachstania* clade (Fig. 34.1).

Synonym:

Torulopsis humilis E.E. Nel & van der Walt (1968)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, 3–6 $\times$ 5–8 μ m, and occur singly or in pairs (Fig. 90.78).

Dalmay plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present. Aerobic growth is off-white, smooth, glistening and butyrous, and with an entire edge.

Fermentation

Glucose	+	Lactose	—
Galactose	+	Raffinose	—
Sucrose	—	Trehalose	+
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	v
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	—
Maltose	—	D-Glucitol	—
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	+
Soluble starch	—	Succinate	—
Cellobiose	—	Citrate	—
Salicin	—	D-Gluconate	—
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	—	Cycloheximide 0.01%	+
L-Lysine	—	Cycloheximide 0.1%	—
Cadaverine	—	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 6 (Suzuki and Nakase 1998).

Mol% G + C: 47.1, CBS 5658 (T_m : Meyer et al. 1984).

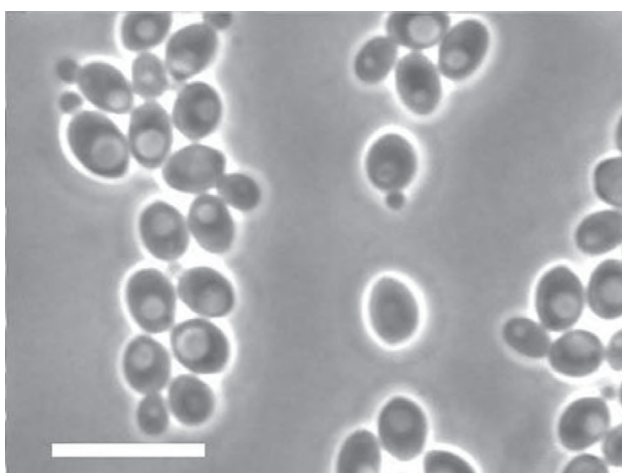


FIGURE 90.78 *Candida humilis* CBS 5658. Budding cells after 3 days, 25°C, YM. Bar = 10 μ m.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U69878.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5658, isolated from Bantu beer; UWOPS 92-219.1 and several others from fermenting agave extract in a tequila factory, Mexico; UFMG P-220-2, spontaneous fermentation of sour cassava starch, Minas Gerais, Brazil.

Type strain: CBS 5658.

Systematics: *Candida humilis* was described by Nel and van der Walt (1967) to accommodate a strain isolated from Bantu beer. Kurtzman and Robnett (1998a) found the type strains of *C. humilis* and *C. milleri* to differ by only one substitution in the D1/D2 LSU rRNA gene and suggested that the two might be conspecific. However, the type cultures were later found to differ by 10 substitutions in the rDNA ITS regions and 11 substitutions in the elongation factor 1 α gene sequences (Kurtzman and Robnett 2003), indicating that a nomenclatural change would be premature. The SSU rRNA gene sequences of the two strains are nearly identical (Kurtzman and Robnett 2003). Based on that multi-gene sequence analysis, *C. humilis* is a member of the *Kazachstania* sub-clade that includes *K. bulderi* and *K. exigua* (Fig. 34.1).

In the present study, the type cultures of *C. humilis* and *C. milleri* were found to differ in the assimilation of sucrose and raffinose, negative in *C. humilis*, which is in agreement with the original descriptions (Nel and van der Walt 1967, Yarrow 1978). Some of the strains from agave extract were capable of growth in the presence of 1% acetic acid.

Ecology: In a study of 138 strains isolated from sourdough in a bakery, Gullo et al. (2003) reported that 97% of the strains utilized trehalose but not sucrose and concluded that these strains belonged to *C. humilis*. They further reported that *C. humilis* and *C. milleri* were discernable by HaeIII digestion of amplified ITS, but did not state whether the restriction patterns correlated well with the growth responses. Lachance (1994) reported that *C. milleri* was an important component of the yeast community found in a natural tequila fermentation. Determination of the ITS and D1/D2 LSU rRNA gene sequences in a representative strain (UWOPS 92-219.1, AY493349) showed that the isolates are closer to *C. humilis*. The strain differed from the type of *C. humilis* by three substitutions in the ITS1 and one in the D1/D2. In contrast, the numbers of substitutions observed when compared to *C. milleri* were 12 and 2, respectively.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.127. *Candida hungarica* Péter, Tornai-Lehoczki, Fülöp & Dlačhy (2003)

Phylogenetic placement: Basal to the *Ogataea* (Figs 53.1, 90.4) and *Kuraishia* clade (Fig. 39.1).

(The description is based on Péter et al. 2003.)

Growth on malt agar: After 3 days at 25°C, the streak culture is raised, butyrous, cream colored, smooth, semi-glistening and with an entire to finely undulating margin.

Growth in malt extract broth: After 3 days at 25°C, the cells are spherical to ellipsoidal, 1.5–4.5 $\times$ 2.3–5.5 μ m, occur singly, in pairs, in short chains or in small clusters and reproduce by multilateral budding (Fig. 90.79). A pellicle is absent, but sediment is formed.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, poorly developed pseudohyphae are produced, but septate hyphae are not formed.

Fermentation

Glucose	v	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	+
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+/s
Melibiose	–	Erythritol	–
Galactose	s/ws	Ribitol	+
Lactose	+	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	s	DL-Lactate	+/s
Soluble starch	w	Succinate	+
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	v
L-Sorbose	+	D-Glucosamine	s
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	v	Nitrate	+
D-Arabinose	+	Vitamin-free	v

Additional Growth Tests and Other Characteristics

Xylitol	+	Ethylamine	+
2-Keto-D-gluconate	–	50% Glucose	–
L-Arabinitol	–	10% NaCl/5% glucose	–
Propane 1,2 diol	–	Urease	–
Butane 2,3 diol	–	DBB	–
Nitrite	+	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 30°C	+
Creatinine	–	Growth at 35°C	–
L-Lysine	+		

CoQ: 9 (Péter et al. 2003).

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY029355.

Cell carbohydrates: Not determined.

Origin of the strains studied: NCAIM Y 01507 (CBS 9254) and NCAIM Y 01508 (CBS 9255), both isolated from rotten wood of oak

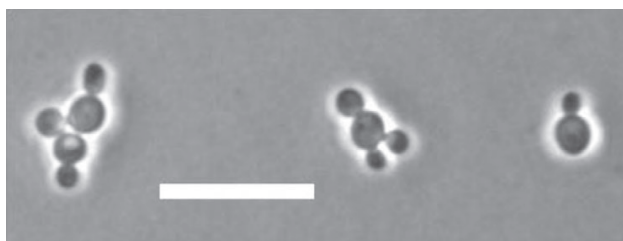


FIGURE 90.79 *Candida hungarica* CBS 9254. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

(*Quercus* sp., Fagaceae), from Gödöllő and Pilis Mountain, respectively, Hungary.

Type strain: NCAIM Y 01507.

Systematics: Based on sequence analysis of the D1/D2 domains of the LSU rRNA gene, *C. hungarica* belongs to the *Kuraishia capsulata* clade, together with *K. capsulata*, *C. cidri* and *C. molischiana* (Péter et al. 2003).

Ecology: The species is known only from rotten wood of oak in Hungary.

Biotechnology: Unknown. *C. hungarica* is methylotrophic.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.128. *Candida hyderabadensis* Rao, Bhadra, Kumar & Shivaji (2007)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Fig. 90.5).

(The description is based on Rao et al. 2007.)

Growth on YM agar: After 2 days at 28°C, colonies are smooth, butyrous, glistening, cream colored and have a complete margin.

Growth in YM broth: After 2 days at 28°C, cells are elongated, 7–10 $\times$ 2–3 μ m, occur singly, in pairs or in groups and reproduce by multilateral budding. After 1 month at 25°C, a pellicle and sediment occur.

Fermentation

Glucose	d	Lactose	–
Galactose	d	Raffinose	–
Sucrose	d	Trehalose	n
Maltose	–		

Growth (in Liquid Media)

Glucose	+w	D-Ribose	n
Inulin	–	Methanol	–
Sucrose	+	Ethanol	n
Raffinose	n	Glycerol	n
Melibiose	n	Erythritol	n
Galactose	+w	Ribitol	+w
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+w
Maltose	n	D-Glucitol	+w
Melezitose	n	myo-Inositol	n
Methyl- α -D-glucoside	n	DL-Lactate	+w
Soluble starch	–	Succinate	+w
Cellobiose	–	Citrate	+w
Salicin	–	D-Gluconate	n
L-Sorbose	+w	D-Glucosamine	–
L-Rhamnose	n	N-Acetyl-D-glucosamine	n
D-Xylose	n	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	n	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	+w	L-Lysine	+
D-Glucuronate	–	Ethylamine	+
Propane 1,2 diol	–	Urease	–
Butane 2,3 diol	–	DBB	–
Nitrite	–	Cycloheximide 0.1%	+
Creatinine	–		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AM159100.

Cell carbohydrates: Not determined.

Origin of the strains studied: YS12 (CBS 10444, IAM 15334, NRRL Y-27953), isolated from wine grapes collected in Hyderabad, Andhra Pradesh, India.

Type strain: YS12.

Systematics: Based on sequence analysis of the D1/D2 domains of the LSU rRNA gene, *C. hyderabadensis* forms a basal lineage to a clade comprising *C. metapsilosis*, *C. orthopsilosis* and *C. parapsilosis* (Rao et al. 2007), which are all clinically relevant species.

Ecology: The single strain was isolated from decaying green wine grapes in India.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.129. *Candida incommunis* Y. Ohara, Nonomura & T. Yamazaki (1965)

Phylogenetic placement: unaffiliated clade (Fig. 90.3).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are elongate, cylindrical, 1.5–2.5 $\times$ 6–12 μ m, and occur singly and in chains (Fig. 90.80 top).

Dalmat plate culture on corn meal agar: After 7 days at 25°C, long pseudohyphae of branched chains of cylindrical cells are present (Fig. 90.80 bottom). Aerobic growth is off-white with a wrinkled center, a smooth periphery and some pseudohyphal development at the margin.

Fermentation

Glucose	s	Lactose	–
Galactose	–	Raffinose	–
Sucrose	s/–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	v	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	s
Maltose	+	D-Glucitol	+
Melezitose	v	myo-Inositol	+
Methyl- α -D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+

D-Xylose	v	Hexadecane	+
L-Arabinose	–	Nitrate	+
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	+	Gelatin	–
Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	+	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	v

CoQ: 8 (Yamada and Kondo 1972a).

Mol% G + C: 48.9, CBS 5604 (T_m : Meyer et al. 1984); 44.1, AJ 5007 (T_m : Nakase and Komagata 1971f).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U62303.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki et al. 1998).

Origin of the strain studied: CBS 5604, isolated from grape must, Japan.

Type strain: CBS 5604.

Systematics: *Candida incommunis* was described from a strain isolated from Japanese grape must (Ohara et al. 1965). Although the species unquestionably belongs to yeasts of ascomycetous affinity, it bears well its name in that sequence analysis fails to establish a specific connection with any degree of confidence. An analysis of D1/D2 LSU rRNA gene sequences (Kurtzman and Robnett 1998a) positioned the species near *C. insectalens* and *Yarrowia lipolytica*. SSU sequences also suggest a weak connection to *Y. lipolytica* (Suzuki et al. 1999, Suzuki and Nakase 1999). The analysis in Fig. 90.3 does not support such a placement, indicating that the exact position of the species remains to be established.

The species utilizes a broad range of carbon compounds, but not pentoses, and bears a superficial resemblance to *C. valdiviana* and *C. oleophila* in growth responses, although these two species do not utilize erythritol.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Esteve-Zarzoso et al. (2001b) reported the isolation of *C. incommunis* as a minor component of the sherry wine yeast community.

Clinical importance: Unknown.

90.130. *Candida inconspicua* (Lodder & Kreger-van Rij) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Pichia* clade (Figs 57.1, 90.1).

Synonyms:

Torulopsis inconspicua Lodder & Kreger-van Rij (1952)

Torulopsis inconspicua Lodder & Kreger-van Rij var. *filiforme* Dietrichson (1954)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, $2\text{--}5 \times 5\text{--}11\text{ }\mu\text{m}$, and occur singly and in pairs (Fig. 90.81).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, poorly developed pseudohyphae of short chains of ovoid cells are sometimes present. Aerobic growth is off-white, semi-dull, soft, mostly smooth and with an entire margin.

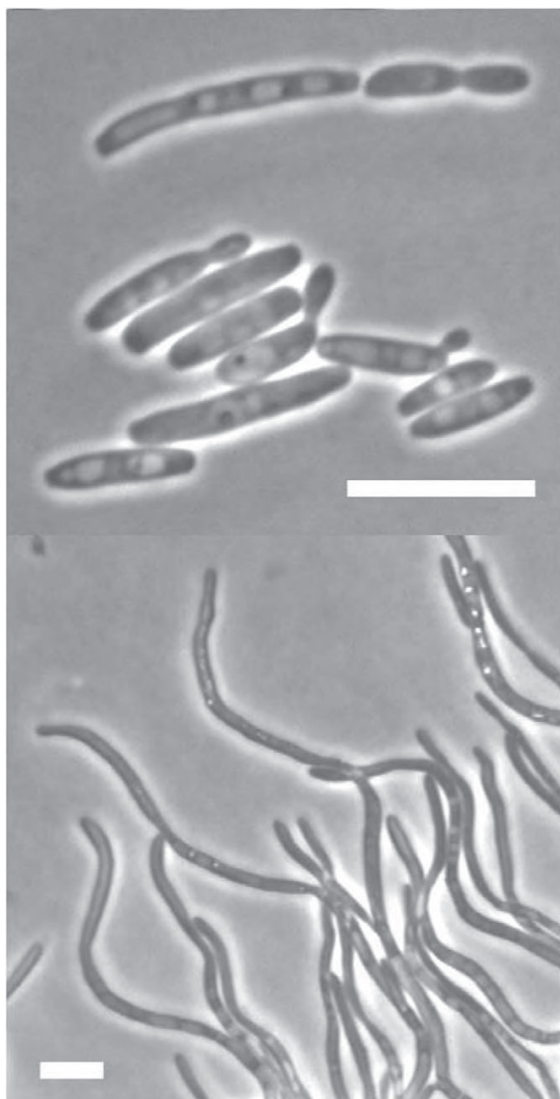


FIGURE 90.80 *Candida incommunis* CBS 5604. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μm .

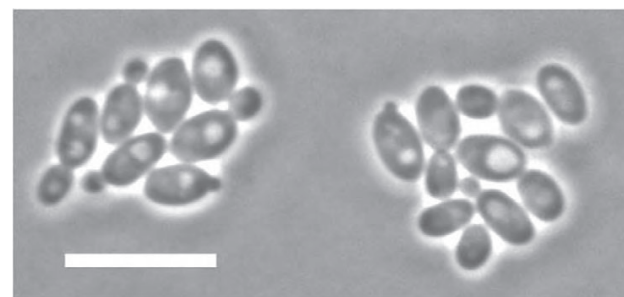


FIGURE 90.81 *Candida inconspicua* CBS 180. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm .

Fermentation

Glucose	–/w	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	v
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	v	Casein	–
Amino acid-free	+	Lipase	w
Nitrite	–	Acid production	w
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	w	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: 8 (Yamada and Kondo 1972a); 7 (Suzuki and Nakase 1998).

Mol% G + C: 36.3, AJ 5139 (T_m : Nakase and Komagata 1971e); 36.7, CBS 180 (BD: Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U71062.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 180, isolated from sputum, The Netherlands; CBS 1735, type of *Torulopsis inconspicua* var. *filiforme*, from sputum, Norway; UWOPS 85-358.1, flux, from Emory oak (*Quercus emoryi*, Fagaceae), Arizona, USA.

Type strain: CBS 180.

Systematics: Lodder and Kreger-van Rij (1952) described *Torulopsis inconspicua* based on four strains from various sources. The species was reported to differ from *C. glabrata* by the lack of fermentation. *C. inconspicua* differs by only one substitution and one gap from *Pichia cactophila* in the D1/D2 LSU rRNA gene sequence (Kurtzman and Robnett 1998a), and shows no differences in gene sequences for translation elongation factor-1 α and mitochondrial SSU rRNA (Kurtzman et al. 2008), strongly indicating that *C. inconspicua* may represent the anamorph of *P. cactophila*. Except for ascospore production, *C. inconspicua*

and *Pichia cactophila* are identical in their descriptions. None of the three strains examined assimilated *N*-acetyl-D-glucosamine as reported by Meyer et al. (1998). A weak fermentation of glucose was observed in the strain from oak.

Ecology: The strains deposited in the CBS Culture Collection are of clinical origin, but a single isolate has been recovered in a large survey of yeasts associated with tree fluxes in Arizona (Ganter et al. 1986), at which time it was identified as “*Pichia cactophila*-like”. The current identification is based on sequence analysis of the D1/D2 domains of the LSU rRNA gene.

Biotechnology: Unknown.

Agriculture and food: Minervini et al. (2001) found *C. inconspicua* to be a significant component of the yeast community in various Italian cheeses, in particular buffalo mozzarella. Suzzi et al. (2003) reported the frequent isolation of the species from Manteca, a buttery whey cheese produced in southern Italy. They noted that the species is capable of proteolytic activity that may contribute to cheese flavoring. In both cases, however, identification was based on growth responses obtained with commercial strips and not confirmed with DNA-based approaches.

Clinical importance: Majoro et al. (2003) reported that *C. inconspicua* can be recovered on occasion from diverse clinical specimens and is easily mistaken for *C. norvegensis* based on formation of pseudohyphae and aesculin hydrolysis. Out of 29 isolates studied by the authors, 28 hydrolyzed aesculin and one produced pseudohyphae, which suggested that they belonged to *C. norvegensis*. However, identification based on restriction analysis of the ITS rDNA regions demonstrated that all strains belonged to *C. inconspicua*.

90.131. *Candida infanticola* Kurtzman (2007b)

Phylogenetic placement: *Wickerhamiella* clade; see Systematics (Fig. 79.1).

(The description is based on Kurtzman 2007b.)

Growth on 5% malt extract agar: After 3 days at 25°C, yeast cells are spherical, 1.8–4.2 μ m, to ovoid, 1.8–3.5 $\times$ 2–5 μ m, divide by multilateral budding and occur singly, in pairs and in small clusters (Fig. 90.82A). Colony growth is light tannish-white, butyrous and with a smooth, dull surface.

Dalmau plate culture on morphology agar: After 7 days at 25°C, growth under the coverglass shows moderately differentiated pseudohyphae (Fig. 90.82B), but true hyphae are absent. Aerobic growth is butyrous, light tannish-white, slightly raised with a flat surface, smooth, dull and with an entire margin.

Fermentation: Absent.

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	–
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	+
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

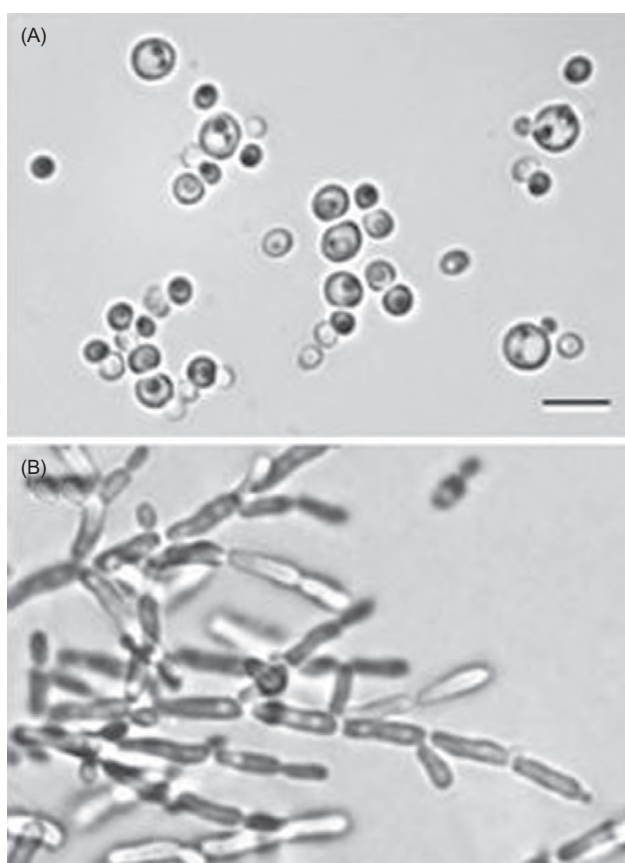


FIGURE 90.82 *Candida infanticola* NRRL Y-17858. Budding cells after 3 days, 25°C, 5% malt extract agar (A) and pseudohyphae after 7 days, 25°C, yeast morphology agar (B). Bar = 5 μm.

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	–	Starch formation	–
5-Keto-D-gluconate	–	Gelatin liquefaction	–
Saccharate	–	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 37°C	+
10% NaCl/5% glucose	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA = DQ438230, ITS = DQ911458, mitochondrial SSU rRNA = DQ442746, COXII = DQ443074.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-17858 (CBS 7922), isolated from the ear of a human infant, by R. Kappe, Germany.

Type strain: NRRL Y-17858.

Systematics: Multigene analysis placed *C. infanticola* in a clade with *C. sorbophila* and *C. spandovensis* with *Wickerhamiella* spp. and several *Candida* species (e.g., *C. drosophilae*, *C. azyma*, *C. pararugosa*, *C. galacta*) as a sister group and with *W. domerqiae* and *C. versatilis* forming a basal lineage (Kurtzman 2007b).

Ecology: Unknown, but the only isolate originated from the ear of a human baby.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.132. *Candida insectalens* (D.B. Scott, van der Walt & van der Klift) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: unaffiliated clade (Fig. 90.1).

Synonym:

Torulopsis insectalens D.B. Scott, van der Walt & van der Klift (van der Walt et al. 1971b)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to subglobose, 2–3.5 × 2–3.5 μm, and occur singly and in pairs (Fig. 90.83).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphal development is not evident. Aerobic growth is off-white, smooth, convex and with an entire margin.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	–
Melibiose	–	Erythritol	–
Galactose	s	Ribitol	s
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D-Lactate	v
Soluble starch	–	Succinate	+
Cellobiose	s	Citrate	–
Salicin	s	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	s
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	v	Vitamin-free	v

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 44.9, CBS 6036 (*T_m*: Stenderup et al. 1972).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = 62304.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 6036, CBS 6149, isolated from beetle tunnels in trees, South Africa.

Type strain: CBS 6036.

Systematics: *Candida insectalens* was described by van der Walt et al. (1971b) from several isolates from tunnels, frass and associated

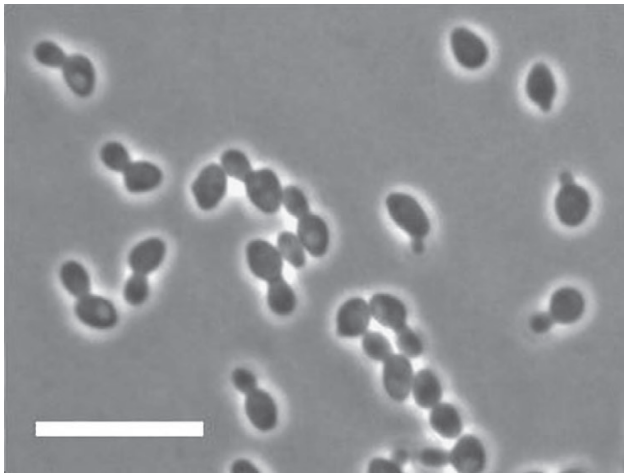


FIGURE 90.83 *Candida insectalens* CBS 6036. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

materials of wood-boring beetles. A similarity with *C. torresii* was suggested. Kurtzman and Robnett (1998a) proposed a connection with *C. incommunis* based on analysis of D1/D2 LSU rRNA gene sequences, but the analysis given by Sugita and Nakase (1999) based on SSU rRNA gene sequences indicated a basal position next to the *Starmerella* clade, with *C. silvatica* as an outgroup. An analysis of the same LSU data conducted in this study positioned *C. insectalens* on a long branch next to *C. sorboxylosa* (Fig. 90.1).

The physiological profile of *C. insectalens* is specialized and bears a passing resemblance to the characteristics of *C. silvae* and *C. silvatica*, but the species is easily distinguished from others primarily on the basis of a unique combination of responses that include the assimilation of trehalose and β-glucosides.

Ecology: The species has been isolated from various South African Coleoptera in the families Platypodidae, Scolytidae and Cerambycidae, indicating that it may be symbiotic in these insects.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.133. *Candida insectamans* D.B. Scott, van der Walt & van der Klift (van der Walt et al. 1972)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Figs 68.1, 90.5).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are spherical, ovoid to long ovoid, ellipsoidal and cylindrical, 1.5–6 × 2.5–12 µm, occur singly, in pairs and chains (Fig. 90.84 top), and pseudohyphae are present.

Dalmat plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of cylindrical cells with some verticils of ovoid cells (Fig. 90.84 bottom). Aerobic growth is cream colored with a raised, wrinkled central area, smooth near the periphery and with a fringed margin.

Fermentation

Glucose	s	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

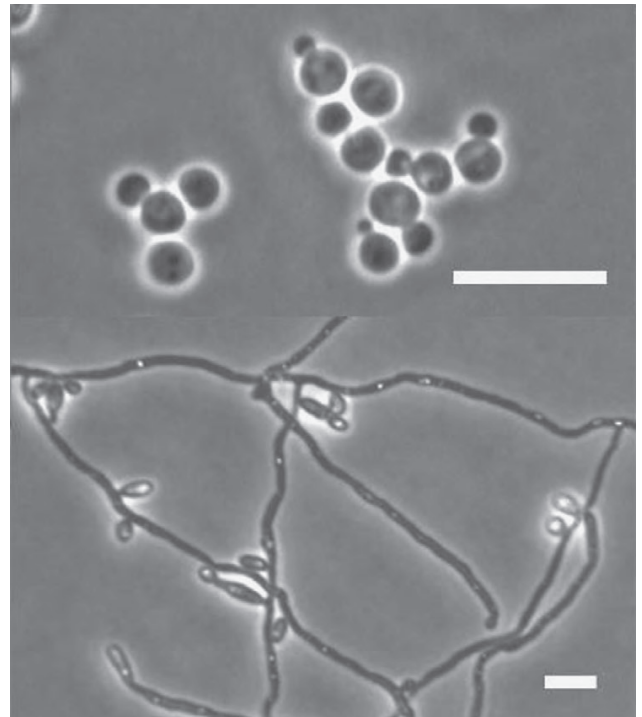


FIGURE 90.84 *Candida insectamans* CBS 6033. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 µm.

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	v
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	s	myo-Inositol	–
Methyl-α-D-glucoside	s	D-Lactate	–
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	s	Casein	–
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 35.9, CBS 6033 (BD: Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45753.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6033, isolated from frass of beetle (Coleoptera: Buprestidae) larvae in gum Arabic tree (*Acacia nilotica*, Fabaceae), South Africa.

Type strain: CBS 6033.

Systematics: *Candida insectamans* was described to accommodate an isolate from frass of buprestid larvae in a tree (van der Walt et al. 1972). The authors noted a resemblance to *C. bogoriensis*, currently reassigned to *Rhodotorula*. Kurtzman and Robnett (1998a) linked the species to *C. sake* on the basis of D1/D2 LSU rRNA gene sequences. Analysis of available SSU rRNA gene data (Sugita and Nakase 1999) weakly links *C. insectamans* to *C. lyxosophila* and to the *Lodderomyces* clade. More recent studies based on both sequences (Nguyen et al. 2006b) document a link to the ascogenous genus *Spathaspora* and related *Candida* species including *C. lyxosophila*.

Examination of the strain by replica plating revealed some differences from previous descriptions. In particular, a strong assimilation of *N*-acetyl-D-glucosamine and the absence of growth on citric acid were noted. Although the species differs in growth response profile from most other species, a superficial resemblance exists *C. insectalens* and species in the large-spored *Metschnikowia* clade. Utilization of D-xylose and the lack of growth on L-sorbose are useful for separation.

Ecology: *Candida insectamans* may be a specific symbiont of the buprestid beetles from which it was isolated. The work of Nguyen et al. (2006b) further suggests that the entire *Spathaspora* clade may be strongly associated with wood-boring beetles.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	D-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	s	D-Glucosamine	v
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	—
D-Arabinose	v	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	v	DBB	—
D-Glucuronate	—	Gelatin	v
Glucono- δ -lactone	v	Casein	v
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	v
L-Lysine	+	Cycloheximide 0.1%	v
Cadaverine	+	1% Acetic acid	—
10% NaCl	v	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	v

90.134. *Candida insectorum* D.S. Scott, van der Walt & van der Klift (van der Walt et al. 1972)

Phylogenetic placement: *Yamadazyma* clade (Figs 81.1, 90.2).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to cylindrical, 1.5–2 $\times$ 3–8 μ m, occur singly or in small groups and pseudohyphae are present (Fig. 90.85 top).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae of branched chains of cylindrical cells and septate hyphae are present (Fig. 90.85 bottom). Aerobic growth is yellowish-white to light tan-colored, mostly creamy, but with some wrinkled areas and a fringed border.

Fermentation

Glucose	+	Lactose	—
Galactose	s	Raffinose	—
Sucrose	s/—	Trehalose	s
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	s	Glycerol	+
Melibiose	v	Erythritol	+
Galactose	+	Ribitol	+
Lactose	v	Galactitol	—
Trehalose	+	D-Mannitol	+

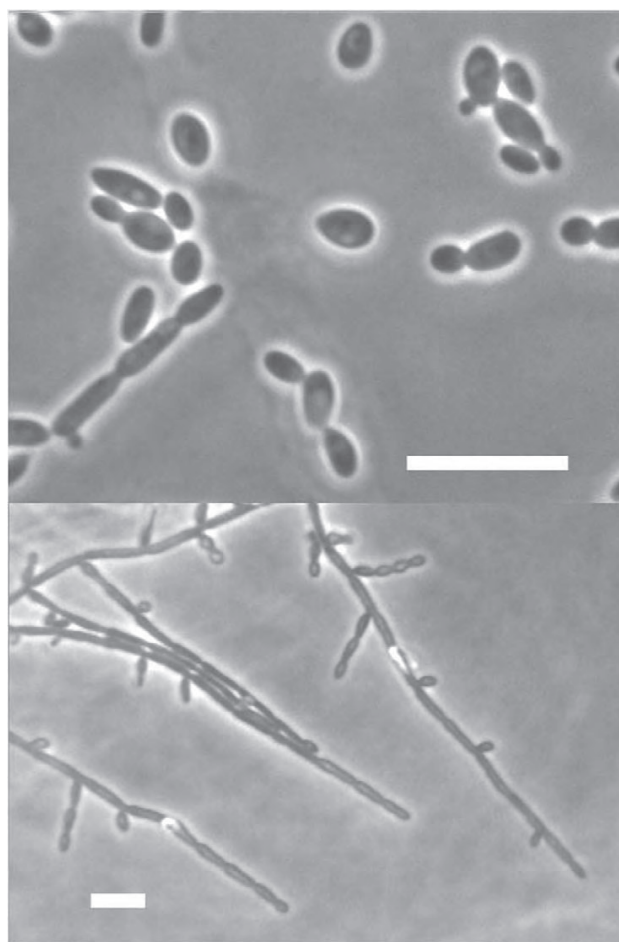


FIGURE 90.85 *Candida insectorum* CBS 6214. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μ m.

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 39.5, CBS 6213 (T_m : Stenderup et al. 1972).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45789.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 6213, isolated from frass of *Eucalyptus* longhorn borer (*Phorocantha recurva*, Coleoptera: Cerambycidae) in *Eucalyptus maculata* (Myrtaceae); CBS 6214, tunnels of ambrosia beetle (*Platypus* (syn. *Crossotarsus*) *externedentatus*, Platypodidae) in Natal guarri (*Euclea natalensis*, Ebenaceae), South Africa; UWOPS 05-230.2, beetle in bertam palm (*Eugeissona tristis*, Arecaceae), Malaysia.

Type strain: CBS 6213.

Systematics: Van der Walt et al. (1972) described *C. insectorum* from three isolates from frass of tree-boring beetles. The strains were physiologically similar to *Yamadazyma (Pichia) scolyti*, but failed to mate when mixed with the mating types of that species. Sequence analysis confirmed this connection (Kurtzman and Robnett 1998a) and further suggested that *C. conglobata* is a close relative (Sugita and Nakase 1999).

Van der Walt et al. (1972) indicated that the species can be separated from *Yamadazyma scolyti* on the basis of latent L-sorbose utilization. This character and others unfortunately show some lability. Both strains examined by replica plating gave a negative response on L-sorbose as well as the assimilation of organic acids and growth at 37°C. Separation from similar species is difficult, although the assimilation of raffinose and the lack of growth on L-rhamnose are useful.

Ecology: *Candida insectorum* has not been reported in substrates other than tree-associated beetles, indicating a possible symbiotic relationship.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.135. *Candida insectosa* (Kurtzman) Kurtzman (Kurtzman and Suzuki 2010)

Phylogenetic placement: *Scheffersomyces* clade (Figs 65.1, 90.2).

Synonym:

Candida shehatae H.R. Buckley & van Uden var. *insectosa* Kurtzman (1990b)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, $2\text{--}4.5 \times 3.5\text{--}6\text{ }\mu\text{m}$, and occur singly, in pairs and short chains. Pseudohyphae are also present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of elongate cells with globose to ovoid blastoconidia. Aerobic growth is white to cream colored, glistening and smooth with a reticulated margin.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	+/s	D-Xylose	+

Growth (in Liquid Media and on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	v	Glycerol	+

Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	v	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	–
Soluble starch	v	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	v
L-Sorbose	–	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	–	Nitrate	–
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	w
Glucono- δ -lactone	v	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	v	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: 44.4, 44.6, 2 strains (BD: Kurtzman 1990b).

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = U45773, SSU rRNA = AB013583.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 4286 (NRRL Y-12854), CBS 4287 (NRRL Y-12855), both from a longhorn beetle (*Leptura maculicornis*), H. Kühlwein.

Type strain: CBS 4286.

Systematics: As discussed under *C. shehatae*, *C. insectosa* and *C. lignosa* are closely related. Nuclear DNA reassociation studies showed ca. 50% relatedness among the species (Kurtzman 1990b), which initially led to their classification as varieties of *C. shehatae*. Upon re-evaluating this extent of relatedness, Kurtzman (Kurtzman and Suzuki 2010) elevated the varieties to the status of closely related species.

Ecology: *Candida insectosa* is currently known only from an association with insects.

Biotechnology: As discussed under *C. shehatae*, the three closely related species in this complex, i.e., *C. shehatae*, *C. insectosa* and *C. lignosa*, are known for their ability to ferment D-xylose. Some of the relevant literature was reviewed by Kastner et al. (1999). A majority of the D-xylose fermentation studies have been done using *C. shehatae*.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.136. *Candida intermedia* (Ciferri & Ashford) Langeron & Guerra (1938)

Phylogenetic placement: *Metschnikowia* clade (Fig. 90.1).

Synonyms:

Blastodendron intermedium Ciferri & Ashford (1929)

Cryptococcus intermedius (Ciferri & Ashford) Nannizzi (1934)

Mycotorula intermedia (Ciferri & Ashford) Krasil'nikov (1954c)

Candida intermedia (Ciferri & Ashford) Langeron & Guerra var. *ethanophila* Verona & Zardetto de Toledo (1954)

Kluyveromyces cellobiovorus Morikawa, Takasawa, Masunaga & Takayama (1985) nom. nud.¹

¹ Synonymy determined from nuclear DNA reassociation experiments (Martini and Vaughn-Martini 1992).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, 2–4 × 3–6 μm, occur singly and in pairs, and elongate cells are present as well (Fig. 90.86 top). A thick, wrinkled pellicle is present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of many branched chains of cylindrical cells (Fig. 90.86 bottom). Aerobic growth is white to cream colored, smooth to slightly wrinkled and soft.

Fermentation

Glucose	+	Lactose	–
Galactose	+/s	Raffinose	v
Sucrose	+	Trehalose	s/–
Maltose	v		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	v	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	v
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	v
Lactose	+	Galactitol	v
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	v	D-Lactate	–
Soluble starch	v	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	v
L-Sorbose	+	D-Glucosamine	v
L-Rhamnose	v	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	v	Nitrate	–
D-Arabinose	v	Vitamin-free	v

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	v	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	v
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	v	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	–

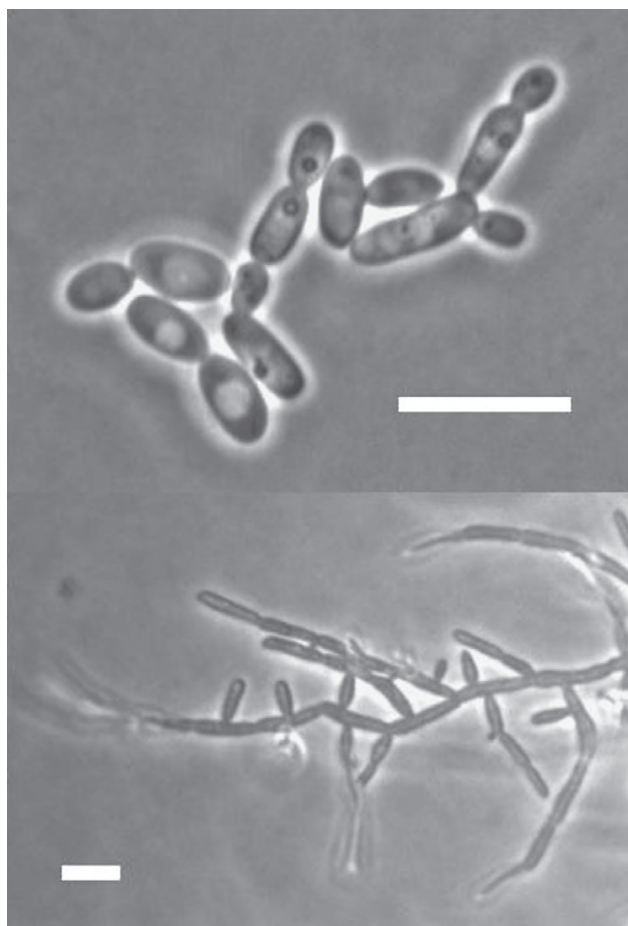


FIGURE 90.86 *Candida intermedia* CBS 572. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μm.

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 43.7, AJ 4621; 44.4, AJ 4632; 44.4, AJ 4619 (CBS 592) (T_m : Nakase and Komagata 1971f).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U44809.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 572, isolated from feces from a patient with sprue in Africa; CBS 5310, type strain of *C. intermedia* var. *ethanophila*, from grape, Brazil; CBS 7153 (DBVPG 6286), type strain of *Kluyveromyces cellobiovorus*, origin unknown; UWOPS 92-266.2 and others, from *Agave tequilana* var. *azul* (Agavaceae), Jalisco, Mexico; UWOPS 99-341.3, from fermenting stem of banana (*Musa* sp., Musaceae), Costa Rica; UWOPS 00-175.1, from flux of gliricidia (*Gliricidia sepium*, Fabaceae), Costa Rica; UWOPS 01-219.1 and others, frass of various caterpillars, Costa Rica.

Other strains available: CBS 2044, from a washed beer bottle, Sweden; CBS 2049, from beer, South Africa; CBS 2879, from soil, South Africa; CBS 5159, from skin, Germany; CBS 5460, from fruit.

Type strain: CBS 572.

Systematics: *Candida intermedia* exhibits affinities with the Metschnikowiaceae, and in particular with the genus *Clavispora* (Kurtzman and Robnett 1998a, Sugita and Nakase 1999). The species is a close relative of *C. pseudointermedia*. Martini and Vaughan-Martini (1992) determined by DNA reassociation that strain CBS 7153, cited but not validly described as *Kluyveromyces cellobiovorus* by Morikawa et al. (1985), belongs to *C. intermedia*.

Candida intermedia and some strains of *C. pseudointermedia* share the ability to assimilate lactose, an unusual property in species with

affinities in the Metschnikowiaceae. This characteristic is useful to separate *C. intermedia* from other similar species. Other useful properties include the absence of growth on melibiose. Separation from *C. pseudointermedia*, *C. shehatae* and *Schwanniomyces occidentalis* may be difficult. Strain CBS5310, originally named *C. intermedia* var. *ethanophila*, differs from other strains only by the lack of assimilation of D-xylose. No significant difference in ethanol tolerance was noted. Strain CBS 7153, which has been invalidly described as *Kluyveromyces cellobiovorus*, is somewhat typical of the species, except for the lack of assimilation of raffinose, melezitose and methyl- α -D-glucoside.

Ecology: The recovery of *C. intermedia* from a wide array of substrates suggests that the species is a generalist.

Biotechnology: Gárdonyi et al. (2003) found *C. intermedia*, and in particular strain PYCC 4715, to be highly efficient in the uptake and utilization of D-xylose.

Agriculture and food: Yeasts identified as *C. intermedia* have been reported as important contaminants of foods such as artisanal ewes' cheese (Pereira-Dias 2000) and beverages such as orange juice (Arias et al. 2002).

Clinical importance: Unknown.

90.137. *Candida ipomoeae* Lachance, Rosa, Starmer & Bowles (1998a)

Phylogenetic placement: *Metschnikovia* clade (Figs 46.1, 90.1).

Growth on malt agar: After 2 weeks at 17°C, the colonies are high, spreading, rugose, with a highly convoluted surface, white and with a stellate or lobate border (Fig. 90.87 C,D). Old colonies easily fall off the agar medium if a plate is inverted over a hard surface.

Growth in glucose–yeast extract broth: After 3 days at 25°C, the cells occur singly, in pairs or in chains (Fig. 90.87 A,B). The cells are ovoid to cylindrical, 2–4 $\times$ 4–12 μ m. Budding is multilateral. The cells remain attached and form tight flocs that may float or sediment.

Dalmat plate culture on corn meal agar: After 2 weeks at 18°C, extensive, but undifferentiated pseudohyphae are formed.

Fermentation

Glucose	w/–	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	w
Raffinose	–	Glycerol	w
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	s
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	s	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	w
Salicin	+	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	v
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

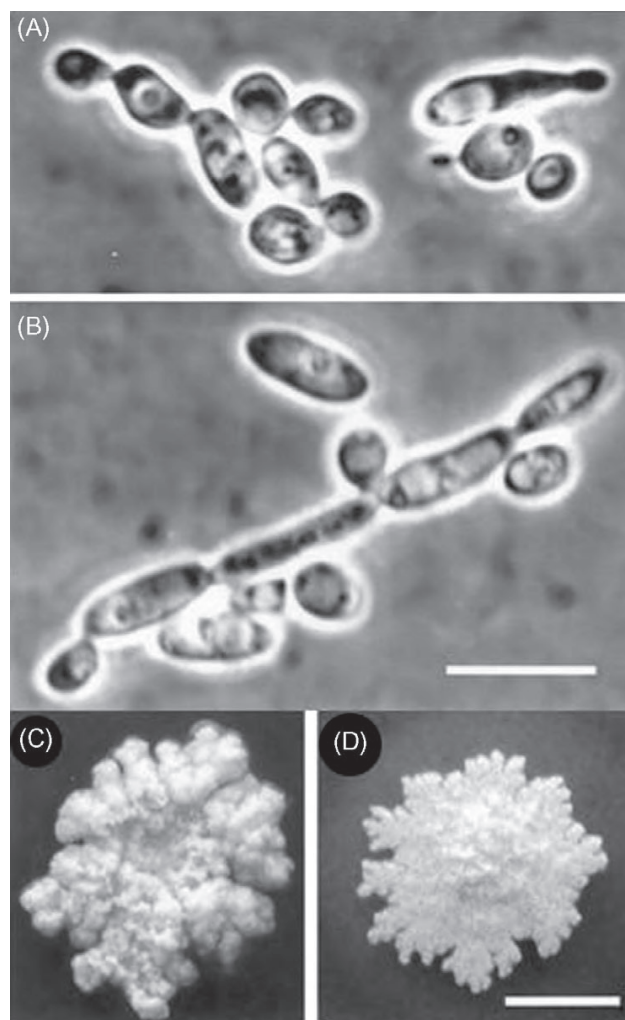


FIGURE 90.87 *Candida ipomoeae* CBS 8466. Budding cells (A) and pseudohypha (B) after 3 days, 25°C, YM agar; Bar = 10 μ m. Colonies after 1 month on 10% malt extract–12% gelatin (C) or yeast morphology agar (D). Bar = 1 cm. Reproduced with permission from Lachance et al. (1998a).

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Gluconate	–	Gelatin	–
Glucono- δ -lactone	w	Casein	w
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	v

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF050148.

Cell carbohydrates: Not determined.

Origin of the strains studied: UWOPS 87-2161.3, UWOPS 91-672.1 (CBS 8466), and many other strains, isolated from flowers of morning glories (*Ipomoea indica* and *I. pes-caprae*, Convolvulaceae), fruit flies (*Drosophila floricola*, *Exaloscaptomyza calliginosa*, Diptera: Drosophilidae) and nitidulid beetles (*Conotelus mexicanus* and *Prosopopeus subaeneus*, Coleoptera: Nitidulidae) collected from these and other flowers, Hawai'i; UWOPS 99-324.1 and others, *Conotelus* sp. in flowers of robe de sabana (*Tabebuia rosea*, Bignoniaceae), morning glories (*I. carnea*, *I. batatas*) and other flowers, Costa Rica; UWOPS 95-247.1 and others, from *Conotelus* sp. in flowers of *I. indica* and *I. cairica* var. *fistulosa*, Brazil; SUB 99-201.2 and others, *Conotelus obscurus* in flowers of *I. purpurea* and *I. pandurata*, Tennessee, USA.

Type strain: CBS 8466.

Systematics: *Candida ipomoeae* is a close relative of the large-spored *Metschnikowia* species. Analysis of D1/D2 LSU rRNA gene sequences suggested a possible anamorph–teleomorph connection with *Metschnikowia lochheadii* (Lachance et al. 2001b), but examination of other sequences such as the various ribosomal spacers or the mitochondrial SSU rRNA gene (Marinoni and Lachance 2004) does not support that conclusion, indicating instead that the species might be the result of hybridization followed by chromosome loss during the early stages of radiation of the group. Some strains mate and form sterile asci when mixed with the h^+ mating type of *M. lochheadii* and *M. continentalis*, corroborating the close relationship. The possibility also remains that the lack of sexuality in the species is due to the loss of the h^+ mating type in the species.

Physiologically, the species is more or less identical to most large-spored *Metschnikowia* species, except for fermentation, which is absent or weak. Moreover, *C. ipomoeae* forms characteristic, dry, convoluted colonies and is relatively short-lived on agar media.

Ecology: The biogeography of *C. ipomoeae* is intriguing. Unlike the large-spored *Metschnikowia* species, which are typically regional in distribution, *C. ipomoeae* has been recovered almost throughout the entire range of nitidulid beetles of the genus *Conotelus*, including South, Central and North America, as well as Hawai'i, where it has ostensibly been introduced, along with *M. lochheadii*. Eastern North American beetles harbor *Metschnikowia borealis* throughout their range, but *C. ipomoeae* was found only in samples collected in Tennessee and is absent in the Great Lakes region northward (Wardlaw et al. 2009).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.138. *Candida ishiwadae* Sugiyama & S. Goto (1969)

Phylogenetic placement: *Nakazawaea* clade (Figs 57.1, 90.4).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 1.5–5 × 3–6 μm, and occur singly and in pairs (Fig. 90.88).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, a few poorly developed pseudohyphae consisting of chains of elongated cells are present. Aerobic growth is white to slightly cream colored, mucoid, moist, smooth and with an entire margin.

Fermentation

Glucose	+	Lactose	–
Galactose	s/–	Raffinose	–
Sucrose	s/–	Trehalose	s
Maltose	+		

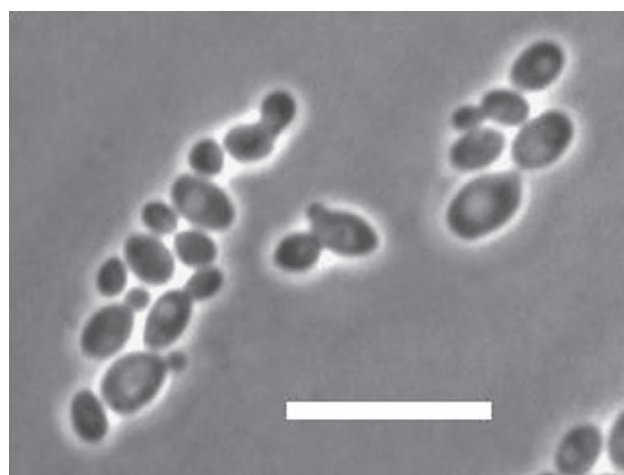


FIGURE 90.88 *Candida ishiwadae* CBS 6022. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	v	Ribitol	+
Lactose	–	Galactitol	v
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	v	myo-Inositol	–
Methyl-α-D-glucoside	v	D,L-Lactate	v
Soluble starch	+	Succinate	+
Cellulose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	s	D-Glucosamine	+
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	s	Nitrate	+
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	s	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	+	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	–

CoQ: 8 (Suzuki and Nakase 1998).

Mol% G + C: 36.7, CBS 6022 (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U71067.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5526, the isolation source is unknown; CBS 6022, isolated from a deep core of stratigraphic drillings, Japan.

Other strains: CBS 7348, from human feces, Finland; CBS 7401, from grape pigment, Portugal.

Type strain: CBS 6022.

Systematics: *Candida ishiwadae* belongs to a small clade (Kurtzman and Robnett 1998a, Suzuki and Nakase 1999) with an affinity for the genus *Nakazawaea* (Yamada et al. 1994c).

Candida ishiwadae and related species (Fig. 90.4) share some degree of physiological similarity, including a tendency to assimilate β -glucosides, L-rhamnose, pentose sugars and nitrate, as well as cycloheximide resistance. The utilization of sucrose, starch and erythritol is useful for separation from similar species.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.139. *Candida jeffriesii* N.H. Nguyen, S.-O. Suh & M. Blackwell (Nguyen et al. 2006b)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Figs 68.1, 90.5).

(The description is based on Nguyen et al. 2006b.)

Growth on YM agar: After 7 days at 25°C, colonies are white, butyrous and smooth.

Growth in YM broth: After 7 days at 25°C, cells are globose, 5–9 μ m, occur singly, in clusters or in short chains, and pseudohyphae or true hyphae are not present.

Dalmeu plate culture on corn meal agar: After 7–14 days at 25°C, neither pseudohyphae nor true hyphae are present.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	d
Maltose	d	D-Xylose	d

Growth (in Liquid Media)

Glucose	+	D-Ribose	d
Inulin	–	Methanol	–
Sucrose	+	Ethanol	w
Raffinose	–	Glycerol	w
Melibiose	–	Erythritol	d
Galactose	+	Ribitol	d
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	d
Maltose	+	D-Glucitol	d
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	d	DL-Lactate	w
Soluble starch	d	Succinate	w
Cellobiose	+	Citrate	d
Salicin	+	D-Gluconate	w
L-Sorbose	–	D-Glucosamine	d
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	d	50% Glucose	–
2-Keto-D-gluconate	+	10% NaCl/5% glucose	w
D-Glucuronate	–	Starch formation	–
Propane 1,2 diol	d	Urease	–
Butane 2,3 diol	–	DBB	–
Nitrite	–	Cycloheximide 0.01%	–
Cadaverine	+	Growth at 25°C	+
Creatinine	–	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	–
Ethylamine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY520415, SSU rRNA = AY520287.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27738 (CBS 9898), isolated from gut of adult wood-boring beetle (*Phrenapates bennettii*, Coleoptera, Tenebrionidae), Fortuna Station, Chiriqui, Panama.

Type strain: NRRL Y-27738.

Systematics: Based on phylogenetic analysis of the D1/D2 domains of the LSU rRNA gene and the SSU rRNA gene, *C. jeffriesii* is a sister species to *Spathaspora paspalidarum*, another D-xylose-fermenting species. These two species may belong to the *Lodderomyces elongisporus* clade (Nguyen et al. 2006b).

Ecology: The species was isolated from gut of wood-boring beetle in Panama.

Biotechnology: Unknown, but the capability of *C. jeffriesii* to ferment xylose may have potential to generate biofuels.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.140. *Candida jianshihensis* C.F. Lee & Liu (Liu et al. 2008)

Phylogenetic placement: *Wickerhamomyces* clade; see Systematics (Fig. 90.4).

(The description is based on Liu et al. 2008.)

Growth in YM broth: After 3 days at 25°C, the cells are globose, ellipsoidal or ovoid, 2.5–5.2 $\times$ 3.4–6 μ m, occur singly or in pairs and reproduce by multilateral budding. Sediment is present.

Growth on YM agar: After 7 days at 25°C, the streak culture is creamy to brownish, butyrous, smooth, glistening and has an entire margin.

Dalmeu plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and true hyphae are absent.

Fermentation: Absent.

Growth (Media not Specified)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	–
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	d
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	d
Soluble starch	–	Succinate	–
Cellobiose	+	Citrate	–

Salicin	+	D-Gluconate	—
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	+	Hexadecane	n
L-Arabinose	—	Nitrate	+
D-Arabinose	—	Vitamin-free	n

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	—	50% Glucose	—
5-Keto-D-gluconate	—	10% NaCl/5% glucose	—
D-Glucuronate	—	Starch formation	—
Propane 1,2 diol	+	Urease	—
Butane 2,3 diol	+	DBB	—
Cadaverine	+	Cycloheximide 0.01%	—
Creatinine	—	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	—

CoQ: Not determined.**Mol% G + C:** Not determined.**Gene sequence accession number, type strain:** D1/D2 LSU rRNA = EF460593.**Cell carbohydrates:** Not determined.**Origin of the strain studied:** SM8S04 (CBS 10591, BCRC 23096, NBRC 102650), isolated in 2006 from forest soil in Jianshih, Hsinchu, Taiwan.**Type strain:** SM8S04.**Systematics:** From sequence analysis of the D1/D2 domains of the LSU rRNA gene, *C. jianshihensis* belongs to the *Wickerhamomyces* clade.**Ecology:** The single isolate originated from forest soil in Taiwan.**Biotechnology:** Unknown.**Agriculture and food:** Unknown.**Clinical importance:** Unknown.**90.141. *Candida kipukae* Lachance, Bowles & Starmer (2003b)****Phylogenetic placement:** *Metschnikowia* clade (Figs 46.1, 90.1).**Growth on malt agar:** After 2 weeks at 17°C, colonies are low convex to convex, glossy, smooth, white and butyrous.**Growth in glucose–yeast extract broth:** After 3 days at 25°C, the cells are spherical to ovoid, 3–4 × 4–6 μm, and occur singly or in parent–bud pairs.**Dalmau plate culture on GY agar:** Pseudohyphae or true hyphae are not formed. The streak culture develops a yellow pigmentation under and outside the coverslip.**Fermentation**

Glucose	s	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	w
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	s
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+

Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl-α-D-glucoside	w	D-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	s
L-Sorbose	+	D-Glucosamine	w
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	w
Glucono-δ-lactone	s	Casein	—
Amino acid-free	+	Lipase	s
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	w	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	—

CoQ: Not determined.**Mol% G + C:** Not determined.**Gene sequence accession number, type strain:** D1/D2 LSU rRNA = AF514294.**Cell carbohydrates:** Not determined.**Origin of the strains studied:** UWOPS 00-669.2 (CBS 9147, NRRL Y-27474) and several other strains were isolated from a nitidulid beetle (*Prosopeus subaeneus*, Coleoptera: Nitidulidae); UWOPS 02-104b2, from hibiscus flower beetle (*Aethina concolor*, Coleoptera: Nitidulidae) collected in flowers of morning glory (*Ipomoea indica*, Convolvulaceae), Island of Hawai'i, USA.**Type strain:** CBS 9147.**Systematics:** *Candida kipukae* exhibits a clear affinity with the large-spored *Metschnikowia* species (Lachance et al. 2003b), but could be seen as a phylogenetic link to the rest of the genus. The D1/D2 LSU rRNA gene sequences occupy an intermediate position between the short sequences found in the large-spored group and the longer sequences of other species in the *Metschnikowia* clade. In a comparison of the secondary structure of the D2 domains of various *Metschnikowia* species, Hong et al. (2003) showed that the sequences range in size from 48–64 bp in the large-spored clade to 154–184 bp in other species, compared to 210 in *Saccharomyces cerevisiae*. As a result, the construction of a credible sequence alignment for these species was deemed impossible. However, inclusion of *C. kipukae* in the set of sequences allows the discovery of some regions that are homologous to either group. The formation of smooth colonies separates the species clearly from *C. ipomoeae*, and the absence of asci may be used to differentiate it from other species in the large-spored *Metschnikowia* clade. Mating with related species where sexual compatibility is generally conserved did not give rise to conjugation.*Candida kipukae* is physiologically similar to several *Metschnikowia* and related *Candida* species. The utilization of methyl-α-D-glucoside (weak) and ribitol (slow) separates the species from most but not all similar species.**Ecology:** *Candida kipukae* is of special interest in ecological terms, as the species occurs frequently in association with the Hawaiian endemic beetle *Prosopeus subaeneus*, and only rarely in other insects found in the same locality, including *Conotelus mexicanus*, which

abounds with the related species, *Metschnikowia lochheadii* and *C. ipomoeae* (Lachance et al. 2003a).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.142. *Candida kofuensis* Mikata, Ueda-Nishimura, Goto, Kurtzman, M. Suzuki, Yarrow & Nakase (1999)

Phylogenetic placement: *Metschnikowia* clade (Fig. 46.1). (Some of the morphological characteristics are based on Mikata et al. 1999.)

Growth on YM agar: After 1 month at 25°C, growth is cream or tan colored, with a smooth or glistening surface, convex and slightly raised, butyrous and with an entire margin.

Growth in YM broth: After 3 days at 25°C, the cells are globose to ellipsoidal, 4–8 × 5–9 μm, occur singly or in pairs and reproduce by multilateral budding (Fig. 90.89). After 1 month, chlamydospores (pulcherrima cells) are usually present. A thin ring is formed.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, rudimentary pseudohyphae are formed.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	s	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	w	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	–

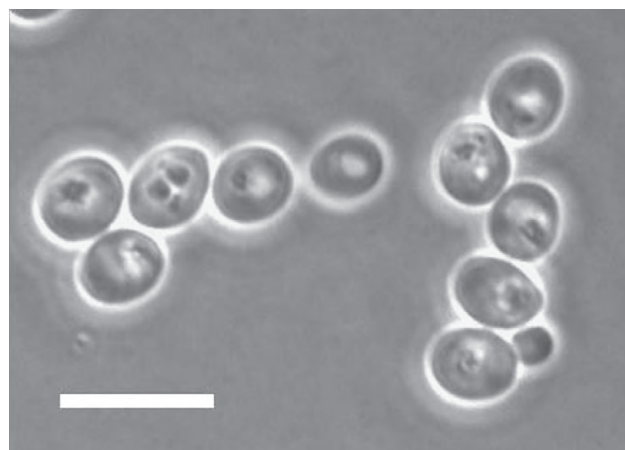


FIGURE 90.89 *Candida kofuensis* CBS 8058. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

CoQ: 9 (Mikata et al. 1999).

Mol% G + C: 46.1–46.5, three strains, including the type (HPLC: Mikata et al. 1999).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF158019.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 8058 (IFO 10931), isolated from wild grape (*Vitis coignetiae*, Vitaceae), Japan.

Type strain: CBS 8058.

Systematics: *Candida kofuensis* was described by Mikata et al. (1999) on the basis of three strains, two of which had been previously identified as *C. agrestis* (anamorph of *Saturnispora zaruensis*). The authors observed similarities between the strains and *Metschnikowia pulcherrima*, in particular the formation of chlamydospores. DNA reassociation confirmed identity of the three strains and further demonstrated their distinctness from *S. zaruensis* or *M. pulcherrima*. Péter et al. (2005b) found the SSU and D1/D2 LSU rRNA gene sequences of the species to be identical to that of two grape isolates that they described as *M. viticola*. Although it is possible that *M. viticola* might be the teleomorph of *C. kofuensis*, the latter did not sporulate when examined in the same conditions. The two species should therefore be treated as distinct until DNA reassociation studies become available.

The growth characteristics of *C. kofuensis* are nearly identical to the characteristics of many *Metschnikowia* species, making identification by growth tests impractical.

Ecology: The three known strains of *C. kofuensis* were isolated from wild grapes.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.143. *Candida krabiensis* Limtong, Srisuk, Yongmanitchai, Kawasaki, Yurimoto, Nakase & Kato (2004)

Phylogenetic placement: *Ogataea* clade (Fig. 90.4).

(The description is based on Limtong et al. 2004.)

Growth on YM agar: After 3–5 days at 25°C, cells are spherical to ovoid, 2–4 × 3.5 μm, and occur singly or in pairs. The streak culture is white to cream, smooth, glistening, butyrous and has an entire margin.

Growth on the surface of assimilation media: A pellicle is not formed.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae and true hyphae are absent.

Fermentation: Absent.

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	+
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+/l
Melibiose	—	Erythritol	+
Galactose	—	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	+	D,L-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	+
Salicin	—	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	n
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	+	Hexadecane	n
L-Arabinose	—	Nitrate	+
D-Arabinose	+/l	Vitamin-free	—

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	—	Urease	—
5-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin liquefaction	+
Nitrite	+	Cycloheximide 0.01%	+
Cadaverine	+	Cycloheximide 0.1%	+
L-Lysine	+	Growth at 25°C	+
Ethylamine	+	Growth at 30°C	+
50% Glucose	—	Growth at 35°C	+
10% NaCl/5% glucose	—	Growth at 37°C	+
Starch formation	—	Growth at 40°C	+

CoQ: 7 (Limtong et al. 2004).

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AB120219.

Cell carbohydrates: Not determined.

Origin of the strain studied: N051 (JCM 12266, TISTR5820), isolated in the year 2000 from soil collected in Krabi Province, Thailand.

Type strain: TISTR 5820.

Systematics: Sequence analysis of the D1/D2 domains of the LSU rRNA gene placed *C. krabiensis* in a weakly supported clade with *Ogataea glucozyma*, *O. henricii*, *O. pini*, *C. ortonii* and *C. nemodendra* (Limtong et al. 2004).

Ecology: The species is known from soil in Thailand.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.144. *Candida kruisii* (Kocková-Kratochvílová & Ondrušová) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Candida kruisii* clade (Fig. 90.5).

Synonym:

Torulopsis kruisii Kocková-Kratochvílová & Ondrušová (1971)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, long-ovoid to cylindrical, 2–4 $\times$ 5–8 μ m, and occur singly, in pairs and chains.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of cylindrical cells with ovoid and elongate blastoconidia in verticils and short chains. Aerobic growth is off-white to cream colored, smooth, butyrous, shiny and with an entire margin.

Fermentation

Glucose	+	Lactose	—
Galactose	+	Raffinose	—
Sucrose	—	Trehalose	+
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	s	myo-Inositol	—
Methyl- α -D-glucoside	+	D,L-Lactate	—
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	s
L-Sorbose	s	D-Glucosamine	s
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	s	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	s	Casein	—
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	—

CoQ: 9 (Nakase et al. 1988b).

Mol% G + C: 44.6, 45.4, 44.2, CBS 6451 (T_m : Meyer et al. 1984; T_m and HPLC: Nakase et al. 1988b, respectively).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45718.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 6451, isolated from the fruiting body of a mushroom (*Boletus purpureus*); CBS 7846, from the leaf of a plant, China.

Type strain: CBS 6451.

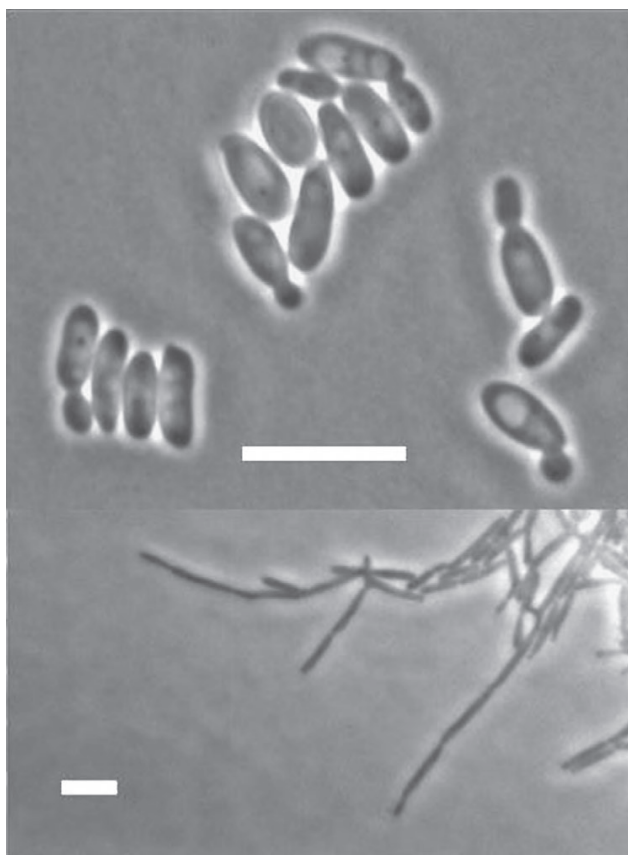


FIGURE 90.90 *Candida kruisii* CBS 6451. Budding cells after 3 days, 25°C, YM agar (top), and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bar = 10 μm.

Systematics: Kocková-Kratochvílová and Ondrušová (1971) described *Torulopsis kruisii* after subjecting a collection of yeasts collected on the fruiting bodies of various mushrooms to phenetic analysis of their growth characteristics. Fourteen strains stood out from the rest, forming a cluster that shared similar profiles. The strains were also typified by serology. *C. kruisii* has moderate phylogenetic affinities with the genera *Debaryomyces* and *Lodderomyces* (Kurtzman and Robnett 1998a, Sugita and Nakase 1999), but its precise placement is uncertain. The species has recently become the focal point of a moderately sized clade due to the isolation of several new *Candida* species from basidiomata or associated beetles (Suh et al. 2006a, Middelhoven and Kurtzman 2007). The newly described relatives are *C. aglyptinia*, *C. atbi*, *C. barrocoloradensis*, *C. cretensis*, *C. gatuensis*, *C. lycoperdinae*, *C. pallodes*, *C. panamensis*, *C. stri* and *C. tritomae*.

Vitamin independence reported in the original description was not verified by replica plating. However, growth on melezitose and D-glucitol, reported as positive by Meyer et al. (1998) and negative in the original description, was confirmed. Separation from many species is difficult. *C. lyxosophila* can be separated based on the absence of growth on lactic acid. Other species usually differ in one or more of the following: growth on galactose, D-xylose, citrate, 10% NaCl, 0.01% cycloheximide (positive in *C. kruisii*), as well as lactose, L-rhamnose, at 37°C, and in the presence of 0.1% cycloheximide (negative in the species). Separation from *C. viswanathii* (formerly *C. lodderae*) on the basis of growth characteristics is problematic.

Ecology: Based on the known sources of *C. kruisii* isolates, but more importantly on the origin of the recently described relatives mentioned above, it appears probable that the species is a symbiont of fungivorous beetles.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.145. *Candida kunorum* S.-O. Suh & M. Blackwell (Suh et al. 2004b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5). (The description is based on Suh et al. 2004b.)

Growth on YM agar: After 7 days at 25°C, colonies are white, membranous, butyrous and have a smooth margin.

Growth in YM broth: After 7 days at 25°C, cells are subglobose to fusiform, but mostly subglobose, 2–5 × 3–6 μm, and occur singly, in pairs or in short chains.

Dalmau plate culture on corn meal agar: After 10 days, at 25°C, pseudohyphae and septate hyphae are absent. Aerobic growth is white and smooth.

Fermentation

Glucose	+	Lactose	w
Galactose	w	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	w		

Growth (in Liquid Media)

Glucose	+	D-Ribose	w
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D,L-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	d
Salicin	d	D-Gluconate	+
D-Sorbose	–	D-Glucosamine	d
D-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	d	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	w	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	w	Ethylamine	+
2-Keto-D-gluconate	+	50% Glucose	+
D-Glucuronate	–	10% NaCl/5% glucose	–
Arbutin	+	Starch formation	–
Propane 1,2 diol	w	Urease	–
Butane 2,3 diol	–	DBB	–
Nitrite	–	Cycloheximide 0.01%	–
Cadaverine	+	Growth at 25°C	+
Creatinine	–	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY309809, SSU rRNA = AY426955.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27580 (CBS 9825), isolated from the gut of a nitidulid beetle (*Teichostethus testaceus*, Nitidulaceae), Barro Colorado Island, Panama.

Type strain: NRRL Y-27580.

Systematics: A combined SSU and D1/D2 LSU rRNA gene sequence analysis indicated that *C. kunorum* belongs to the *Candida tanza-waensis* clade, where it is closely related to *C. bokatorum* and *C. guay-morum* (Suh et al. 2004b).

Ecology: The species is known only from the gut of a beetle collected from a fungus (*Nodulisporium* sp.) in Panama.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.146. *Candida labiduridarum* S.-O. Suh, N.H. Nguyen & M. Blackwell (2008)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Fig. 90.5).

(The description is based on Suh et al. 2008.)

Growth on YM agar: After 7 days on YM agar at 25°C, colonies are off-white, smooth, shiny, butyrous and have an undulating and slightly filamentous margin.

Growth in YM broth: After 7 days at 25°C, cells are subglobose to fusiform, $3-9 \times 5-9 \mu\text{m}$, but mostly ellipsoidal or ovoid, occur singly, in pairs, in short chains or in clusters, and pseudohyphae and true hyphae may be present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae with blastoconidia are present. Aerobic growth is off-white, butyrous, smooth and with a filamentous margin.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	+	Trehalose	d
Maltose	+		

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+/d
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	+
Soluble starch	–	Succinate	–
Cellobiose	v	Citrate	d/w
Salicin	–	D-Gluconate	–
L-Sorbose	v	D-Glucosamine	+/d
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	d	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	50% Glucose	+/w
2-Keto-D-gluconate	+	10% NaCl/5% glucose	v
D-Glucuronate	–	Starch formation	–
L-Arabinitol	v	Urease	–
Arbutin	d	DBB	–
Propane 1,2 diol	–	Cycloheximide 0.01%	+
Butane 2,3 diol	–	Cycloheximide 0.1%	+
Nitrite	–	Growth at 25°C	+
Cadaverine	+	Growth at 30°C	+
Creatinine	–	Growth at 35°C	v
L-Lysine	+	Growth at 37°C	–
Ethylamine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = DQ655687, SSU rRNA = EF120584.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27940 (CBS 10452), isolated from the gut of an earwig (Dermaptera: Labiduridae), Walker, Louisiana, USA.

Type strain: NRRL Y-27940.

Systematics: Within the *C. albicans*/*Lodderomyces elongisporus* clade *C. labiduridarum* is a sister species to *C. frijolesensis* in the *C. tropicalis* lineage (Suh et al. 2008).

Ecology: The species is known from the gut of an earwig and that of an unidentified cricket, both from Walker County, Louisiana, USA, the gut of a female owl-fly (*Ululodes macleayanus*, Neuroptera, Ascalphidae) in Levy County, Florida, USA and the gut of an elephant beetle (*Megasoma elephas*, Scarabidae) from Barro Colorado Island, Panama (Suh et al. 2008).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.147. *Candida lactis-condensi* (B.W. Hammer) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

Synonyms:

Torula lactis-condensi B.W. Hammer (1919)

Torulopsis lactis-condensi (B.W. Hammer) Lodder & Kreger-van Rij (1952)

Torulopsis caroliniana Etchells & T.A. Bell (1950b)¹

¹ Synonymy based on phenotype.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, $1.5-2.5 \times 3-7 \mu\text{m}$, and occur singly and in pairs (Fig. 90.91).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present. Aerobic growth is white, butyrous, soft and with an entire margin.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	+
Sucrose	+	Trehalose	–
Maltose	–		

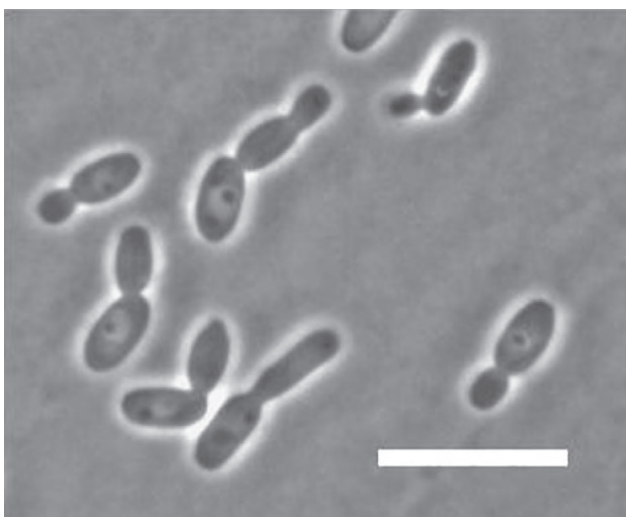


FIGURE 90.91 *Candida lactis-condensi* CBS 52. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	—
Raffinose	v	Glycerol	—
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	—
Maltose	—	D-Glucitol	—
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	—
Soluble starch	—	Succinate	—
Cellobiose	—	Citrate	—
Salicin	—	D-Gluconate	—
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	+
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	—	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	+	Acid production	—
Ethylamine	—	Cycloheximide 0.01%	v
L-Lysine	v	Cycloheximide 0.1%	—
Cadaverine	—	1% Acetic acid	—
10% NaCl	v	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	—

CoQ: 8 (Yamada and Kondo 1972a).

Mol% G + C: 42.4, type strain (T_m : Nakase and Komagata 1971e); 43.2, CBS 52 (BD: Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45724.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 52, isolated from sweetened condensed milk; CBS 54, syntype of *Torulopsis caroliniana*, from fermenting brined cucumbers.

Type strain: CBS 52.

Systematics: *Candida lactis-condensi* is a relative of *C. stellata* and other species in the *Starmerella sensu stricto* clade (Fig. 71.1, Rosa et al. 2003, Suzuki et al. 1999).

The species is nutritionally specialized, with growth occurring weakly on glucose and sucrose but no other carbon sources. Although nitrate and nitrite are utilized, ethylamine, L-lysine and cadaverine are not. This combination of traits is unique to *C. lactis-condensi*. Growth occurs on 50% glucose, which is typical in the *Starmerella* clade. The strain deposited in CBS as *Torulopsis caroliniana* differs by being halotolerant.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Based on the known sources and the generalizations made by Stratford et al. (2002), *C. lactis-condensi* has the potential for being an agent of food spoilage vectored by insects.

Clinical importance: Unknown.

90.148. *Candida lassenensis* Kurtzman (1999)

Phylogenetic placement: *Saccharomycopsis* clade (Figs 63.1, 90.4).

(Some of the morphological characteristics are based on Kurtzman 1999.)

Growth on 5% malt extract agar: After 3 days at 25°C, the cells are ellipsoidal to elongate, $2-3.5 \times 3-11 \mu$ m, occur singly or in pairs and reproduce by multilateral budding (Fig. 90.92 top). The culture is tannish-white, low-convex, dull and butyrous to hyphal.

Growth in liquid media: Pellicles are not formed.

Dalmat plate culture on morphology agar: After 7 days at 25°C, pseudohyphae and true hyphae are formed (Fig. 90.92 bottom).

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	w
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	w
Melibiose	—	Erythritol	+
Galactose	—	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	w
Maltose	—	D-Glucitol	w
Melezitose	—	myo-Inositol	s
Methyl- α -D-glucoside	—	DL-Lactate	—
Soluble starch	s	Succinate	s
Cellobiose	—	Citrate	—
Salicin	—	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	w	Vitamin-free	—

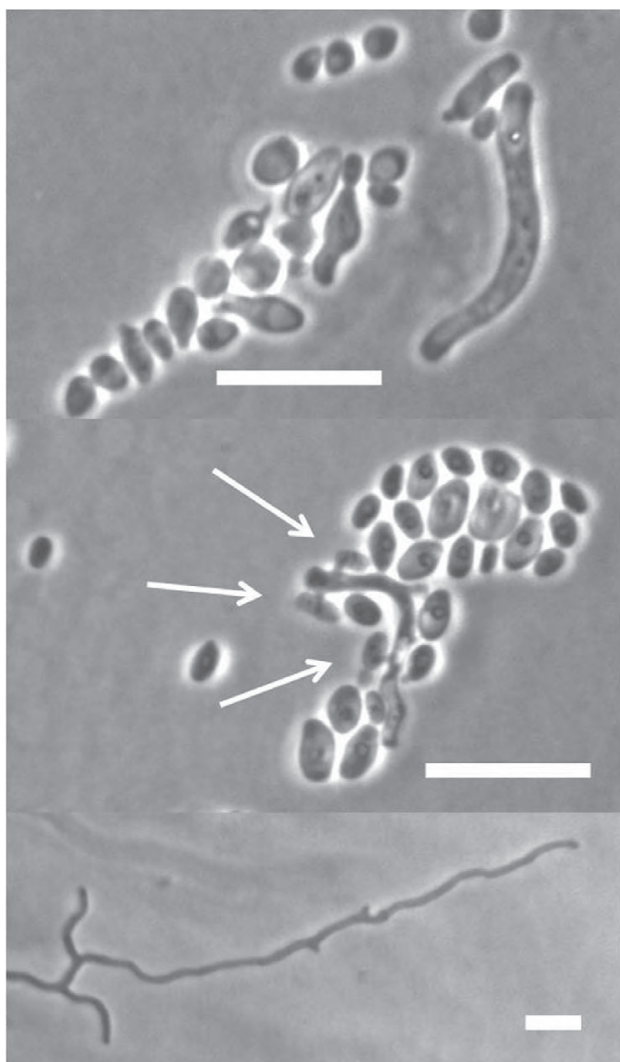


FIGURE 90.92 *Candida lasseensis* CBS 8524. Budding cells after 3 days, 25°C, YM agar (top). Predation of *Candida ontarioensis* CBS 8502 (arrows) by elongated cell of *C. lasseensis* after 3 days, 25°C, GY agar (middle). True hyphae after 14 days, 25°C, YCBAS agar (bottom). Bars = 10 µm.

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	s	DBB	—
D-Glucuronate	—	Gelatin	s
Glucono-δ-lactone	w	Casein	—
Amino acid-free	—	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	—	Cycloheximide 0.01%	+
L-Lysine	w	Cycloheximide 0.1%	—
Cadaverine	w	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF017726.

Cell carbohydrates: Not determined.

Origin of strain studied: CBS 8524 (NRRL YB-3657, UCD-FST 52-129), isolated from *Ips "oregonii"* (Coleoptera: Scolytidae) from lodge-pole pine (*Pinus contorta* var. *latifolia*, Pinaceae), California, USA.

Type strain: CBS 8524.

Systematics: A strain isolated from a bark beetle was described as *C. lasseensis* on the basis of the D1/D2 LSU rRNA gene sequence, which differs from the sequence of any other species (Kurtzman 1999). *C. lasseensis* is a member of the *Saccharomycopsis* clade and most closely related to *S. synnaedendra* and *S. microspora* (Fig. 63.1), which are basal to the *S. malanga* subclade.

The physiological characteristics of *C. lasseensis* resemble somewhat those of *Saccharomycopsis malanga* and *S. selenospora*. The utilization of starch but few sugars, combined with the inability to utilize sulfate as a source of sulfur, is unique to the three species. *C. lasseensis* can be distinguished from the other two by the lack of growth on cellobiose or galactose. Growth in general was poor as assessed by replica plating, with many weak responses on many of the tests reported as positive in the original description (Kurtzman 1999). Growth on Yeast Carbon Base with added nitrogen sources is particularly weak because of the yeast's inability to assimilate sulfur in the sulfate form combined with the low amount of methionine added to the medium.

Ecology: Like most species with affinities in the family Saccharomycopsidaceae, *C. lasseensis* is capable of necrotrophic parasitism on other yeasts (Fig. 90.92 middle). The possible association with bark beetles is consistent with the frequent isolation of other members of the family in tree sap fluxes and similar insect–plant interfaces that harbor rich yeast communities.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.149. *Candida leandrae* Ruivo, Pagnocca, Lachance & Rosa (Ruivo et al. 2004)

Phylogenetic placement: *Kodamaea* clade (Fig. 36.1). (The description is based on Ruivo et al. 2004.)

Growth on YM agar: After 4 days at 25°C, the colonies are white, convex, glabrous or membranous, smooth or rugose, butyrous to tough due to filamentous growth and sometimes with a fringed margin.

Growth in 0.5% yeast extract–2% glucose broth: After 3 days at 25°C, the cells are ellipsoidal to elongate, 2–4 × 3–6 µm, and occur singly, in budding pairs or in short chains.

Dalmat plate culture on corn meal agar: After 2 weeks, poorly developed pseudohyphae occur.

Fermentation

Glucose	+	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (in Liquid Media)

Glucose	+	D-Ribose	v
Inulin	+/w	Methanol	—
Sucrose	+	Ethanol	—
Raffinose	+/w	Glycerol	n
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	v	Citrate	+/w
Salicin	v	D-Gluconate	v
L-Sorbose	+	D-Glucosamine	v
L-Rhamnose	—	N-Acetyl-D-glucosamine	+/w
D-Xylose	+	Hexadecane	+/w
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Ethylamine	+
2-Keto-D-gluconate	+	50% Glucose	+
5-Keto-D-gluconate	—	10% NaCl/5% glucose	—
D-Glucuronate	v	Urease	—
Amino acid-free	+	DBB	—
Nitrite	—	Cycloheximide 0.01%	—
Cadaverine	+	Growth at 35°C	+
L-Lysine	+	Growth at 37°C	—

CoQ: Not determined.**Mol% G + C:** Not determined.**Gene sequence accession number, type strain:** D1/D2 LSU rRNA = AY449659.**Cell carbohydrates:** Not determined.**Origin of the strain studied:** UNESP 00-64R (CBS 9735, NRRL Y-27757), isolated in 2000 from a decaying fruit of *Leandra reversa* (Miconieae, Melastomataceae), in Atlantic rainforest, Pinguab area, Serra do Mar State Park, São Paulo State, Brazil (Ruivo et al. 2004).**Type strain:** UNESP 00-64R.**Systematics:** Based on an analysis of sequences of the D1/D2 domains of the LSU rRNA gene, *C. leandrae* belongs to the *Kodamaea ohmeri* clade where it is a sister species to *C. restingae* (Ruivo et al. 2004).**Ecology:** The species is known from fruit of *Leandra reversa* (Melastomataceae) from Atlantic rainforest in Brazil and *Drosophila floricola* from a morning glory (*Ipomoea indica*, Convolvulaceae) from the Island of Oahu, Hawai'i, USA.**Biotechnology:** Unknown.**Agriculture and food:** Unknown.**Clinical importance:** Unknown.**90.150. *Candida lessepsii* S.-O. Suh, N.H. Nguyen & M. Blackwell (2005b)****Phylogenetic placement:** *Yamadazyma* clade (Fig. 90.2). (The description is based on Suh et al. 2005b.)**Growth on YM agar:** After 7 days at 25°C, the colonies are white, smooth and butyrous.**Growth in YM broth:** After 7 days at 25°C, the cells are globose to ovoid, 2–4 × 3–5 μ m, mostly subglobose, occur singly, in pairs, in short chains or in clusters and pseudohyphae are present.**Dalmat plate culture on corn meal agar:** After 10 days at 25°C, pseudohyphae and hyphae are present. Aerobic growth is white with a slightly fuzzy margin.**Fermentation**

Glucose	+	Lactose	—
Galactose	d	Raffinose	—
Sucrose	—	Trehalose	+
Maltose	—		

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	—
Sucrose	+	Ethanol	—
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	d	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	d
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	d	Nitrate	—
D-Arabinose	+	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	50% Glucose	+
2-Keto-D-gluconate	—	10% NaCl/5% glucose	+
D-Glucuronate	—	Starch formation	—
Arbutin	+	Urease	—
Propane 1,2 diol	w	DBB	—
Butane 2,3 diol	—	Cycloheximide 0.01%	+
Cadaverine	+	Cycloheximide 0.1%	—
Creatinine	—	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	+
Ethylamine	+		

CoQ: Not determined.**Mol% G + C:** Not determined.**Gene sequence accession numbers, type strain:** D1/D2 LSU rRNA = AY640214, SSU rRNA = AY64021, ITS and 5.5S rRNA = AY964671.**Cell carbohydrates:** Not determined.**Origin of the strain studied:** NRRL Y-27766 (CBS 9941), isolated from the gut of an unidentified beetle, Barro Colorado Island, Panama (Suh et al. 2005b).**Type strain:** NRRL Y-27766.**Systematics:** Based on the analysis of combined sequences of the SSU and D1/D2 LSU rRNA genes, *C. lessepsii* belongs to a clade of closely related species, namely, *C. amphimixiae*, *C. cerambycidarum*, *C. gorgasii*, *C. michaelii* and *C. endomychidarum*, which forms a sister clade to *C. membranifaciens*, *C. friedrichii*, *C. blattariae* and *C. buinensis* (Suh et al. 2005b).**Ecology:** This species is known only from the gut of an unidentified beetle in Panama.**Biotechnology:** Unknown.**Agriculture and food:** Unknown.**Clinical importance:** Unknown.

90.151. *Candida lignohabitans* Kurtzman (2007a)

Phylogenetic placement: *Sugiyamaella* clade (Figs 72.1, 90.3).
(The description is based on Kurtzman 2007a.)

Growth on 5% malt extract agar: After 3 days at 25°C, yeast cells are spherical, 2–6 µm, to ellipsoidal, 1.8–3 × 4–9 µm, occur singly or in pairs and reproduce by multilateral budding (Fig. 90.93A). Hyphae develop after 7–10 days and form blastoconidia on denticles. Growth is tannish-white, dull-glistening, butyrous and with a hyphal fringe.

Growth on the surface of assimilation media: Pellicles do not occur.
Dalmau plate culture on morphology agar: After 7 days at 25°C, pseudohyphae may be present (Fig. 90.93B) and produce blastoconidia on denticles. Aerobic growth is tannish-white, dull-glistening, butyrous and with an irregular margin bordered by a thin hyphal fringe. True hyphae did not form on morphology agar, but were abundant on 5% malt extract agar after 7–10 days at 25°C.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	+
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	w
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	v
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

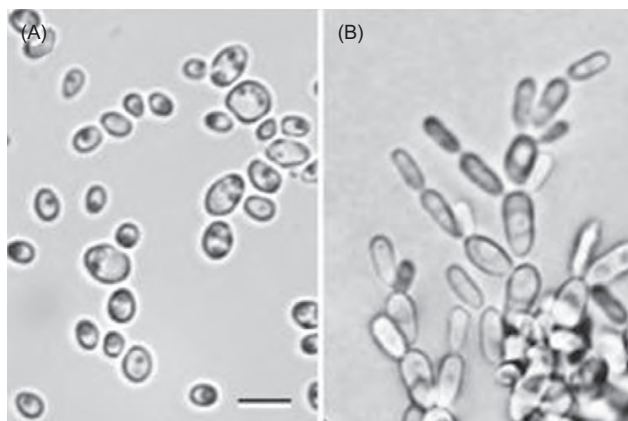


FIGURE 90.93 *Candida lignohabitans* NRRL YB-1473. Budding cells after 3 days, 25°C, 5% malt agar (A) and pseudohyphae after 7 days, 25°C, yeast morphology agar (B). Bar = 5 µm.

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	+	Starch formation	–
5-Keto-D-gluconate	+	Gelatin liquefaction	–
Saccharate	–	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 37°C	+
10% NaCl/5% glucose	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA = DQ438199, ITS = DQ911443, mitochondrial SSU rRNA = DQ442729, COXII = DQ443056.

Cell carbohydrates: Not determined.

Origin of the strains studied: NRRL YB-1473 (CBS 10342), isolated from a decayed tree log, Peoria, Illinois, USA; NRRL YB-2070 (CBS 10343), isolated from frass on paper birch (*Betula papyrica*, Fagaceae), Cadillac, Michigan, USA (Kurtzman 2007a).

Type strain: NRRL YB-1473.

Systematics: Based on concatenated gene sequences for LSU rRNA, mtSSU rRNA and COXII, *C. lignohabitans* belongs to the *Sugiyamaella* clade with *C. marionensis* as sister species (Kurtzman 2007a). Other closely related species are *C. novakii*, *C. grinbergii*, *C. pinicola*, *C. neo-mexicana* and *Sugiyamaella japonica*.

Ecology: The species is known from a decayed tree log and frass on paper birch from the USA.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.152. *Candida lignosa* (Kurtzman) Kurtzman (Kurtzman and Suzuki 2010)

Phylogenetic placement: *Scheffersomyces* clade; see Systematics (Fig. 90.2).

Synonym:

Candida shehatae H.R. Buckley & van Uden var. *lignosa* Kurtzman (1990b)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, 2–4.5 × 3.5–6 µm, and occur singly, in pairs and short chains. Pseudohyphae are also present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of elongate cells with globose to ovoid blastoconidia. Aerobic growth is white to cream colored, glistening and smooth with a reticulated margin.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	+/s	D-Xylose	+

Growth (in Liquid Media and on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	v	Glycerol	+
Melibiose	–	Erythritol	v
Galactose	+	Ribitol	+
Lactose	v	Galactitol	+
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+

Melezitose	+	<i>myo</i> -Inositol	—
Methyl- α -D-glucoside	+	D,L-Lactate	w
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	v
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	v	Nitrate	—
D-Arabinose	v	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	v	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	v	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: Not determined.

Mol% G + C: 44.1, NRRL Y-12856 (BD: Kurtzman 1990b).

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = U45772, SSU rRNA = AB013584.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 4705 (NRRL Y-12856), isolated from rotted wood, Chile, H. K hlwein.

Type strain: CBS 4705.

Systematics: As discussed under *C. shehatae*, *C. insectosa* and *C. lignosa* are closely related. Nuclear DNA reassociation studies showed ca. 50% relatedness among the species (Kurtzman 1990b), which initially led to their classification as varieties of *C. shehatae*. Upon re-evaluating this extent of relatedness, Kurtzman (Kurtzman and Suzuki 2010) elevated the varieties to the status of closely related species.

Ecology: The single known strain of this species was isolated from rotted wood in Chile.

Biotechnology: As discussed under *C. shehatae*, the three closely related species in this complex, i.e., *C. shehatae*, *C. insectosa* and *C. lignosa*, are known for their ability to ferment D-xylose. Some of the relevant literature was reviewed by Kastner et al. (1999). A majority of the D-xylose fermentation studies have been done using *C. shehatae*.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.153. *Candida linzhiensis* Bai & Wu (Wu and Bai 2006)

Phylogenetic placement: unaffiliated clade (Fig. 90.5). (The description is based on Wu and Bai 2006.)

Growth on YM agar: After 1 month at 25°C, the colony is low and raised, butyrous, viscous, cream colored, semi-glossy, smooth, with faint striations as well as ridged protuberances and with a slightly undulating margin.

Growth in YM broth: After 3 days at 25°C, the cells are subglobose, 3–5 $\times$ 4–6 μ m, to ovoid to elongate, 4–5 $\times$ 24–25 μ m, and occur singly, in pairs or in groups. Elongated cells are straight or curved and may produce small denticles that bear blastoconidia. Reproduction is by multilateral budding.

Growth on the surface of YM broth: After 1 month at 25°C, sediment and a climbing ring are present.

Dalmau plate culture on corn meal agar: Pseudohyphae and true hyphae are present.

Fermentation

Glucose	d/w	Lactose	—
Galactose	d/w	Raffinose	—
Sucrose	—	Trehalose	n
Maltose	—		

Growth (Liquid Media)

Glucose	d	D-Ribose	d
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	d/w	Glycerol	+
Melibiose	d/w	Erythritol	d
Galactose	+	Ribitol	+
Lactose	d	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	—	<i>myo</i> -Inositol	—
Methyl- α -D-glucoside	+	D,L-Lactate	—
Soluble starch	—	Succinate	d
Cellobiose	+	Citrate	—
Salicin	d	D-Gluconate	n
L-Sorbose	d	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	—
L-Arabinose	+	Nitrate	—
D-Arabinose	—	Vitamin-free	w/d

Additional Growth Tests and Other Characteristics

Nitrite	—	Urease	—
Cadaverine	+	DBB	—
L-Lysine	—	Growth at 25°C	+
Ethylamine	+	Growth at 30°C	—
Formation of starch-like compounds	—		

CoQ: 8 (Wu and Bai 2006).

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = DQ269921.

Cell carbohydrates: Not determined.

Origin of the strain studied: XZ 92-1 (AS 2.3073, CBS 10299), isolated from a fruit of an unidentified plant collected in Linzhi District, Tibet, in July 2004 (Wu and Bai 2006).

Type strain: XZ 92-1.

Systematics: Sequence analysis of the D1/D2 domains of the LSU rRNA gene indicated that *C. linzhiensis* belongs to a well-supported clade including *C. sequanensis* and *C. melibiosacea* (Wu and Bai 2006).

Ecology: *Candida linzhiensis* is only known from a single isolate from a fruit collected between 3111 and 3300 m in Tibet (Wu and Bai 2006).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.154. *Candida litsaeae* Kurtzman (2001a)

Phylogenetic placement: unaffiliated clade (Fig. 90.1).

(Some of the morphological characteristics were based on Kurtzman 2001a.)

Growth on 5% malt extract agar: After 3 days at 25°C, yeast cells are ovoid to elongate, $1.5\text{--}5 \times 2.5\text{--}6.5\ \mu\text{m}$, occur singly, in pairs or in short chains and clusters and reproduce by multilateral budding (Fig. 90.94A). Some of the larger cells produce a short rachis-like protuberance that forms successive blastoconidia (Fig. 90.94B,C). Short catenulate pseudohyphae composed of 6–10 ellipsoidal cells are present as well. True hyphae are abundant and form blastoconidia on short denticles (Fig. 90.94D). Growth is tannish-white, glistening, butyrous and with a fringe of true hyphae.

Dalmau plate culture on morphology agar: After 7 days at 25°C, growth under the coverglass shows limited pseudohyphae, but true hyphae are abundant. Both produce blastoconidia.

Fermentation

Glucose	+	Lactose	–
Galactose	w	Raffinose	w
Sucrose	+	Trehalose	+
Maltose	w		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	+	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	D-Lactate	–
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

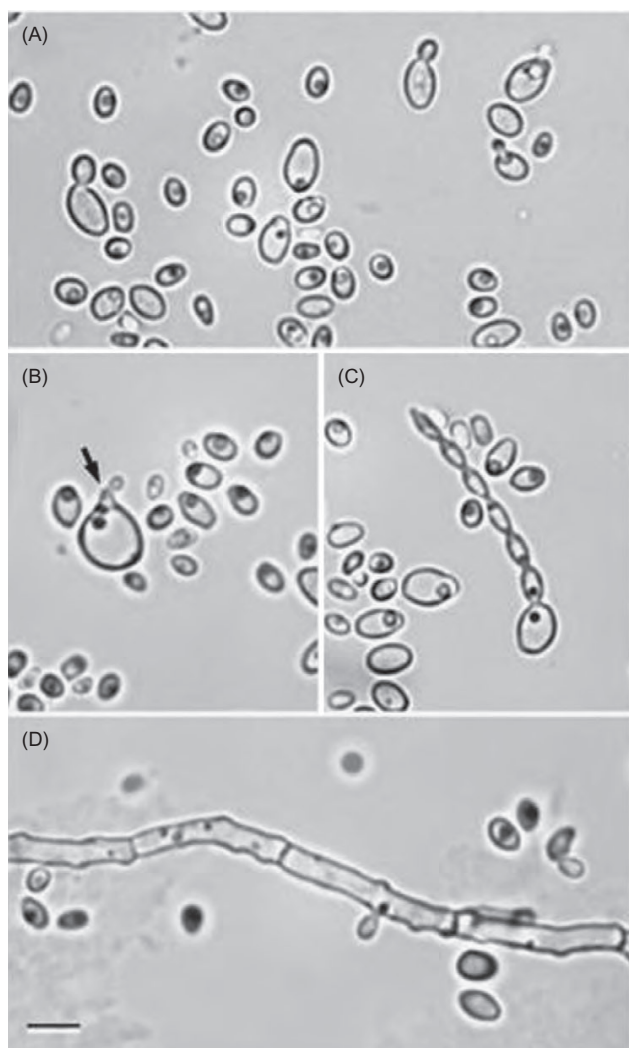


FIGURE 90.94 *Candida litsaeae* NRRL YB-3246. Budding cells (A), cell (arrow) forming a blastoconidium on a short rachis-like extension (B), short pseudohyphal fragment (C), and true hypha with blastoconidia formed on denticles (D), after 3 days, 25°C, 5% malt agar. Bar = 5 μm .

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	w	DBB	–
D-Glucuronate	–	Gelatin	s
Glucono- δ -lactone	–	Casein	–
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF271086.

Cell carbohydrates: Not determined.

Origin of strain studied: CBS 8799 (NRRL YB-3246), collected from insect frass from soalu (*Litsaea polyantha*, Lauraceae), India.

Type strain: CBS 8799.

Systematics: Analysis of D1/D2 LSU rRNA gene sequences (Kurtzman 2001a) was the basis for establishing the new species *C. litsaeae* and demonstrated a significant relationship with *C. ontarioensis*. The exact placement of these species could not be established based on D1/D2 LSU rRNA gene sequences. As SSU rRNA gene sequences were not available for these species, they were determined (*C. litsaeae* = AY500848). The analysis confirmed that the two are sister species and suggested a significant connection to *C. entomophila* and *C. silvanorum*, which also occupy basal positions in Fig. 90.1. However, Kurtzman and Robnett (2007), using a multi-gene approach, placed the two species in a sister clade to *Sporopachydermia* species.

Candida litsaeae has a broad spectrum of carbon assimilations, similar to that of *C. ontarioensis*. The two species differ in the assimilation of gluconic acid, which is negative in *C. litsaeae*, and growth at 37°C, which is positive in the species. As assessed by replica plating, the type strain did not grow in the presence of 10% NaCl, but hydrolyzed gelatin. The assimilation of raffinose, starch and erythritol, growth at 37°C and the lack of growth on L-sorbose, L-rhamnose or in the presence of 10% NaCl or 50% glucose can be used to separate *C. litsaeae* from similar species.

Ecology: The isolation of a single strain from insect frass would not on its own allow a generalization as to the habitat, but the fact that all four

related species discussed above have similar origins in insect frass or beetles suggests that they may be symbionts of wood-boring insects.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.155. *Candida llanquihuensis* C. Ramírez & A. González (1984f)

Phylogenetic placement: *Ogataea* clade (Fig. 90.4).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, $2.5\text{--}7 \times 5\text{--}7\text{ }\mu\text{m}$, and occur singly and in pairs (Fig. 90.95 top).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of elongate cells with verticils of ovoid blastoconidia (Fig. 90.95 bottom). Aerobic growth is white, waxy, dull and with an irregular margin.

Fermentation

Glucose	s	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	s
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	–	Ribitol	s
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	D,L-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	s	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

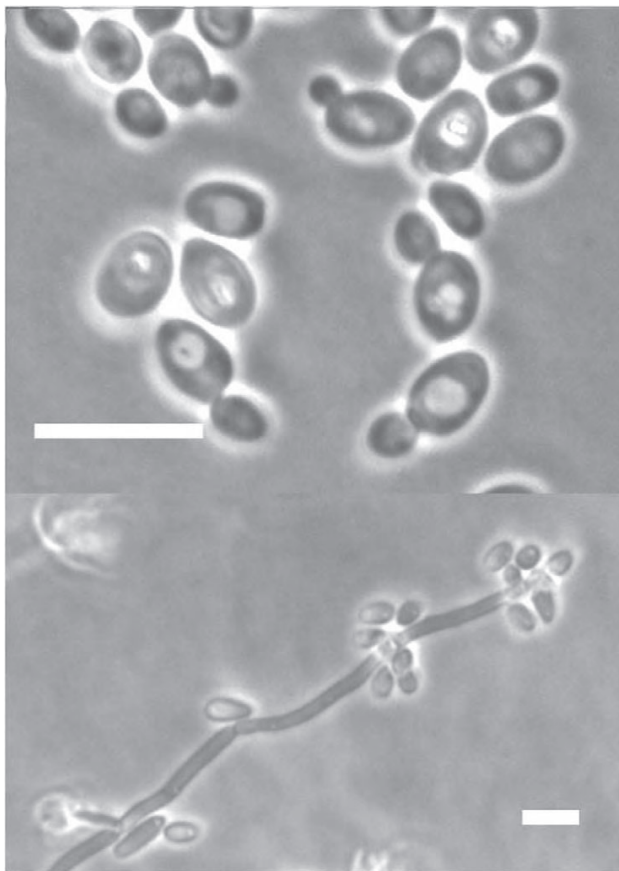


FIGURE 90.95 *Candida llanquihuensis* CBS 8182. Budding cells after 3 days, 25°C, YM agar (top) and pseudohypha after 14 days, 25°C, YCBAS agar (bottom). Bars = 10 μm .

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: 40.5, type strain (T_m : Tengku Zainal Mulok 1988).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70190.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 8182, isolated from a fallen trunk of southern beech (*Nothofagus obliqua*, Fagaceae), Valdivian Forest, Chile.

Type strain: CBS 8182.

Systematics: *Candida llanquihuensis* was described by Ramírez and González (1984f) to accommodate a strain isolated from a decaying southern beech tree. Based on D1/D2 LSU rRNA gene sequences (Kurtzman and Robnett 1998a), the species has affinities within the methylotrophic yeasts and the genus *Ogataea*. This link is also supported by SSU sequences (Suzuki and Nakase 2002).

The physiology of *C. llanquihuensis* is distinct, combining the utilization of erythritol with absence of growth on most carbohydrates tested, as only trehalose and some pentoses are utilized.

Ecology: The species is known only from an isolate from a fallen tree.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.156. *Candida lycoperdinae* S.-O. Suh, N.H. Nguyen & M. Blackwell (2006a)

Phylogenetic placement: *Candida kruisii* clade (Fig. 90.5).

(The description is based on Suh et al. 2006a.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, smooth, slightly wrinkled in the center and with a filamentous margin.

Growth in YM broth: After 7 days at 25°C, cells are globose to ovoid, 2–7.5 × 3–10 μm, mostly ellipsoidal, occur singly, in pairs, in short chains or in clusters and pseudohyphae are present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and hyphae with blastoconidia are present. Aerobic growth is white, shiny, smooth and with a filamentous margin.

Fermentation

Glucose	+	Lactose	–
Galactose	d	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	–
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	w
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	d/w	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	w	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Ethylamine	+
2-Keto-D-gluconate	+	50% Glucose	v
D-Glucuronate	–	10% NaCl/5% glucose	+
L-Arabinitol	–	Starch formation	–
Arbutin	+	Urease	–
Propane 1,2 diol	–	DBB	–
Butane 2,3 diol	–	Cycloheximide 0.01%	–
Nitrite	–	Cycloheximide 0.1%	–
Cadaverine	+	Growth at 30°C	+
Creatinine	–	Growth at 35°C	–
L-Lysine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA = AY242315, SSU rRNA = AY242204, ITS and 5.8S rRNA = AY640198.

Cell carbohydrates: Not determined.

Origin of the strains studied: NRRL Y-27658 (CBS 9850), isolated from the gut of the handsome fungus beetle (*Lycoperdina ferruginea*, Nitidulidae) on a fruiting body of a gasteromycete mushroom, the common puffball (*Lycoperon perlatum*), Athens, Georgia, USA; NRRL Y-27658 (CBS 9851), from the body surface of dung beetle (*Canthon* sp., Scarabaeidae), Oconee National Forest, Georgia, USA (Suh et al. 2006a).

Type strain: NRRL Y-27658.

Systematics: Sequence analysis of the LSU and SSU rRNA genes placed *C. lycoperdinae* in a well-supported cluster with *C. tritomae*, *C. pallodes* and *C. panamensis* in the *C. kruisii* clade (Suh et al. 2006a).

Other phylogenetically related species are *C. atbi*, *C. aglyptinia*, *C. barcoloradensis*, *C. gatunensis* and *C. stri*.

Ecology: The species is known from basidiocarp-feeding beetles in the south-east USA (Suh et al. 2006a).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.157. *Candida lyxosophila* van der Walt, N.P. Ferreira & Steyn (1987a)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Figs 68.1, 90.5).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to subglobose, ovoid to ellipsoidal, 3.5–5 × 3.5–6 μm, occur singly and in pairs (Fig. 90.96) and pseudohyphae are present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of elongate cells with ovoid blastoconidia, and septate hyphae may be present. Aerobic growth is white, smooth, soft and butyrous with a hyphal margin.

Fermentation

Glucose	s	Lactose	–
Galactose	s	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	s	D-Xylose	–

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	s
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	v	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	+
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	s
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	v	Casein	–
Amino acid-free	+	Lipase	s
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	v
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

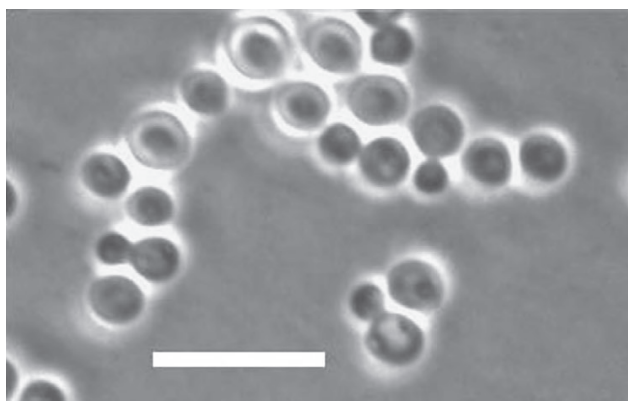


FIGURE 90.96 *Candida lyxosophila* CBS 8194. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 37.9, CBS 8194 (van der Walt et al. 1987a); 38.2, CBS 8194 (T_m : S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U76204.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 7268, CBS 8194, isolated from the surface of woodland soil, South Africa.

Type strain: CBS 8194.

Systematics: *Candida lyxosophila* was described on the basis of six strains isolated in the course of a search for D-xylose-fermenting yeasts (van der Walt et al. 1987a). An overall similarity was noted with *C. viswanathii*. Analysis of the D1/D2 LSU (Kurtzman and Robnett 1998a) and the SSU (Sugita and Nakase 1999) rRNA gene confirmed a basal relationship with species related to *Lodderomyces*, which include *C. viswanathii*, but also suggested a connection to *C. insectamans*. The closest relative, however, is *C. jeffriesii*, recently described by Nguyen et al. (2006b). According to the analysis presented by these authors, *C. jeffriesii*, *C. lyxosophila*, *C. insectamans* and the ascosporic species *Spathaspora passalidarum* form a sister clade to the *Lodderomyces* clade.

In addition to the ability to ferment D-xylose, *C. lyxosophila* utilizes a broad array of carbon compounds, rather typical of the profile of species in the *Lodderomyces* and the *Spathaspora* clades. Differentiation from *C. albicans*, *C. sake*, *C. shehatae* and potentially some of the more recently described relatives on the basis of growth tests may be difficult, but not necessarily impossible. Cellobiose, lactic acid and citric acid are among the more useful traits for separation from other species.

Ecology: *Candida lyxosophila* is known from six soil isolates.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.158. *Candida magnoliae* (Lodder & Kreger-van Rij) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Starmerella* clade (Figs 71.1, 90.3).

Synonyms:

Torulopsis magnoliae Lodder & Kreger-van Rij (1952)

Entelexis magnoliae van der Walt & E. Johannsen (1973)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to slightly ovoid, 2–4 × 3–4.5 μm, and

occur singly and with buds (Fig. 90.97). A few short chains and small clusters are present.

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present. Aerobic growth is white, smooth, creamy and with an entire margin.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	+	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	–	Methanol	–
Sucrose	v	Ethanol	s
Raffinose	v	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	s	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D-Lactate	–
Soluble starch	–	Succinate	s
Cellobiose	–	Citrate	v
Salicin	v	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	+
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	w	Starch production	–
2-Keto-D-gluconate	v	DBB	–
D-Glucuronate	–	Gelatin	w/–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	+	Acid production	–
Ethylamine	s	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	w	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	v

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 60.0, type strain (T_m : Nakase and Komagata 1971d).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45722.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 166, isolated from a flower of *Magnolia* sp. (Magnoliaceae); CBS 2677, from concentrated orange juice, South Africa; CBS 2800, from gut of a bee, Croatia.

Other strains available: CBS 6424, CBS 6425, origin unknown.

Type strain: CBS 166.

Systematics: *Candida magnoliae* is a member of the *Starmerella sensu lato* subclade (Fig. 71.1) and a close relative of *C. sorbosivorans* and *C. geochares*, based on D1/D2 LSU rRNA gene sequences (Rosa et al. 2003). SSU rRNA gene sequences (Suzuki et al. 1999) suggest a more distant

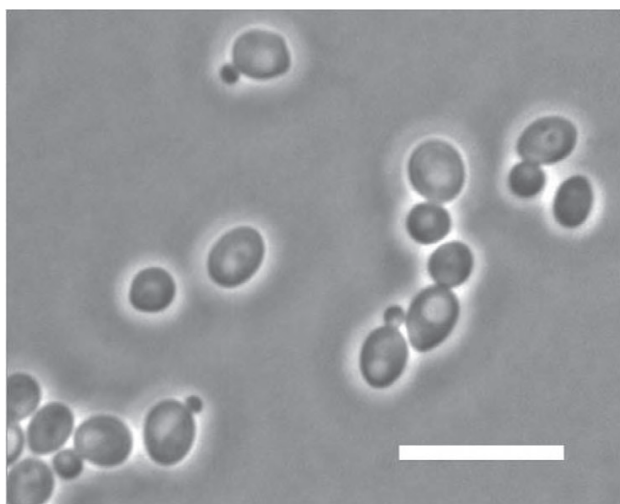


FIGURE 90.97 *Candida magnoliae* CBS 166. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

position from *C. geochares* but provide a comparable phylogenetic structure for the subclade. Nakase et al. (1994a) reported on the heterogeneity among strains of *C. magnoliae*. Based on DNA base composition, DNA reassociation and isozyme electrophoresis, 10 strains were shown to represent five distinct genetic groups. This report has apparently not been followed up. Of the nine strains received from the CBS, three did not group well with others on the basis of growth tests. Strains CBS 3086 and CBS 6201 were physiologically closer to *C. sorbosivorans*, and their membership in that species was confirmed by sequencing of the D1/D2 domains of the LSU rRNA gene. Strain CBS 2250 occupied an intermediate position, physiologically, between *C. magnoliae* and *C. sorbosivorans*. The D1/D2 sequence (AY521567) was found to differ by three substitutions from that of *C. sorbosivorans*, the closest relative, and seven substitutions from either *C. magnoliae* or *C. geochares* (Fig. 71.1). Of the remaining six strains, only two matched the type perfectly in their D1/D2 sequences. The remaining three strains differed substantially. Strain CBS 2798 (AY521568; isolated from a flower by A. Capriotti), selected by van der Walt and Johannsen (1973) to be the type of *Entelelexis magnoliae*, differed from *C. magnoliae* by 30 substitutions and one gap, and is distinct from other members of the clade. Strains CBS 5659 (AY521569), from larval feed of African carpenter bee (*Xylocopa caffra*, Hymenoptera: Apidae), and CBS 6396 (AY521570), from larval pabulum of *Xylocopa scioensis* in South Africa, differed by one substitution from each other and by 24–25 substitutions from the type. These strains appear distinct from other species and are possibly more closely related to *C. tilneyi* and to strain UWOPS 00-334.3, an unassigned isolate found in a beetle in Hawai'i.

As is typical in the *Starmerella* clade, the species assimilates few carbon sources and gives ambiguous responses for the utilization of β -fructosides. The three authentic strains that remain after reassignment of other strains previously recognized in the species show variability in the assimilation of salicin, growth at 37°C, and the hydrolysis of gelatin. The responses listed above are based on these strains. Identification on the basis of physiological responses is difficult. The assimilation of D-ribose, ethanol and nitrate is one of the more useful characteristics for separation from similar species.

Ecology: The distribution of *C. magnoliae* isolates is typical of species in the *Starmerella* clade, which are often recovered in association with bees and their habitats.

Biotechnology: *Candida magnoliae* and related cryptic species are of interest in biotechnology. Strains assigned to the species are used in

the production of erythritol (Yang et al. 1999) and D-mannitol (Song et al. 2002) as substitute sweeteners.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Van der Walt and Johannsen (1973) examined 24 strains of *Torulopsis (Candida) magnoliae* to see if mating and sexuality could be observed. A strain subjected to a heat treatment at 57°C gave rise to variant colonies that contained cell pairs reminiscent of zygotes. The cell pairs later formed swollen structures that developed into larger, refringent resting spores. X-ray inactivation suggested that this stage was diploid. The resting cells were thought to undergo meiosis at the time of germination, although the four structures seen in a Giemsa-stained cell are probably too small to have been nuclei. The authors commented on the high G+C content of nuclear DNA of the species, a characteristic normally associated with yeasts of basidiomycetous affinity. This was in contrast to other features of *C. magnoliae*, which suggested that the species is ascomycetous. From these observations, the authors proposed that certain yeast species, although primarily ascomycetous in nature, achieve sexual reproduction by means other than ascus formation. The authors used the term “dangeardien” to designate such a phenomenon, and created the genus *Entelelexis* to accommodate the teleomorph of *C. magnoliae*. Ascospore formation following conjugation of compatible mating type has since been demonstrated in *C. bombycola*, a relative of *C. magnoliae*, and the genus *Starmerella* was created to accommodate the teleomorph (Rosa and Lachance 1998). The possibility remains, however, that alternative life cycles do arise in these unusual yeasts. It is clear that the *Starmerella* clade contains a large amount of uncovered diversity (Rosa et al. 2003).

90.159. *Candida maltosa* Komagata, Nakase & Katsuya (1964a)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Fig. 90.5).

Synonyms:

Candida cloacae Komagata, Nakase & Katsuya (1964a)

Candida novellus Watanabe, Shimada, Kawaharada, K. Suzuki & Tanaka (1973) nom. nud.

Candida subtropicalis Nakase, Fukazawa & Tsuchiya (1972)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 3–5 $\times$ 4–7 μ m, and occur singly or in pairs or small groups (Fig. 90.98).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of cylindrical cells with verticils of ovoid blastoconidia. Aerobic growth is white, creamy, soft, smooth or slightly folded and with a fringed margin.

Fermentation

Glucose	+	Lactose	–
Galactose	v	Raffinose	–
Sucrose	+	Trehalose	+
Maltose	v		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	v
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+

Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	D,L-Lactate	v
Soluble starch	—	Succinate	+
Cellobiose	v	Citrate	v
Salicin	v	D-Gluconate	v
L-Sorbose	v	D-Glucosamine	v
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	—
Amino acid-free	+	Lipase	w
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	v	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	+

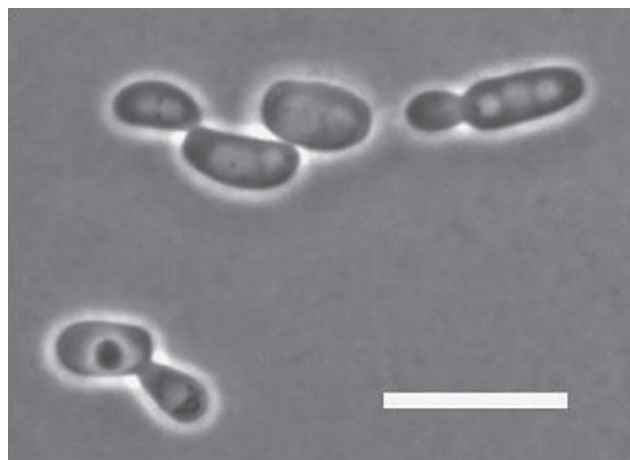


FIGURE 90.98 *Candida maltosa* CBS 5611. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

CoQ: 9 (Yamada and Kondo 1972a, Kaneko et al. 1977).

Mol% G+C: 36.3, AJ 4718 (T_m : Nakase and Komagata 1971f); 35.6–36.8, six strains (T_m : Meyer et al. 1975); 36.1, CBS 5611; 36.6, ATCC 20184; 37.3, #36 (CBS 6658) and CBS 6465 (T_m : Kaneko et al. 1977); 36.6, CBS 6658; 36.8, CBS 6680 (T_m : Su and Meyer 1991).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45745.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5611, isolated from neutralizing tanks for monosodium glutamate in Japan; CBS 5612, type strain of *C. cloacae*, from mud in Japan; CBS 6465, type strain of *C. subtropicalis*, from atmosphere in Japan.

Other strains available: CBS 6658 (received as *C. novellus*) and CBS 6680, isolated from soil in Japan; CBS 7327, waste water, Germany.

Type strain: CBS 5611.

Systematics: Komagata et al. (1964a) screened 498 yeast strains for their ability to assimilate kerosene. Positive strains were characterized for their ability to metabolize pure alkanes ranging in size from 5 to

16 carbons. Two of the 49 isolates utilized nonane, decane, undecane, dodecane, tetradecane and hexadecane. These isolates did not fit previous descriptions and were described as *C. cloacae* and *C. maltosa*, respectively. The two were later found to be conspecific by DNA reassociation (Meyer et al. 1975). DNA reassociation also demonstrated that *C. maltosa* is distinct from *C. sake* and *C. tropicalis* (Kaneko et al. 1977, Meyer et al. 1975). The rRNA gene sequences of the last three species are distinct although not dissimilar and indicate a connection to *Lodderomyces* (Kurtzman and Robnett 1998a, Sugita and Nakase 1999).

The species is physiologically typical of the *Lodderomyces* clade, where many species assimilate hexadecane. Among species with a similar growth profile, *C. sake*, *C. tropicalis* and *C. viswanathii* can be separated on the basis of starch utilization, growth at 37°C or growth in the presence of cycloheximide.

Ecology: Schmitz et al. (2000) studied survival and competition among *n*-alkane-assimilating yeasts in sandy soils, in the context of possible use for decontamination of oil pollution. A strain of *C. maltosa* was found to possess a particularly high degree of survivorship compared to other species or yeasts as well as bacteria.

Biotechnology: As for other *n*-alkane-assimilating yeasts, *C. maltosa* is thought to have potential application in the decontamination of soil polluted by petroleum products (Schmitz et al. 2000).

Agriculture and food: Unknown.

Clinical importance: In a survey of rainforest yeasts in Brazil, Buzzini and Martini (2000c) recovered a large number of strains assigned to *C. maltosa* that exhibited strong killer activities. Buzzini and Martini (2001b) later investigated their possible application in the treatment of mycoses.

90.160. *Candida marilandica* Kurtzman (2007a)

Phylogenetic placement: *Sugiyamaella* clade (Fig. 90.3).

(The description is based on Kurtzman 2007a.)

Growth on 5% malt extract agar: After 3 days at 25°C, yeast cells are spherical, 2–4 μ m, to elongate, 2 $\times$ 3–7 μ m, form by multilateral budding and occur singly or in pairs (Fig. 90.99A). Additionally, some cells are tapered and others form a sterigma-like outgrowth that produces blastoconidia. Aerobic growth is tannish-white, dull-glistening and butyrous.

Growth on the surface of assimilation media: Pellicles are not formed on stationary cultures.

Dalmau plate culture on morphology agar: After 7 days at 25°C, pseudohyphae with blastoconidia are present. Aerobic growth is tannish-white, dull-glistening, butyrous and with a finely serrate margin. True hyphae are formed on various media after several weeks and often have a spherical, inflated terminal cell that produces buds (Fig. 90.99B). Blastoconidia may form on short denticles on the hyphal cells.

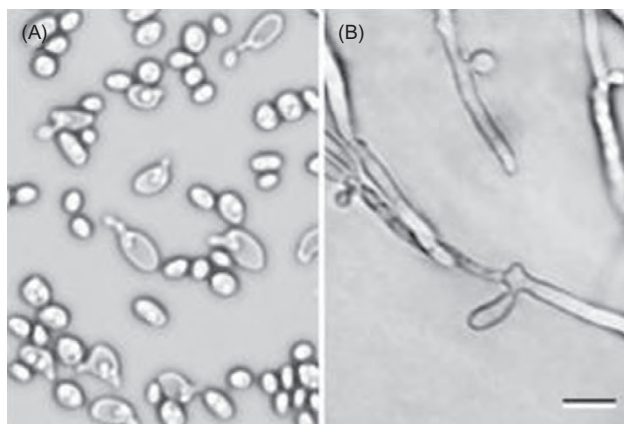


FIGURE 90.99 *Candida marilandica* NRRL YB-1847. Budding cells, some with denticles that form blastoconidia, after 3 days, 25°C, 5% malt agar (A). True hypha with blastoconidia formed on denticles, after 7 days, 25°C, yeast morphology agar (B). Bar = 5 μ m.

Fermentation: Absent.

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	–
Melibiose	+	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	+
Methyl- α -D-glucoside	+	D,L-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	+
D-Arabinose	+	Vitamin-free	w

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	+	Starch formation	–
5-Keto-D-gluconate	+	Gelatin liquefaction	–
Saccharate	–	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 37°C	+
10% NaCl/5% glucose	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA = DQ438219, ITS = DQ911445, mitochondrial SSU rRNA = DQ442735, COXII = DQ443063.

Cell carbohydrates: Not determined.

Origin of the strains studied: NRRL YB-1847 (CBS 10346), isolated from frass on a dead pine tree (*Pinus* sp.), Towson, Maryland; NRRL YB-2020, isolated from frass on longleaf pine (*Pinus palustris*), Wilma, Florida, both USA (Kurtzman 2007a).

Type strain: NRRL YB-1847.

Systematics: Phylogenetic analysis of the combined gene sequences for LSU rRNA, mitochondrial SSU rRNA and COXII, placed *C. marilandica* in the *Sugiyamaella* clade where it clusters with *Sugiyamaella smithiae* and *S. chilensis* (Kurtzman 2007a).

Ecology: Known from frass on pine trees, USA.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.161. *Candida marionensis* Kurtzman (2007a)

Phylogenetic placement: *Sugiyamaella* clade (Figs 72.1, 90.3).

(The description is based on Kurtzman 2007a.)

Growth on 5% malt extract agar: After 3 days at 25°C, cells are spherical, 2.5–6 μ m, to elongate, 1.8–2.8 $\times$ 4–11.5 μ m (Fig. 90.100A). There are also numerous triangular cells, some of which form blastoconidia on denticles. Budding is multilateral and cells occur singly or in pairs. Aerobic growth is tannish-white, dull and hyphal.

Growth on the surface of assimilation media: Pellicles do not form on stationary liquid media.

Dalmau plate culture on morphology agar: After 7 days at 25°C, pseudohyphae and true hyphae are present (Fig. 90.100B). Aerobic growth is tannish-white, dull, wrinkled, butyrous and with an

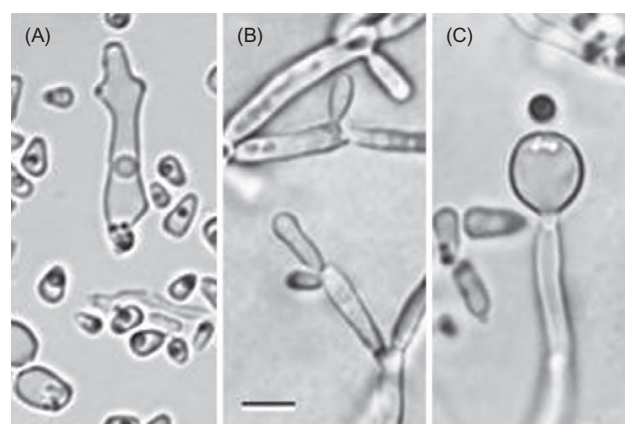


FIGURE 90.100 *Candida marionensis* NRRL YB-1336. Budding cells after 3 days, 25°C, 5% malt agar (A). Pseudohyphae with blastoconidia (B), and true hypha with a spherical inflated tip cell forming a bud (C), after 7 days, 25°C, yeast morphology agar. Bar = 5 μ m.

irregularly lobed margin. Hyphae on various media often show a spherical, inflated terminal cell that may produce buds (Fig. 90.100C).

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	–	Ethanol	v
Raffinose	–	Glycerol	–
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	D,L-Lactate	–
Soluble starch	–	Succinate	v
Cellobiose	+	Citrate	v
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	w
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	+	Starch formation	–
5-Keto-D-gluconate	+	Gelatin liquefaction	–
Saccharate	–	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 37°C	+
10% NaCl/5% glucose	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA = DQ438197, ITS = DQ911452, mitochondrial SSU rRNA = DQ442727, COXII = DQ443055.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL YB-1336 (CBS 10341), isolated from a rotten log, Marion, Illinois, USA.

Type strain: NRRL YB-1336.

Systematics: Phylogenetic analysis of the combined gene sequences for LSU rRNA, mitochondrial SSU rRNA and COXII placed *C. marionensis* in the *Sugiyamaella* clade. In this clade it clusters with *C. lignohabitans*, the closest relative, and *C. novakii*, *C. grinbergsii*, *C. pinicola*, *C. neomexicana*, *Sugiyamaella americana* and *S. japonica*. Two other subclades in this clade comprise *S. chiloensis*, *S. smithiae*, *C. marilandica* and *C. valdiviana*, *C. boreocaroliensis* and *C. floridensis*, respectively (Kurtzman 2007a).

Ecology: This species is known from a single strain from a rotten log in USA.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.162. *Candida maris* (van Uden & Zobell) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Ogataea* clade (Figs 53.1, 90.4).

Synonym:

Torulopsis maris van Uden & Zobell (1962)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 2–4 × 2.5–4.5 µm, and occur singly and in pairs (Fig. 90.101).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present. Aerobic growth is cream colored, soft, smooth and with an entire margin.

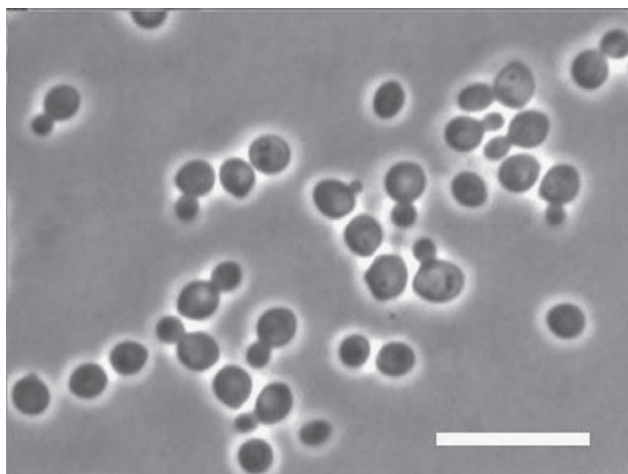


FIGURE 90.101 *Candida maris* CBS 5151. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	+
Sucrose	–	Ethanol	+

Raffinose	–	Glycerol	v
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	v
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	+	N-Acetyl-D-glucosamine	–
D-Xylose	v	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	w

CoQ: 7 (Yamada and Kondo 1972a).

Mol% G + C: 47.3, CBS 5151 (T_m : Nakase and Komagata 1971d); 50.9, CBS 5151 (BD: Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70181.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 5151, isolated from seawater, Torres Strait, Australia.

Type strain: CBS 5151.

Systematics: In a study of yeasts present in seawater collected near the Great Barrier Reef in Australia, van Uden and Zobell (1962) isolated various strains that could not be assigned to known species on the basis of growth responses. One of these was described as *Torulopsis maris*. *C. maris* is related to *Ogataea wickerhamii* (formerly *Pichia finlandica*) as evidenced by D1/D2 LSU rRNA gene sequence analysis (Kurtzman and Robnett 1998a). The position of the species among methylotrophic yeasts was confirmed by analysis of SSU rRNA gene sequences (Suzuki and Nakase 2002).

Methanol utilization in combination with L-rhamnose as the only assimilated sugar could cause one to suspect a closer relationship with *Komagataella* (*Pichia*) *pastoris* than to members of the *Ogataea* clade. The assimilation of pentitols and the absence of fermentation can be used for separation from the former.

Ecology: Although *C. maris* is rare, a number of related undescribed species are frequently isolated in the sap fluxes of tropical leguminous trees. The possibility exists that *C. maris*, like many other methylotrophs, is associated with the decay of woody plants rather than seawater, where of course it can occur as an allochthonous component.

Biotechnology: Kawano et al. (2003) screened a number of yeast species for their ability to perform the enantioselective reduction of 5-acetylfuro[2,3-*c*]pyridine to (*S*)-5-(1-hydroxyethyl)furo[2,3-*c*]pyridine. *C. maris* was by far the most efficient and the most selective of the species examined. Such transformations are useful in the pharmaceutical industry, and in this particular case, in the synthesis of an HIV reverse-transcriptase inhibitor.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.163. *Candida maritima* (Siepmann) van Uden & H.R. Buckley ex S.A. Meyer & Ahearn (1983)

Phylogenetic placement: *Wickerhamomyces* clade (Figs 42.1, 90.4).

Synonyms:

Trichosporon maritimum Siepmann (Siepmann and Höhnk 1962)

Candida maritima (Siepmann) van Uden & H.R. Buckley (1970) nom. inval.

Candida pilmaiquensis C. Ramírez & A. González (1984g)¹

¹ Synonymy is based on phenotype.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are primarily ovoid, 3–5 × 3.5–8 μm, occur singly and in pairs, but cylindrical cells also are present (Fig. 90.102 top).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of cylindrical cells with verticils of ovoid blastoconidia (Fig. 90.102 bottom). Aerobic growth is off-white to cream colored, soft, smooth to wrinkled and glistening with an irregular or hyphal border.

Fermentation

Glucose	s	Lactose	–
Galactose	–	Raffinose	s/–
Sucrose	s/–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	v	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D,L-Lactate	v
Soluble starch	v	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	v
L-Rhamnose	+	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	–
L-Arabinose	v	Nitrate	–
D-Arabinose	v	Vitamin-free	–

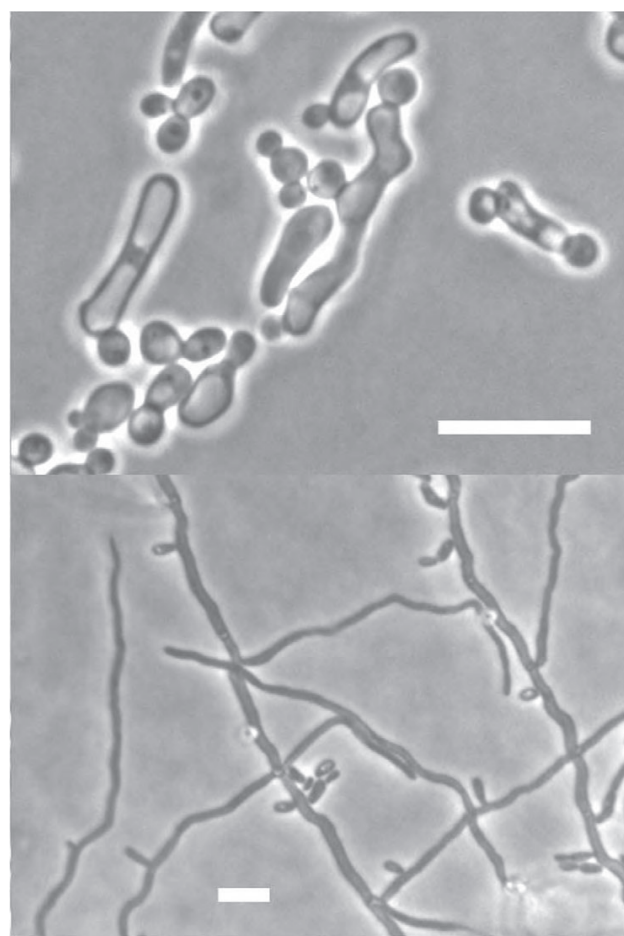


FIGURE 90.102 *Candida maritima* CBS 5107. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 25°C, YCBAS agar (bottom). Bars = 10 μm.

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	v	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	v
50% Glucose	–	Growth at 37°C	–

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: 45.4, type strain (*T_m*: Meyer et al. 1984); 46.8, CBS 8176 (*T_m*: M.Th. Smith, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U69877.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 4112, isolated from tunnel of ambrosia beetle; CBS 4606, from beetle; CBS 5107, from egg of shrimp;

CBS 8176, type strain of *C. pilmaiquensis*, rotten trunk of southern beech (*Nothofagus obliqua*, Fagaceae), Chile.

Type strain: CBS 5107.

Systematics: *Candida maritima* belongs to the *Lindnera* clade (Kurtzman et al. 2008). Four strains received from the CBS matched the description, but strain CBS 7762, isolated from a scolytid beetle (*Anisandrus dispar*, Coleoptera: Scolytidae) collected on a hazelnut in Italy, differed by the absence of growth on L-rhamnose, xylitol and gluconic acid. The D1/D2 LSU rRNA gene was sequenced and it appeared that the strain is a close relative of *Lindnera (Pichia) veronae*. A number of recently described species appear to be closely related to *C. maritima*. These include *C. mycetangii* (see the discussion under that species) as well as *C. easanensis*, *C. pattaniensis* and *C. nakhonratchasimensis* (Jindamorakot et al. 2004).

The growth characteristics of *C. maritima* are similar to those of several *Lindnera* species, including *Lindnera veronae*, from which it is practically indistinguishable. Differentiation from *Lindnera euphorbiae* and a few others can be made from the inability of the species to grow at 37°C. Further separation from *C. freyschussii* can be based on the lack of growth on rhamnose.

Ecology: *Candida maritima* has been recovered from a number of sources, including woody substrates undergoing decay due to the action of beetles. Relatives of the species, including the aforementioned recent isolates, abound in such habitats.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.164. *Candida maxii* S.-O. Suh & M. Blackwell (Suh et al. 2004b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5). (The description is based on Suh et al. 2004b.)

Growth on YM agar: After 7 days on YM agar at 25°C, colonies are flat, white, glistening, ridged and have a filamentous margin.

Growth in YM broth: After 7 days at 25°C, cells are globose to subglobose, 2.5–6 × 4–6 µm, and pseudohyphae and hyphae are present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae are present. Aerobic growth is white, shiny and smooth and has a filamentous margin.

Fermentation

Glucose	d	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	w
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	d
Melibiose	–	Erythritol	d
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+

L-Sorbose	–	D-Glucosamine	d
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	–	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	w	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	w	50% Glucose	+
2-Keto-D-gluconate	+	10% NaCl/5% glucose	+
D-Glucuronate	–	Starch formation	–
Arbutin	+	Urease	–
Propane 1,2 diol	–	Cycloheximide 0.01%	–
Butane 2,3 diol	–	Cycloheximide 0.1%	–
Cadaverine	+	Growth at 25°C	+
Creatinine	–	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	–
Ethylamine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY242253, SSU rRNA = AY242144.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27588 (CBS 9836), isolated from the gut of an unidentified tenebrionid beetle (Tenebrionidae) on a polypore, Barro Colorado Island, Panama (Suh et al. 2004b).

Type strain: NRRL Y-27588.

Systematics: Phylogenetic analysis of the SSU and LSU rRNA gene sequences placed *C. maxii* in the *C. tanzawaensis* clade in a cluster with *C. anneliseae* and *C. taliae* and with *C. bibrorum* as a sister species (Suh et al. 2004b).

Ecology: The species is known only from the gut of an unidentified tenebrionid beetle in Panama (Suh et al. 2004b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.165. *Candida melibiosica* H.R. Buckley & van Uden (1968)

Phylogenetic placement: *Metschnikowia* clade (Fig. 90.1).

Synonyms:

Candida parapsilosis (Ashford) Langeron & Talice var. *hokkai* S. Goto & Yokotsuka (1962b)

Torulopsis navarrensis Moriyon & Ramírez (1974)¹

Candida navarrensis (Moriyon & C. Ramírez) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Torulopsis pampelonensis C. Ramírez & A.T. Martinez (1978)¹

Candida pampelonensis (C. Ramírez & A.T. Martinez) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

¹ Synonymy based on DNA reassociation experiments and protein electrophoresis (Daniel 1983).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 2.5–4.5 × 2.5–5 µm, and occur singly and in pairs (Fig. 90.103).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, poorly developed pseudohyphae consist of short, branched chains of cells. This type of growth gives the colony a bushy, feathery appearance. Aerobic growth is cream colored, butyrous, soft and with an entire lobate margin. Occasionally, tufts of pseudohyphal growth may be present.

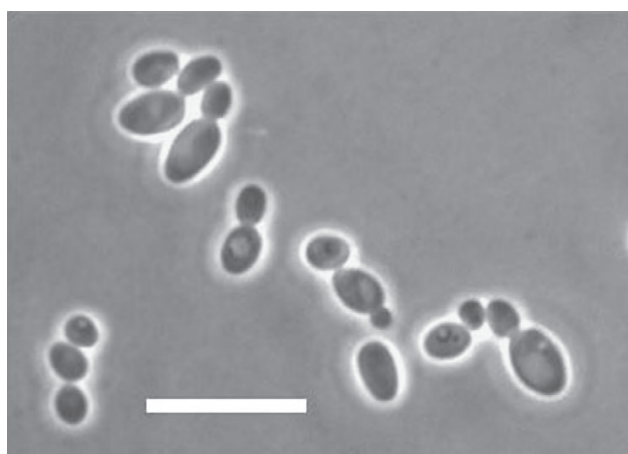


FIGURE 90.103 *Candida melibiosica* CBS 5814. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Fermentation

Glucose	+	Lactose	–
Galactose	s	Raffinose	–/s
Sucrose	–/s	Trehalose	–/s
Maltose	–/s		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	v	Glycerol	v
Melibiose	+	Erythritol	–
Galactose	+	Ribitol	v
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	v	D,L-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	v
L-Sorbose	v	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	v

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–/w
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	+

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 54.5–55.5, 3 strains (T_m : Meyer et al. 1984); 55.9, AJ 4611 (T_m : Nakase and Komagata 1971f); 54.1, CBS 5605; 55.1, CBS 6612; 55.6, CBS 6611; 56.8, CBS 5814 (T_m : Daniel 1983).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U44813.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5605, type strain of *C. parapsilosis* var. *hokkai*, isolated from film on wine, Japan; CBS 5814, from sputum, USA; CBS 6611, type strain of *Torulopsis pampelonensis*, and CBS 6612, type strain of *Torulopsis navarrensis*, both from soil, Spain.

Other strain available: CBS 6211, from a tunnel of false powder-post beetle (*Xyloporus capucinus*, Coleoptera: Bostrichidae), in white stinkwood (*Celtis africana*, Ulmaceae), South Africa.

Type strain: CBS 5814.

Systematics: Buckley and van Uden (1968) described *C. melibiosica* from a clinical isolate. The species is one of several that have highly divergent rRNA gene sequences but can be linked to the Metschnikowiaceae. D1/D2 LSU rRNA gene sequences indicate a weak connection with *C. hawaiiiana*, in proximity to *Clavispora* species, which is compatible with the placement suggested by SSU sequences (Sugita and Nakase 1999). Daniel (1983) employed DNA reassociation and protein electrophoresis to demonstrate the conspecificity of *Torulopsis pampelonensis*, *T. navarrensis*, *C. parapsilosis* var. *hokkai* and *C. melibiosica*.

The strains included in the species are similar in growth characteristics and distinct from other species. A superficial resemblance to *Schwannomyces occidentalis* exists, but the latter species utilizes starch and is resistant to cycloheximide.

Ecology: The species has been found sporadically in miscellaneous substrates and a defined habitat has not been identified.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Swoboda-Kopeck et al. (2001) reported the isolation of two strains of *C. melibiosica* among 42 fungal strains recovered from blood cultures in a hospital in Poland. Identification was based on commercial kits that assess physiological properties.

90.166. *Candida membranifaciens* (Lodder & Kreger-van Rij) Wickerham & K.A. Burton (1954b)

Phylogenetic placement: *Yamadazyma* clade (Figs 81.1, 90.2).

Synonyms:

Candida melibiosi Lodder & Kreger-van Rij var. *membranifaciens* (as *membranaefaciens*) Lodder & Kreger-van Rij (1952)

Candida majoricensis Genestar Serra (1956)¹

Procandida majoricensis (Genestar Serra) Novák & Zsolt (1961)

¹ Synonymy based on phenotype.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, 2.5–6 × 3.5–8 μm, and occur singly and in clusters (Fig. 90.104 top).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of cylindrical or long-ovoid cells with verticils of ovoid blastoconidia (Fig. 90.104 bottom). Septate hyphae may be present. Aerobic growth is off-white to chalky, dull, powdery, dry and partly wrinkled with a hyphal border.

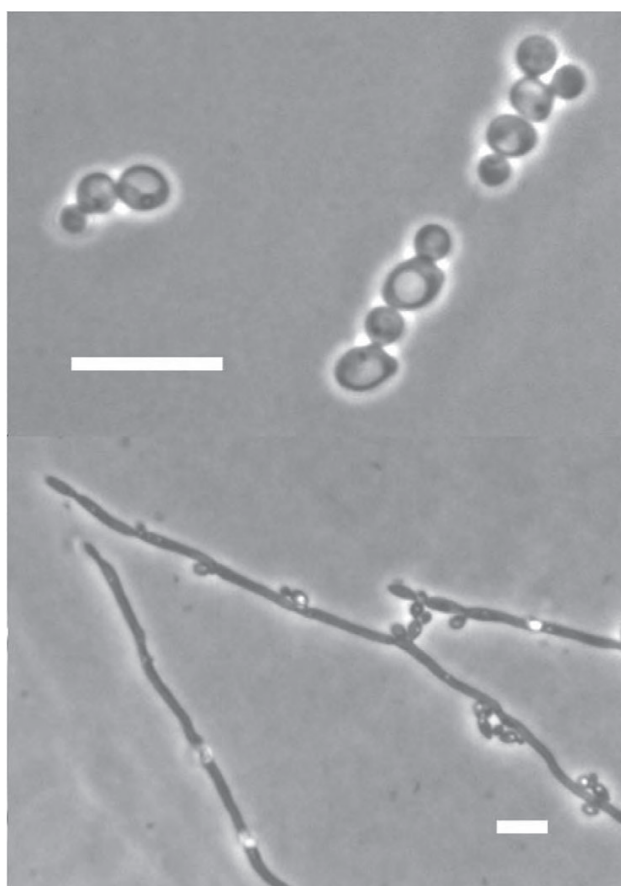


FIGURE 90.104 *Candida membranifaciens* CBS 1952. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 25°C, YCBAS agar (bottom). Bars = 10 μm.

Fermentation

Glucose	s	Lactose	—
Galactose	—/s	Raffinose	s
Sucrose	s	Trehalose	s
Maltose	—/s		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	+	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	+	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	+
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl-α-D-glucoside	v	DL-Lactate	v
Soluble starch	v	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	v	D-Glucosamine	v
L-Rhamnose	v	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	—
D-Arabinose	+	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Gluconate	—	Gelatin	—
Glucono-δ-lactone	v	Casein	—/w
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	v	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	v

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 33.4, CBS 2875 (T_m : Stenderup et al. 1972).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45792.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 1952, isolated from urine of cystitis patient; CBS 2090, from a scale insect (*Pulvinaria* sp., Homoptera: Coccidae) on lantana (*Lantana camara*, Verbenaceae), India, received by CBS as *Oospora srinivasii*.

Other strains available: CBS 2296, from leprous ulcer, India; CBS 2297, from eucalypt (*Eucalyptus saligna*, Myrtaceae), South Africa; CBS 2875, type strain of *C. majoricensis*, from tanning fluid, Balearic Islands, Spain; CBS 4430, CBS 4431, origin unknown; CBS 6060, Lake Champlain, USA; CBS 9752, from hindgut of termite (*Zootermopsis angusticollis*, Isoptera: Hodotermitidae).

Type strain: CBS 1952.

Systematics: Wickerham and Burton (1954b) examined strains assigned to *Candida melibiosi* var. *membranifaciens*, *C. melibiosi* var. *melibiosi* and *C. guilliermondii*. They observed mating reactions in all except the three strains assigned to the variety *membranifaciens*, which were found to ferment melibiose more vigorously. The variety was therefore elevated to the rank of species. *C. membranifaciens* formed a small clade with *C. friedrichii* and *C. buinensis* (Kurtzman and Robnett 1998a, Sugita and Nakase 1999) until the recent expansion of the clade by the addition of *C. diospyri* (Lu et al. 2004a), *C. amphixiae*, *C. blattariae*, *C. cerambycidarum*, *C. endomychidarum*, *C. gorgasii*, *C. lessepsii*, *C. michaelii*, *C. temnochilae* and *C. sinolaborantium* (Suh et al. 2005b). Note that the membership of all of these species in a monophyletic clade centered on *C. membranifaciens* is not entirely certain given the data available. However, it is probably safe to postulate an affinity to the genus *Yamadazyma* as phylogenetically circumscribed by Kurtzman and Suzuki (2010).

The species is highly polyphagic, which makes it difficult to distinguish from *C. friedrichii* and *Debaryomyces hansenii*. Separation from *C. friedrichii* can be based on the utilization of inulin, but the extensive variation found in *D. hansenii* precludes identification of a physiological diagnostic trait.

Ecology: *Candida membranifaciens* has been recovered from diverse sources, including insects and clinical specimens, but a precise habitat remains to be identified.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.167. *Candida mesenterica* (Geiger) Diddens & Lodder (1942)

Phylogenetic placement: *Kodamaea* clade (Figs 36.1, 90.3).

Synonyms:

Pseudomonilia mesenterica Geiger (1910)

Azymoprocandida mesenterica (Geiger) Novák & Zsolt (1961)

Pseudomonilia albomarginata Geiger (1910)¹
Candida albomarginata (Geiger) Windisch (1953)

¹ Synonymy based on phenotype.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, elongate and cylindrical, 1.5–2 × 6–12 μm, occur in chains and clusters, and pseudohyphae may be present (Fig. 90.105 top). Islets are present or an incomplete pellicle may form.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of cylindrical cells (Fig. 90.105 bottom). Septate hyphae are present. Aerobic growth is white to cream colored, dull, wrinkled and with a fringed margin.

Fermentation

Glucose	–/s	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	–	Ribitol	v
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	v	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	v
Salicin	+	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	v	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	v	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	–
50% Glucose	–	Growth at 37°C	–

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 47.6, 1 strain (T_m : Meyer and Phaff 1972).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45720.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 602, isolated from a beer conduit in a brewery, Germany; CBS 6299, from beer; UWOPS 79-91, from exudate of Douglas fir (*Pseudotsuga menziesii*, Pinaceae); UWOPS 79-

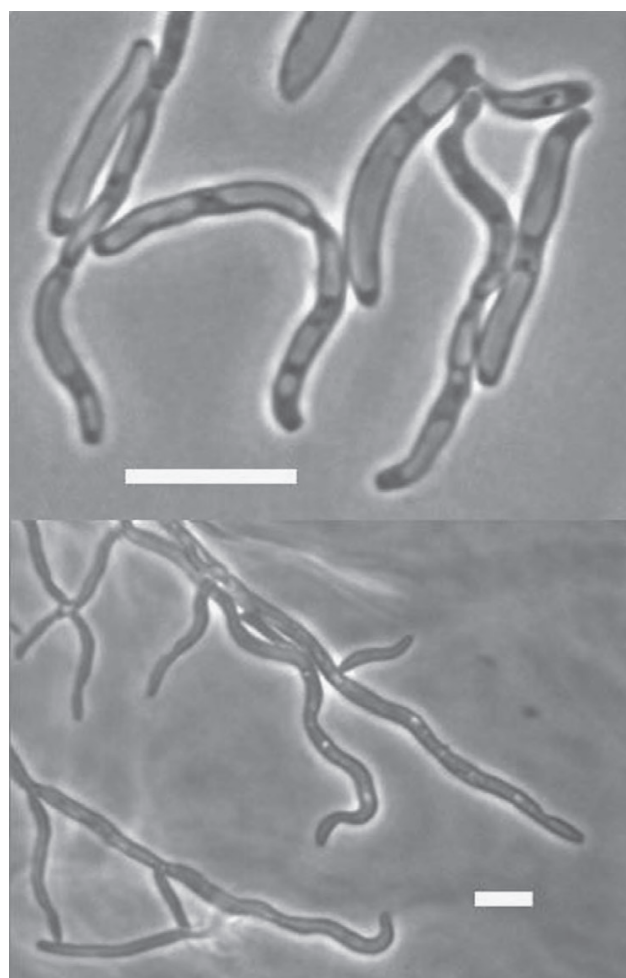


FIGURE 90.105 *Candida mesenterica* CBS 602. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 25°C, YCBAS agar (bottom). Bars = 10 μm.

101, from exudate of California black oak (*Quercus kelloggii*, Fagaceae), California, USA; UWOPS 91-102.2, UWOPS 91-121.2, and several others, from exudate of red oak (*Quercus rubra*), Ontario, Canada.

Type strain: CBS 602.

Systematics: Analysis of D1/D2 LSU rRNA gene sequences by Kurtzman and Robnett (1998a) placed *C. mesenterica* in a basal position relative to a loose clade of unrelated species that includes *C. incommunis* among others, with *Kodamaea ohmeri* and *C. suecica* as a sister clade. Analysis of these and newer data places the species in a basal position with respect to the *Kodamaea* clade. This conclusion is supported by analyses of SSU rRNA gene sequences (Nakase et al. 1999, Sugita and Nakase 1999), which further suggest that *C. mesenterica* and *C. suecica* are sister species. Further corroboration came from Suh and Blackwell (2005) who regarded *C. mesenterica* as an archetype for some, but not all members of the *Kodamaea* clade.

Candida mesenterica is physiologically well defined, although a similarity exists between *C. ergatensis* and *C. atmospherica*, as well as some species in the *Kodamaea* clade. The utilization of sorbose and erythritol, and the lack of growth on starch are useful for separation from these species.

Ecology: The species is infrequently recovered from a variety of sources and has been reported as one of several minority species found in clinical specimens (Dorko et al. 2000). Recovery from sap fluxes, in both California and Ontario, could suggest an association

with the plant–fungus–insect interface, as is becoming better documented for the entire *Kodamaea* clade.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: *Candida mesenterica* has been reported as one of several minority species found in clinical specimens (Dorko et al. 2000).

90.168. *Candida metapsilosis* Tavanti, Davidson, Gow, Maiden & Odds (2005a)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Fig. 90.5).

Synonyms:

Monilia onychophila Pollacci & Nannizzi (Marengo 1926)

Saccharomyces verticillatus Dietrichson (1954)

Growth on yeast morphology agar: After 10 days at 25°C, the colony is flat to button-like, 12 mm wide, dull to shiny, cream-white, butyrous smooth to somewhat ridged, toward the margin somewhat striated and has an entire margin. Cells are ellipsoid, subglobose to fusiform, 4 × 3–6 µm, and reproduce by polar budding; larger subglobose cells are present that are 6–10 µm in diameter and filaments may be present.

Growth in 3% glucose in yeast nitrogen base: Cells are subglobose, ovoid to ellipsoid, 4–10 × 3–6.5 µm, reproduce by multilateral budding, and may adhere in short chains. Filaments, 10–28 × 1.8–4 µm, are present and form blastoconidia laterally. A flocky ring and sediment are present.

Dalmau plate culture on potato dextrose agar: Well-developed pseudohyphae occur. The colony produces an ester-like odor.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	n
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	v
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	v	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	n
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Butane 2,3 diol	–
2-Keto-D-gluconate	+	Isopropyl alcohol	n
5-Keto-D-gluconate	n	Nitrite	–
D-Glucuronate	–	Cadaverine	+
L-Arabinitol	n	Creatinine	–
Arbutin	–	L-Lysine	+
Propane 1,2 diol	v	Ethylamine	+

50% Glucose	–	Cycloheximide 0.01%	+
10% NaCl/5% glucose	+	Cycloheximide 0.1%	–
Starch formation	–	Growth at 37°C	+
Urease	–	Growth at 42°C	+
DBB	–		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: partial SSU rRNA, ITS1, 5.8S rRNA, ITS2, partial LSU rRNA AJ698049.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 10907 (ATCC 96144), isolated from a human hand, Tacoma, Washington, USA; CBS 10746, from a clinical sample, F.C. Odds; CBS 2315, type of *Monilia onychophila*, from a fingernail, Italy; CBS 2916, type of *Saccharomyces verticillatus*, from sputum, Norway; MCO 429 and MCO 448, clinical isolates (Medical College of Ohio Culture Collection).

Type strain: ATCC 96144.

Systematics: *Candida metapsilosis* represents the former *C. parapsilosis* group III (Tavanti et al. 2005a). The species cannot be distinguished morphologically from *C. parapsilosis* and *C. orthopsilosis*, but can be separated based on multi-locus sequence analysis (MLST) using four genes, comparison of amplicon patterns of 11 genes and ITS sequences (Asadzadeh et al. 2009, Borman et al. 2009, Johnson 2009, Tavanti et al. 2005a).

Ecology: *Candida metapsilosis* is known from clinical samples and has been found on all continents (Lockhart et al. 2008b). The species is isolated from abscesses, ascites fluid, bronchial alveolar lavage fluid and joint fluid (Lockhart et al. 2008b). As far as is known, no isolates have been documented to originate from non-human sources.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: *Candida metapsilosis* is an emerging human pathogen that has been isolated from various clinical materials. In a study of 175 clinical and environmental isolates belonging to the *C. parapsilosis* species complex, 2.9% were reidentified as *C. metapsilosis* (Silva et al. 2009), but among 114 isolates belonging to the *C. parapsilosis* complex from Kuwait, no *C. metapsilosis* was observed (Asadzadeh et al. 2009). In Brazil, 2% of candidaemia were found to be caused by *C. metapsilosis* (Miranda et al. 2009). Among 1929 isolates from invasive candidosis in the ARTEMIS antifungal surveillance program, 34 (1.8%) were found to belong to *C. metapsilosis* (Lockhart et al. 2008b). Sixty percent of the *C. metapsilosis* isolates with a known origin from this program originated from bloodstream infections (Lockhart et al. 2008b). In a virulence study using reconstituted human tissue models, *C. metapsilosis* was found to be less virulent than *C. parapsilosis* and *C. orthopsilosis* (Gácsér et al. 2007).

Isolates of the species are susceptible to amphotericin B, flucytosine, fluconazole, itraconazole, ketoconazole and miconazole (Tavanti et al. 2005a), but resistance to echinocandins (caspofungin and anidulafungin) was noted (Silva et al. 2009). Contrary to these observations, van Asbeck et al. (2008) noted lower MIC values of *C. metapsilosis* to caspofungin and anidulafungin than those of *C. parapsilosis*. These authors also noted that *C. metapsilosis* was least susceptible to fluconazole. In another study, *C. metapsilosis* isolates were found to be susceptible to fluconazole, caspofungin, anidulafungin and micafungin, although MIC values were lower than those of *C. parapsilosis* (Lockhart et al. 2008b).

90.169. *Candida methanosorbosa* (Abe & Yokote) J.A. Barnett, R.W. Payne & Yarrow (1983)

Phylogenetic placement: *Ogataea* clade (Figs 53.1, 90.4).

Synonyms:

Torulopsis methanosorbosa Abe & Yokote (Yokote et al. 1974)

Torulopsis nagoyaensis Asai & Makiguchi (Asai et al. 1976)¹
Candida nagoyaensis (Asai & Makiguchi) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

¹ Synonymy based on phenotype (Barnett et al. 1983).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, 3–4 × 3–5 μm, and occur singly and in pairs (Fig. 90.106).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present. Aerobic growth is off-white to cream colored, smooth, soft, glistening and with an entire margin.

Fermentation

Glucose	+	Lactose	–
Galactose	s	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	+
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D,L-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	v	Citrate	–
Salicin	+	D-Gluconate	s
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	w
L-Arabinose	+	Nitrate	+
D-Arabinose	–	Vitamin-free	w

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Gluconate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	+	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70186.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 6852, type strain of *Torulopsis nagoyaensis*, and CBS 6853 were isolated from sewage in Nagoya, Japan; CBS 7029, from soil, Japan.

Type strain: CBS 7029.

Systematics: Yokote et al. (1974) screened 850 soil samples and 125 strains of hydrocarbon-utilizing yeasts for the presence of yeasts capable of growth on methanol. This resulted in the isolation of 24 methylotrophic strains, two of which could not be assigned to any known species. One was described as *Torulopsis methanosorbosa* and the other as *T. methanodomerccii*. The fate of the latter is not clear. *C. nagoyaensis* was listed as a synonym by Barnett et al. (1983), presumably on the basis of identical physiological profiles. Analysis of D1/D2 LSU rRNA gene sequences (Kurtzman and Robnett 1998a) indicated that *C. methanosorbosa* is a sister species to *Ogataea naganishii* and occupies a fairly basal position among methylotrophic yeasts. The SSU sequences (Suzuki and Nakase 2002) linked the species to *C. nanaspora* and *C. nitratophila* in the *Ogataea* clade.

The two strains examined by replica plating were similar in growth characteristics, but differed from previous descriptions by the lack of growth on D-ribose, lactic, succinic, citric and gluconic acid, and the ability to grow in the presence of 10% NaCl.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comment: Yokote et al. (1974) found that *C. methanosorbosa* could grow in the presence of up to 5% methanol.

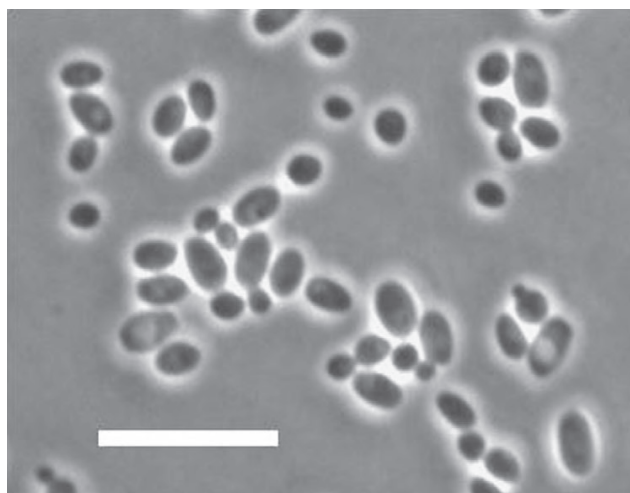


FIGURE 90.106 *Candida methanosorbosa* CBS 7029. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

90.170. *Candida michaelii* S.-O. Suh, N.H. Nguyen & M. Blackwell (2005b)

Phylogenetic placement: *Yamadazyma* clade (Fig. 90.2). (The description is based on Suh et al. 2005b.)

Growth on YM agar: After 7 days at 25°C, the colonies are white, smooth and butyrous.

Growth in YM broth: After 7 days at 25°C, the cells are globose, 2–5 × 2–5 μm, occur singly, in pairs or in short chains, but some cells form clusters, and pseudohyphae were not present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae are present, but septate hyphae are absent. Aerobic growth is white with a slightly fuzzy margin.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	d	Trehalose	d
Maltose	d		

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	+	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Ethylamine	+
2-Keto-D-gluconate	–	50% Glucose	+
D-Glucuronate	–	10% NaCl/5% glucose	+
Arbutin	+	Starch formation	–
Propane 1,2 diol	d	Urease	–
Butane 2,3 diol	+	DBB	–
Nitrite	–	Cycloheximide 0.01%	–
Cadaverine	+	Cycloheximide 0.1%	–
Creatinine	–	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY520329, SSU rRNA = AY520199, ITS1&2 and 5.8S = rRNA AY964673.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27705 (CBS 9878) was isolated from the gut of the handsome fungus beetle (*Amphix laevigatus*, Endomychidae) in Barro Colorado Island, Panama.

Type strain: NRRL Y-27705.

Systematics: Based on the analysis of combined sequences of the SSU and LSU rRNA genes, *C. michaelii* belongs to a cluster of closely related species, namely, *C. amphimixiae*, *C. cerambycidarum*, *C. lessep-sii*, *C. gorgasii* and *C. endomychidarum*, which forms a sister clade to *C. membranifaciens*, *C. friedrichii*, *C. blattariae* and *C. buinensis* within the *C. membranifaciens* clade (Suh et al. 2005b).

Ecology: *Candida michaelii* is known from a single isolate from the gut of a beetle, Panama.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.171. *Candida milleri* Yarrow (1978)

Phylogenetic placement: *Kazachstania* clade (Fig. 90.1).

Synonyms:

Torulopsis acidi-lactici Nakase, Komagata & Konishi (1977)¹

Torulopsis holmii (Jorgensen) Lodder var. *acidi-lactici* C. Ramírez & Sierra (Ramírez Gómez and Sierra Rico 1956)¹

¹ Synonymy based on phenotype.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 3.5–6 × 4–7 μ m, and occur singly and in pairs (Fig. 90.107).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present. Aerobic growth is off-white to cream colored, smooth, glistening and with an entire margin.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	+
Sucrose	+	Trehalose	+/-
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	v	Methanol	–
Sucrose	+	Ethanol	v
Raffinose	+	Glycerol	v
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	–
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	v
Soluble starch	–	Succinate	v
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

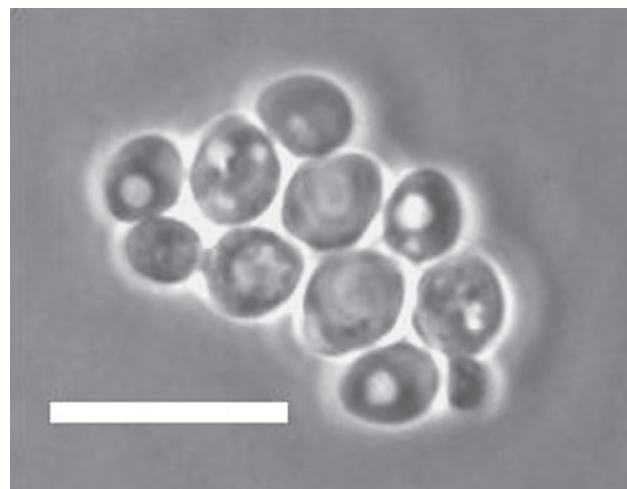


FIGURE 90.107 *Candida milleri* CBS 6897. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	v	Casein	—/w
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	—	Cycloheximide 0.01%	v
L-Lysine	—	Cycloheximide 0.1%	v
Cadaverine	—	1% Acetic acid	v
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 6 (Suzuki and Nakase 1998).

Mol% G + C: 46.1–46.8, three strains (Yarrow 1978); 48.0–48.3, 3 strains (T_m : Nakase et al. 1977).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U94932.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 2664, type strain of *Torulopsis acidi-lactici*, isolated from alpechin, Spain; CBS 6897, CBS 8195, from sour dough in the USA and Finland, respectively.

Type strain: CBS 6897.

Systematics: Yarrow (1978) described *C. milleri* after finding that three strains labeled *Torulopsis holmii* had a large difference from the type in DNA base composition. The two species were difficult to distinguish on the basis of growth characteristics. Vaughan-Martini (1995) examined the three strains by DNA reassociation and confirmed their conspecificity as well as the fact that they were distinct from 16 other strains labeled *Saccharomyces exiguus* or *Candida holmii*. These remaining strains were resolved into three major DNA reassociation groups, which corresponded to *Kazachstania exigua* (*S. exiguus*), the presumed teleomorph of *C. milleri*, and two new species, *Saccharomyces barnettii* and *Saccharomyces spencerorum*, later transferred to the genus *Kazachstania* by Kurtzman (2003). Kurtzman and Robnett (1998a) found the type strains of *C. milleri* and *C. humilis* to differ by only one substitution in the D1/D2 LSU rRNA gene and suggested that the two were conspecific. In agreement with this, Suzuki and Nakase (AB054677, AB054678) found three substitutions and two gaps in the SSU sequences. Kurtzman and Robnett (2003) later reported differences of 10 substitutions in the ITS rDNA regions and 11 substitutions in the translation elongation factor-1 α gene sequences, and suggested that the two names should be retained until more comprehensive information is available on the genetic relatedness of these taxa.

The type cultures of *C. milleri* and *C. humilis* were found, by replica plating, to differ in the assimilation of sucrose and raffinose, which were found to be positive in *C. milleri*. This result is in agreement with the original descriptions (Nel and van der Walt 1968, Yarrow 1978).

Ecology: Strains recovered from a natural tequila fermentation and identified as *C. milleri* (Lachance 1995) were reidentified as *C. humilis* by sequencing of the rDNA ITS and D1/D2 LSU rRNA gene regions.

Biotechnology: Unknown.

Agriculture and food: *Candida milleri* has received attention as a component of the microbial community of sourdough bread. An example is an extensive model of the interaction of the species with *Lactobacillus sanfranciscensis* as a function of the physical–chemical characteristics of their environment (Gänzle et al. 1998). The important question arises as to whether the dominant yeast in sourdough bread is *C. milleri* or one of its sibling species, such as *C. humilis*, *C. holmii*, *S. exiguus*, etc. (see discussion of *C. humilis*). Mäntynen et al. (1999) examined yeast isolates of sourdough from five bakeries. When characterized physiologically with the Biolog system, the majority were identified as *Kluyveromyces lodderae*. A PCR-RFLP based on SSU rRNA gene sequences gave similar results for 13 isolates, but did not link them directly to authentic strains of *C. milleri* or any other species. A similar analysis based on sequence

variation in the elongation factor three gene placed 10 of these strains in proximity to *C. milleri* strain CBS 2664, and three were linked to a strain identified as *S. cerevisiae*. In that analysis, which was corroborated by electrophoretic karyotyping, three other strains of *C. milleri* and one strain of *Kazachstania exigua* (*S. exiguus*) clustered with the type of *C. milleri*, and three more strains of *C. milleri* and one more strain of *K. exigua* were reported to be closely related to strain CBS 2664. Unfortunately, authentic strains of *C. humilis* were not included in the study. This complex set of results adds to the growing impression that members of the *Saccharomyces sensu lato* clade have undergone considerable introgression, and that care should be exercised in drawing hasty conclusions on species delineation in that group.

Clinical importance: Unknown.

90.172. *Candida mogii* Vidal-Leiria (1967)

Phylogenetic placement: *Metschnikowia* clade (Fig. 90.1).

Synonyms:

Torulopsis miso Mogi (1938a) nom. nud.

Torulopsis miso alpha var. 1 Mogi (1938a) nom. nud.

Torulopsis miso alpha var. 2 Mogi (1942) nom. nud.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are long-ovoid, 1–1.5 $\times$ 3–6 μ m, occur singly, in pairs and short chains (Fig. 90.108 top) and pseudohyphae may be present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of elongated cells, sometimes with verticils of blastoconidia (Fig. 90.108 bottom). Aerobic growth is off-white, soft, smooth or wrinkled.

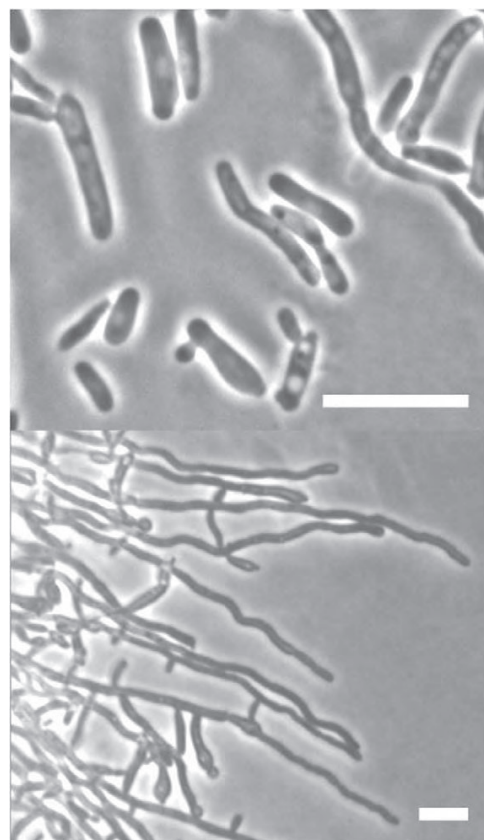


FIGURE 90.108 *Candida mogii* CBS 2032. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 25°C, YCBAS agar (bottom). Bars = 10 μ m.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	+	Trehalose	+
Maltose	—/s		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	v	Methanol	—
Sucrose	+	Ethanol	s
Raffinose	+	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	v
Lactose	—	Galactitol	v
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	v
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	—
Soluble starch	v	Succinate	+
Cellobiose	—	Citrate	v
Salicin	—	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	+
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	—
L-Arabinose	+	Nitrate	—
D-Arabinose	v	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	w
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	+

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 46.1, 44.3, CBS 2032 (T_m : Nakase and Komagata 1971f; BD: Kurtzman 1990c, respectively).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U44820.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 2032, isolated from miso fermentations in Japan.

Type strain: CBS 2032.

Systematics: Vidal-Leiria (1966a) described *Torulopsis mogii* based on seven strains isolated from miso fermentations by M. Mogi and previously described without a Latin diagnosis. She later described *Candida mogii* as a separate species based on three other strains isolated from miso (Vidal-Leiria 1967). The use of the same epithet may explain the confusion regarding the once proposed synonymy between *C. mogii* and *Zygosaccharomyces rouxii* (Yarrow 1984d). Kurtzman (1990c) examined two strains labeled *C. mogii* by DNA reassociation. One of these was CBS 2032, the type strain of *C. mogii*, and the other was CBS 6030, whose identity has not been established. He found that the two strains were unrelated to one another or to any of the type strains of *Zygosaccharomyces* species. Authentic strains of *Torulopsis mogii* were not included in that study and continue to be treated as synonyms of

Z. rouxii in the CBS database. The SSU rRNA gene sequences (Sugita and Nakase 1999) place *C. mogii* in a basal position with respect to a subclade of *Candida* species with affinities to the genus *Clavispora*, whereas D1/D2 LSU sequences (Kurtzman and Robnett 1998a) suggest a weak connection to *C. haemulonii*, in the same subclade.

Physiologically, *C. mogii* bears only a passing similarity to other species, including some species in the genus *Zygosaccharomyces*. The type strain, when evaluated by replica plating, exhibited a few differences from the description given by Meyer et al. (1998) notably in the assimilation of D-mannitol, citric acid, growth at 37°C and growth in the presence of 10% NaCl. The original description (Vidal-Leiria 1967) portrayed *C. mogii* as a halotolerant species, and the strain examined grew well in the presence of 15% NaCl. However, growth on starch, on L-sorbose and in the absence of vitamins could not be confirmed.

Ecology: Unknown.

Biotechnology: *Candida mogii* has been used in the conversion of D-xylose into xylitol (Maciel de Mancilha and Karim 2003).

Agriculture and food: Unknown.

Clinical importance: *Candida mogii* has been identified as a rare species in clinical specimens (Dorko et al. 2000).

90.173. *Candida montana* S. Goto & Oguri (1983)

Phylogenetic placement: *Barnettozyma* clade (Figs 18.1, 90.1).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, $2-3 \times 4-5.5 \mu\text{m}$, and occur singly and in pairs (Fig. 90.109).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, short, poorly developed pseudohyphae are present. Aerobic growth is off-white to cream colored, butyrous, soft and with an entire margin.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	s
Maltose	—	D-Glucitol	—
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	—
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	+	N-Acetyl-D-glucosamine	—
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	s	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	—	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

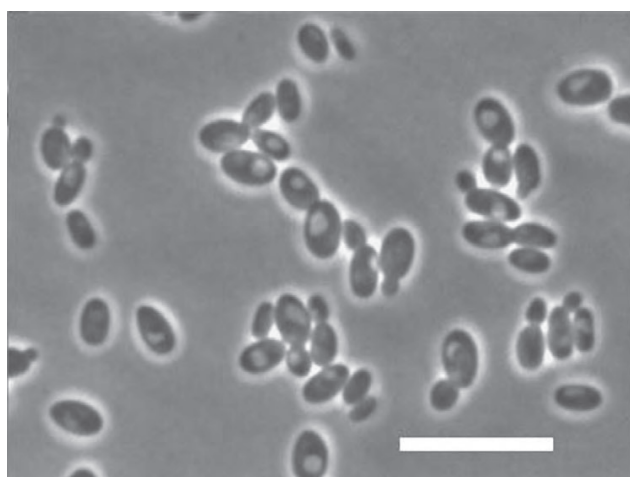


FIGURE 90.109 *Candida montana* CBS 8057. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

CoQ: 7 (Goto and Oguri 1983).

Mol% G + C: 35.6, CBS 8057 (T_m : Goto and Oguri 1983).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U62305.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 8057, isolated from wild grape (*Vitis coignetiae*, Vitaceae) in Japan.

Type strain: CBS 8057.

Systematics: In a study of yeasts occurring on wild grapes, Goto and Oguri (1983) isolated two strains whose growth characteristics did not fit those of any known species. In particular, the growth responses were unusual in that maltose was not assimilated in spite of other α -glucosidase activities. The species is phylogenetically distinct and not easily positioned on the basis of the rRNA gene sequences. Analyses of the D1/D2 LSU (Kurtzman and Robnett 1998a) and the SSU (Suzuki and Nakase 2002) rRNA genes suggested a basal placement near *Barnettozyma* (*Williopsis*) *pratensis* and other moderately related species, including those assigned to the genus *Starmera*. A more recent multi-gene analysis (Kurtzman et al. 2008) placed the species near *B. pratensis* and *C. norvegica*.

Some disagreement exists between the growth characteristics given in the original description (Goto and Oguri 1983), those given by Meyer et al. (1998) and those obtained in this study. In the present study, the type strain did not ferment glucose, nor did it assimilate any β -fructosides, α -glucosides, alditols and lactic acid, or grow at 37°C or in the absence of vitamins.

Ecology: Known only from wild grapes (Goto and Oguri 1983).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.174. *Candida mucifera* Ueda-Nishimura & Mikata (2002)

Phylogenetic placement: *Sugiyamaella* clade (Fig. 90.3).

(Some of the morphological characteristics are based on Ueda-Nishimura and Mikata 2002.)

Growth in beer wort: After 3 days at 28°C, cells are ellipsoidal to elongate, 3–5 $\times$ 4–7 μ m, occur singly or in chains and readily form protuberances (Fig. 90.110 top). Pseudohyphae and true hyphae are formed. The blastoconidia occur in verticils of short chains (Fig. 90.110 bottom).

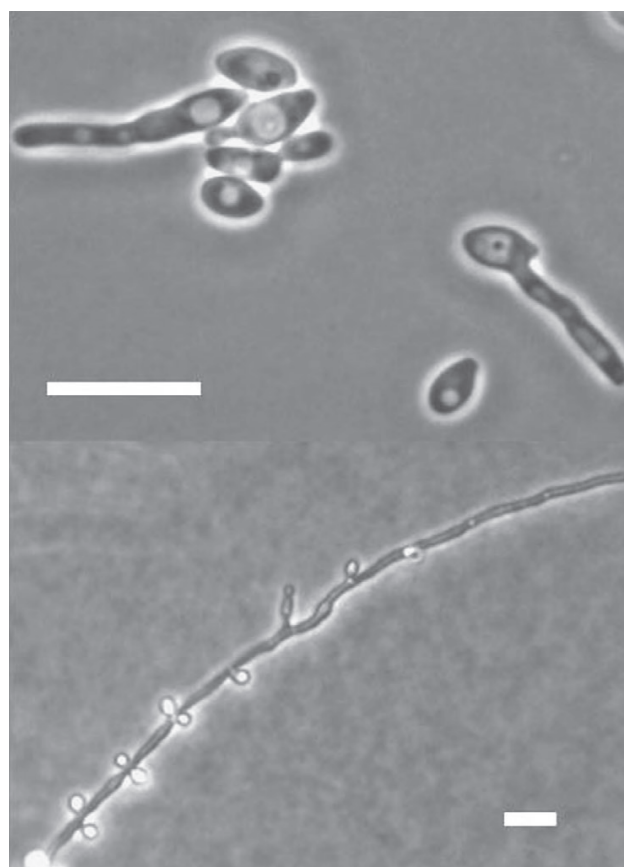


FIGURE 90.110 *Candida mucifera* CBS 7409. Budding cells after 3 days, 25°C, YM agar (top) and hypha after 14 days, 25°C, YCBAS agar (bottom). Bars = 10 μ m.

The pseudohyphae may contain swollen cells and the true hyphae may anastomose. A large amount of gelatinous polysaccharide is formed.

Growth on agar media: The streak culture is pasty, dull, wrinkled and elevated at the margin.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	–	Ethanol	w
Raffinose	–	Glycerol	s
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	+
Trehalose	+	D-Mannitol	–
Maltose	+	D-Glucitol	–
Melezitose	–	myo-Inositol	+
Methyl- α -D-glucoside	–	D-Lactate	–
Soluble starch	–	Succinate	w
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	s
L-Sorbose	s	D-Glucosamine	w
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono-δ-lactone	—	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	w	Growth at 37°C	—

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AB041006.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 7409 (IFO 10918), isolated from the liver of a toad (*Bufo granulosus*) in Brazil.

Type strain: CBS 7409.

Systematics: Kocková-Kratochvílová and Sláviková (1988) examined a number of yeasts recovered from livers of anurans in Amazonia and described *C. mucifera* based on three isolates that formed unusual pseudohyphae and large amounts of a gelatinous polysaccharide rich in mannose. The authors noted that the composition of the mucus differs from that found in *Cryptococcus* species, given that such a trait in combination with the assimilation of *myo*-inositol and D-glucuronic acid might have led one to identify the organism as a member of that genus. Smith and de Hoog (1998a) placed the species in synonymy with *Trichomonascus (Stephanosascus) ciferrii* after observing ascospore formation with an isotype strain of the latter. Ueda-Nishimura and Mikata (2002) re-examined strains assigned to *T. ciferrii*, and found that they could be subdivided into three groups by data from DNA reassociation experiments. One member of the group was described as *C. allociferii*. The type strain of *C. mucifera* differs from that of *T. ciferrii* by one substitution in the D1/D2 LSU rRNA gene and eight substitutions in the SSU rRNA gene. The DNA reassociation values range from 10 to 33%. In addition, the SSU rRNA gene of *C. mucifera* contains two group I introns, 355 and 403 bases in size, whereas the SSU of *C. allociferii* contains one such intron. In view of these results, Ueda-Nishimura and Mikata (2002) performed mating experiments involving members of the three genetic groups. Matings involving *C. mucifera* produced asci and in some cases ascospores that apparently failed to reach maturity. The authors therefore reinstated *C. mucifera* as a separate species.

The growth characteristics of *C. mucifera* are similar to those of its sister species, *T. ciferrii* and *C. allociferii*, but with differences in the assimilation of melibiose and inulin as well as growth at 37°C (negative in *C. mucifera*). The results reported here are those obtained by replica plating. They differ from those in the original description by a few responses.

Ecology: Only known from livers of anurans (Kocková-Kratochvílová and Sláviková 1988).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Other species recovered at the same time from anurans livers included *C. albicans*, *C. tropicalis*, *C. parapsilosis* and *C. kruisei* (Kocková-Kratochvílová and Sláviková 1988), suggesting that *C. mucifera* might be an opportunistic pathogen in these and other animals.

90.175. *Candida multigemmis* (Buhagiar) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Kurtzmaniella* clade (Figs 40.1, 90.2).

Synonym:

Torulopsis multigemmis (as *T. multis-gemmis*) Buhagiar (1975)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are spherical to elongate ovoid, 2.5–6.5 × 3–6.5 μm, and occur singly and in pairs (Fig. 90.111).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent or consist of short chains of budding cells. Aerobic growth is white, smooth, creamy, semi-glossy and with an entire margin.

Fermentation

Glucose	s	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—/s
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	+	Ethanol	—
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	v
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	—
Maltose	+	D-Glucitol	+
Melezitose	+	<i>myo</i> -Inositol	—
Methyl-α-D-glucoside	—	D-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	+
Salicin	—	D-Gluconate	v
L-Sorbose	+	D-Glucosamine	v
L-Rhamnose	—	<i>N</i> -Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	v	Nitrate	—
D-Arabinose	—	Vitamin-free	—

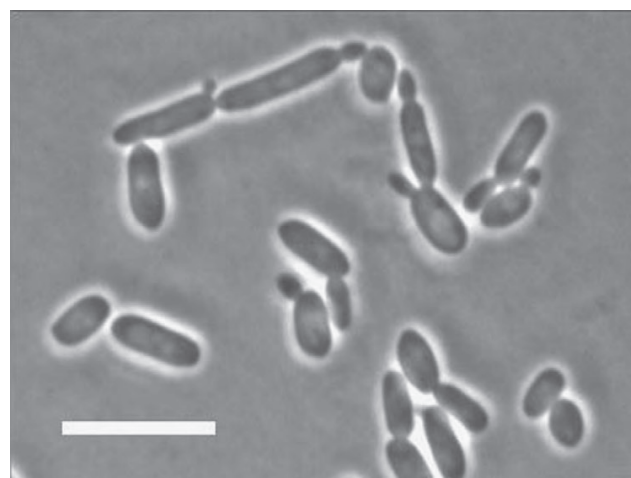


FIGURE 90.111 *Candida multigemmis* CBS 6524. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	w
Glucono-δ-lactone	v	Casein	w
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	v	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	—

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 35.4, type strain (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45782.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6524, isolated from raspberry (*Rubus idaeus*, Rosaceae) in the UK.

Type strain: CBS 6524.

Systematics: Buhagiar (1974) described *Torulopsis multi-gemmis* based on 20 strains isolated in a survey of yeasts from fresh soft fruit. The author noted some similarity with *C. parapsilosis* and *C. xestobii*, in particular the ability of all three species to assimilate decane and hexadecane. *C. multigemmis* is part of a large clade of species related to *Debaryomyces hansenii* (Kurtzman and Robnett 1998a, Sugita and Nakase 1999).

Although the growth characteristics of *C. multigemmis* are typical of many species, for particular species in the unrelated Metschnikowiaceae clade, the responses form a unique combination that separates the species well from others. One distinctive feature is the utilization of D-glucitol but not D-mannitol. The characteristics evaluated by replica plating agreed well with previous descriptions, but the utilization of raffinose, reported by Buhagiar (1974), was not verified.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.176. *Candida musae* (Nakase) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Metschnikowia* clade (Fig. 90.1).

Synonym:

Torulopsis musae Nakase (1971b)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 3–5 × 4–8 μm, and occur singly and in small groups (Fig. 90.112).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present, but chains of budding cells are sometimes present. Aerobic growth is white, creamy, smooth, soft and with an entire margin.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	s
Maltose	—		

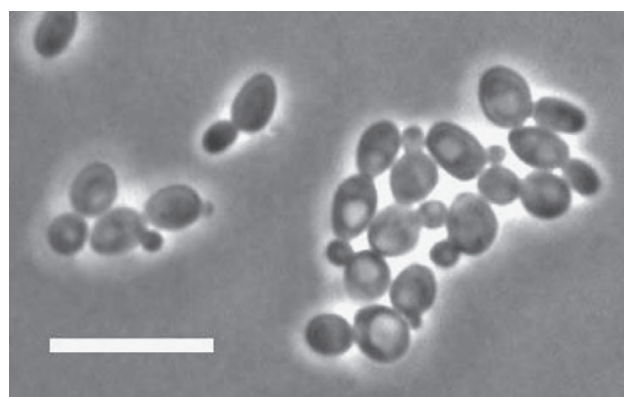


FIGURE 90.112 *Candida musae* CBS 6381. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	v	Ribitol	s
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl-α-D-glucoside	—	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	+
Salicin	—	D-Gluconate	v
L-Sorbose	+	D-Glucosamine	v
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono-δ-lactone	+	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 8 (Suzuki and Nakase 1998).

Mol% G + C: 47.8, 48.0, CBS 6381 (T_m : Nakase 1971b; T_m : S.A. Meyer, unpublished data, respectively).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U44814.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6381, isolated from banana (*Musa* sp., Musaceae) in Japan.

Type strain: CBS 6381.

Systematics: Nakase (1971b) described *C. musae* to accommodate a strain isolated from a banana obtained from a food store. He noted some similarity with *C. ernobii*, but the strain was considered sufficiently distinct to warrant description as a separate species. Kurtzman and Robnett (1997) found *C. musae* and *C. fructus* to have identical sequences in the D1/D2 LSU rRNA gene, suggesting that the two taxa might be conspecific. Lu et al. (2004a) found the two species also to have identical ITS/5.8S rRNA gene regions, and viewed this result as a confirmation of conspecificity. However, the two species were reported to differ by 14 substitutions and seven indels in the SSU rRNA gene (Suzuki and Nakase 1999), indicating that it may be premature to treat them as synonyms. These species belong to a subclade of the Metschnikowiaceae that has affinities to the genus *Clavispora*. Strain CBS 4076, previously assigned to *C. sake*, was reidentified in this study as *C. musae* on the basis of growth characteristics and D1/D2 LSU rRNA gene sequencing.

Unlike *C. fructus*, *C. musae* utilizes sucrose, maltose, melibiose and methyl- α -D-glucoside. The growth characteristics are typical of species in the Metschnikowiaceae clade, and separation from many species on that basis would be difficult. A high similarity exists with the unrelated species *C. multigemmis*, although unlike the latter, *C. musae* utilizes both D-mannitol and D-glucitol. At variance with other data, the original description (Nakase 1971b) reported the slow utilization of rhamnose.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.177. *Candida mycetangii* Kurtzman (2000a)

Phylogenetic placement: *Wickerhamomyces* clade (Figs 42.1, 90.4). (Some of the morphological and physiological characteristics are based on Kurtzman 2000a.)

Growth on 5% malt extract agar: After 3 days at 25°C, the cells are spherical, 1.3–5 μ m, ovoid or elongate, 1.2–4 $\times$ 2–7 μ m, and occur singly or in pairs (Fig. 90.113A). Budding is multilateral. Growth is tannish-white, glistening or semi-glistening and butyrous with a hyphal fringe.

Growth in liquid media: Thin pellicles are formed.

Dalmau plate culture on morphology agar: After 1 week at 25°C growth under the coverslip shows moderately branched pseudohyphae with abundant blastoconidia (Fig. 90.113B). Some pseudohyphae are morphologically similar to true hyphae but readily separate at the septa. A faint, fragrant ester-like odor may be present.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	w
Sucrose	+	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	v	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	D-Lactate	+

Soluble starch	v	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	v
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	+	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	w	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	w
Glucono- δ -lactone	s	Casein	–
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	v
L-Lysine	+	Cycloheximide 0.1%	v
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF017241.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 8675 (NRRL Y-6843), isolated from the mycetangium of an ambrosia beetle in Kansas, USA; UWOPS 03-331t1, from sap flux of northern red oak (*Quercus rubra*, Fagaceae), Ontario, Canada.

Type strain: CBS 8675.

Systematics: Kurtzman (2000a) described *C. mycetangii* from three strains recovered from mycetangia of ambrosia beetles. A sister species to *C. maritima*, *C. mycetangii* belongs to the *Lindnera* clade (Kurtzman et al. 2008). Because of their close relatedness, the two *Candida* species were mixed and observed for mating, which was not observed.

The growth characteristics of *C. mycetangii* are similar to those of *Lindnera* (*Pichia*) *rhodanensis*, a moderately related species, but the two can be separated by the assimilation of raffinose, which is positive for *C. mycetangii*. Distinction from similar species can be based on the utilization of raffinose and rhamnose and the lack of growth on nitrate.

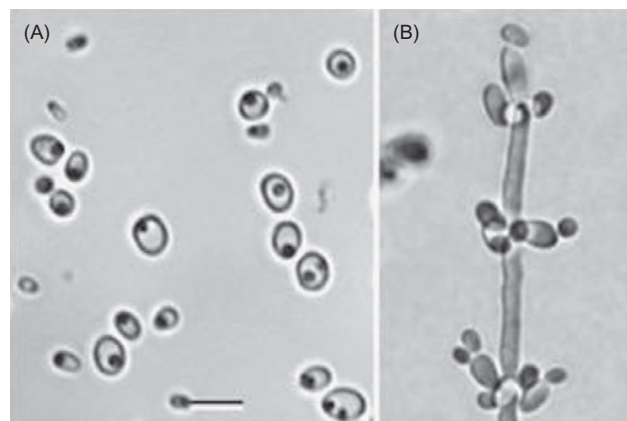


FIGURE 90.113 *Candida mycetangii* NRRL Y-6843. Budding cells after 3 days, 25°C, 5% malt agar (A) and pseudohyphae after 7 days, 25°C, yeast morphology agar (B). Bar = 10 μ m.

Ecology: An association with tree-boring beetles is evident in view of the sources of isolation.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.178. *Candida naeodendra* van der Walt, E. Johannsen & Nakase (1973)

Phylogenetic placement: *Yamadazyma* clade (Fig. 90.2).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, $2\text{--}3 \times 2\text{--}5\text{ }\mu\text{m}$, and occur singly and in pairs (Fig. 90.114).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are essentially absent, although short chains of cells are sometimes present. Aerobic growth is cream colored, soft, smooth and has an entire or irregular margin.

Fermentation

Glucose	+	Lactose	–
Galactose	s	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	D-Lactate	–
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	s	D-Glucosamine	+
L-Rhamnose	s	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	w
L-Arabinose	+	Nitrate	–
D-Arabinose	s	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	–	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	+

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: Not determined.

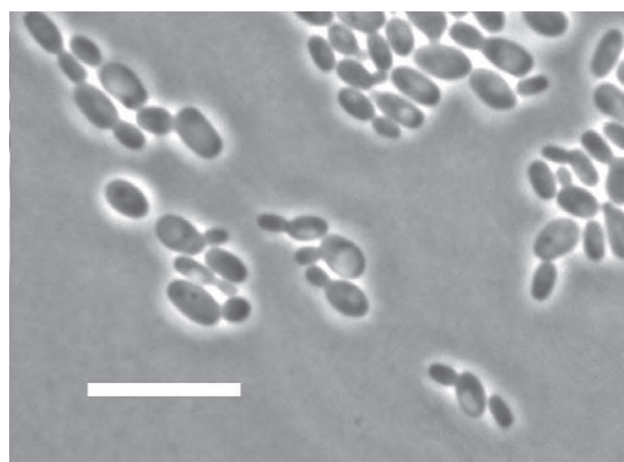


FIGURE 90.114 *Candida naeodendra* CBS 6032. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm .

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45759.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6032, type strain of *C. naeodendra*, isolated from frass of buprestid beetle larvae in gum Arabic tree (*Acacia nilotica*, Fabaceae), South Africa.

Type strain: CBS 6032.

Systematics: Van der Walt et al. (1973) described *C. naeodendra* from two strains recovered from beetle frass. The species was considered to be related to *C. diddensiae*, but differed in several growth characteristics. Kurtzman and Robnett (1997) found the types of *C. diddensiae* and *C. naeodendra* to have identical sequences in the D1/D2 domains of the LSU rRNA gene, suggesting that the two taxa might be conspecific. The SSU rRNA genes (Sugita and Nakase 1999) differ by four substitutions. In view of the physiological differences, the sequences of the ITS/5.8S rDNA regions (AY580315, AY580316) were determined and found to differ by 34 substitutions and 17 gaps. The identity of the D1/D2 regions was also confirmed. The two species are retained as separate. Sequence analyses place *C. naeodendra* in the *Yamadazyma* clade.

According to the original description, *C. naeodendra* and *C. diddensiae* differ in the utilization of starch, L-sorbose, L-rhamnose and quinic acid, the production of extracellular lipase, which is positive in *C. naeodendra*, growth in the absence of vitamins and growth at 37°C. Whereas the present examination confirmed some of the differences in carbon source utilization, all strains required vitamins and grew at 37°C. Lipase production as assessed by Tween 80 hydrolysis was negative in the type of *C. naeodendra* and positive in the type of *C. diddensiae*. The type of *C. naeodendra* did not assimilate succinic acid, citric acid or glucosamine when assessed by replica plating.

Ecology: A possible insect association is reinforced by the phylogenetic position of the species.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.179. *Candida nakhonratchasimensis* Jindamorakot & Nakase (Jindamorakot et al. 2004)

Phylogenetic placement: *Wickerhamomyces* clade (Fig. 90.4). (The description is based on Jindamorakot et al. 2004.)

Growth on YM agar: After 1 month at 20°C, the colony is grayish-white, smooth, shining, soft and has an entire to ciliate margin.

Growth in YM broth: After 3 days at 25°C, the cells are globose to short ovoid to ovoid, $3.5\text{--}7 \times 4\text{--}7\text{ }\mu\text{m}$, and occur singly or in pairs. A fragile ring and sediment are produced.

Growth on the surface of YM broth: After 1 month at 20°C, a trace of a ring and sediment are present.

Dalmau plate culture on potato dextrose agar: Well-developed pseudohyphae are abundantly formed and produce blastoconidia.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	+	Trehalose	n
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	w	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	+
Soluble starch	w	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	+	N-Acetyl-D-glucosamine	–
D-Xylose	+/w	Hexadecane	–
L-Arabinose	–	Nitrate	+
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Ethylamine	+
2-Keto-D-gluconate	–	10% NaCl/5% glucose	–
5-Keto-D-gluconate	–	Starch formation	–
D-Glucuronate	–	Urease	–
Saccharate	–	DBB	–
L-Arabinitol	–	Gelatin liquefaction	–
Propane 1,2 diol	+	Cycloheximide 0.1%	–
Butane 2,3 diol	–	Growth at 19°C	+
Nitrite	+	Growth at 25°C	+
Cadaverine	+	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	–

CoQ: 7 (Jindaramot et al. 2004).

Mol% G + C: 39.2 (HPLC: Jindaramot et al. 2004).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY634567.

Cell carbohydrates: Not determined.

Origin of the strain studied: ST-37 (BCC 7737, JCM 12474, TISTR 5826), isolated from insect frass collected in Kao-Yai, Nakhonratchasima Province, Thailand (Jindaramot et al. 2004).

Type strain: ST-37.

Systematics: Based on sequence analysis of the D1/D2 domains of the LSU rRNA gene, *C. nakhonratchasimensis* belongs to a clade with *Lindnera bimundialis* and *L. americana* (Jindaramot et al. 2004).

Ecology: The species is known only from a single strain from insect frass, Thailand.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.180. *Candida nanaspora* Saëz & Rodrigues de Miranda (1988)

Phylogenetic placement: *Ogataea* clade (Figs 53.1, 90.4).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, $2\text{--}3.5 \times 3\text{--}5\text{ }\mu\text{m}$, and occur singly and in pairs (Fig. 90.115).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present. Aerobic growth is white, butyrous, smooth, soft and entire.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	+
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	s
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	w
L-Arabinose	+	Nitrate	+
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	+	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

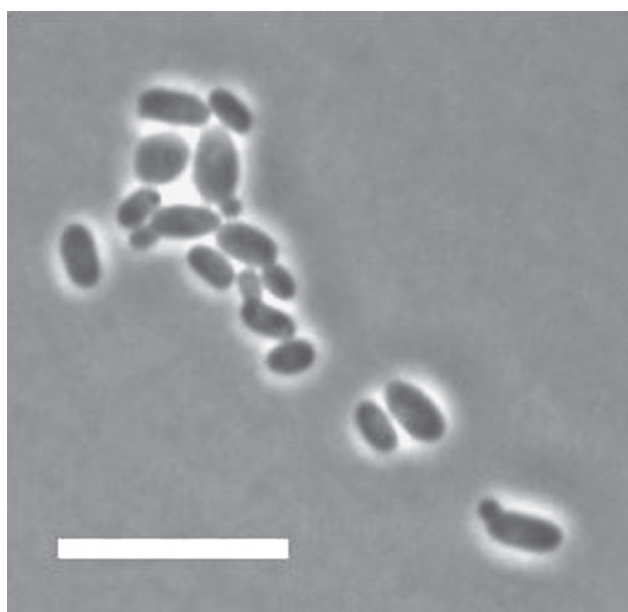


FIGURE 90.115 *Candida nanaspora* CBS 7200. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

CoQ: 7 (C.-F. Lee et al. 1994b).

Mol% G + C: 36.6, type strain (T_m : S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70187.

Cell carbohydrates: Glucose and mannose are present in cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 7200, isolated from capuchin monkey (*Cebus apella*) in a zoo, France.

Type strain: CBS 7200.

Systematics: *Candida nanaspora* is known from a strain isolated in a zoo from a monkey that suffered from hair loss initially suspected to be caused by a mycosis (Saëz and Rodrigues de Miranda 1988). A close relationship with *C. nitratophila* was suspected by the authors. This was confirmed by rRNA gene sequencing, which further identified these species as members of the *Ogataea* clade (Kurtzman and Robnett 1998a, Suzuki and Nakase 2002). The sister species *C. suzukii* was described by Péter et al. (2003).

The physiological profile determined by replica plating agreed well with the description given by Meyer et al. (1998), with the exception of growth on lactic acid, which was found positive after 3 weeks. Differences were observed from the original description (Saëz and Rodrigues de Miranda 1988) in the assimilation of L-sorbose, D-arabinose, lactic acid and gluconic acid. The species is typical of many methylotrophic species, and resembles *C. nitratophila* except for the utilization of erythritol and growth at 37°C, which are positive in *C. nanaspora*. The utilization of galactose, the fermentative ability and the lack of growth on sucrose separate *C. nanaspora* from other similar species.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Although *C. nanaspora* was isolated from a monkey suffering from a dermatological condition, Saëz and Rodrigues de Miranda (1988) regarded the affliction as a pseudomycosis, and did not attribute the ailment to the yeast.

90.181. *Candida natalensis* van der Walt & Tschuschner (1957a)

Phylogenetic placement: *Kurtzmaniella* clade (Figs 40.1, 90.2).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to elongate, 2.5–7 × 6–14 μm, and occur in pairs and chains (Fig. 90.116).

Dalmat plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of elongate cells. Aerobic growth is white, soft, smooth and with an irregular margin.

Fermentation

Glucose	+	Lactose	–
Galactose	s	Raffinose	–
Sucrose	–/s	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	v
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	s
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	v	Hexadecane	+
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	s	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Gluconate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	s
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	–
50% Glucose	–	Growth at 37°C	–

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 37.4, CBS 2935 (T_m : Suzuki and Nakase 1988b); 36.8, AJ 4772 (CCY-29-44-1) (T_m : Nakase and Komagata 1971f).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45818.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 2935 (NRRL Y-17680), isolated from soil, South Africa.

Type strain: CBS 2935.

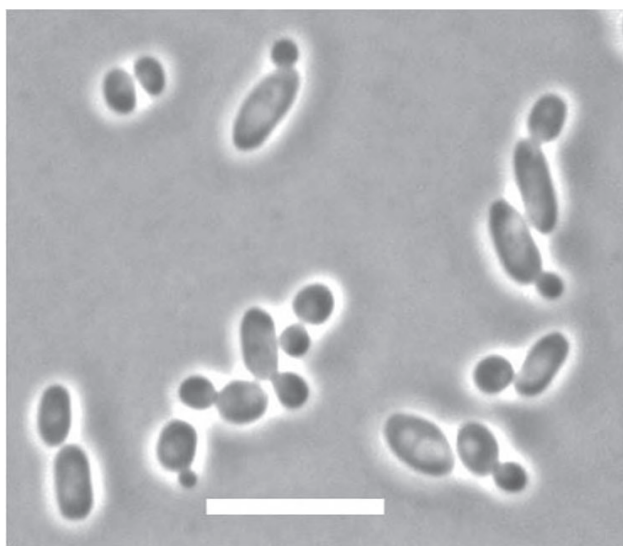


FIGURE 90.116 *Candida natalensis* NRRL Y-17680. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

Systematics: Van der Walt and Tscheuschner (1957a) described *C. natalensis* to accommodate a soil isolate. An affinity with the genus *Pichia* was noted, but ascospores were not observed. *C. natalensis* was considered a synonym of *C. sake* (Meyer et al. 1984), but was restored to species status by Suzuki and Nakase (1988b) on the basis of DNA reassociation experiments. Sequence analyses (Kurtzman and Robnett 1998a, Sugita and Nakase 1999) confirmed this conclusion. The species has an affinity with the monotypic genus *Kurtzmaniella* (Lachance and Starmer 2008).

The growth characteristics of the type as determined by replica plating agreed with previous descriptions, except for the assimilation of D-ribose (negative), glucosamine (slow) and hexadecane (negative), as well as growth at 30°C (positive). Sensitivity to 0.1% cycloheximide can be used to differentiate the species from many similar species, including *C. oleophila* and *C. railenensis*.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.182. *Candida neerlandica* Kurtzman, Robnett & Yarrow (2001b)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Fig. 90.5). (Some of the morphological and growth characteristics are from Kurtzman et al. 2001b.)

Growth on 5% malt extract agar: After 3 days at 25°C, the cells are spherical, 4–11 μ m, or teardrop-like to ellipsoidal to elongate, 3–9 $\times$ 4–18 μ m, and occur singly or occasionally in pairs (Fig. 90.117A). The cells often show a narrowing of the base and longer cells may be curved. Budding is multilateral but large numbers of blastoconidia form laterally on pseudohyphae. Growth is butyrous, dull, tannish-white and has a pseudohyphal margin.

Dalmau plate culture on morphology agar: After 7 days at 25°C, growth under the coverglass is vigorous and highly expanded. The growth consists of well-branched pseudohyphae with abundant blastoconidia, but no hyphae (Fig. 90.117B). The aerobic growth is butyrous, white, dull and convoluted with a pseudohyphal border. The margins are finely to coarsely lobed.

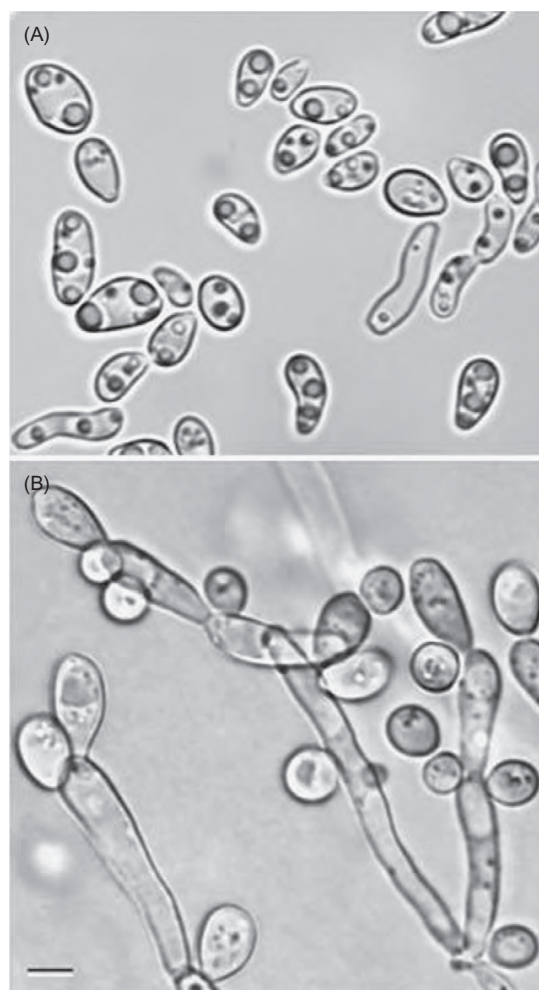


FIGURE 90.117 *Candida neerlandica* NRRL Y-27057. Budding cells after 3 days, 25°C, 5% malt extract agar (A) and pseudohyphae with blastoconidia after 7 days, 25°C, yeast morphology agar (B). Bar = 5 μ m.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	+		

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	–	Methanol	–
Sucrose	s	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	D,L-Lactate	+
Soluble starch	+	Succinate	+

Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	s
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	s	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono-δ-lactone	+	Casein	—
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF245404.

Cell carbohydrates: Not determined.

Origin of strain studied: CBS 434 (NRRL Y-27057), isolated from pressed yeast cake, The Netherlands.

Type strain: CBS 434.

Systematics: *Candida neerlandica* was described from a single isolate, primarily on the basis of a difference of 20 substitutions in the D1/D2 LSU rRNA gene from the related species *C. viswanathii* (Kurtzman et al. 2001b). Other close relatives include *C. tropicalis* and *C. sojae* in the *Lodderomyces* clade. The isolate had apparently been recovered by M.W. Beijerinck in pressed yeast.

The growth characteristics determined by replica plating agreed well with the original description, except that growth on starch was not observed. The profile bears some similarity to that of *C. fragi*, although several differences exist, including the assimilation of trehalose, melezitose and lactic acid.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.183. *Candida nemodendra* (van der Walt, van der Klift & D.B. Scott) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Ogataea* clade (Figs 53.1, 90.4).

Synonym:

Torulopsis nemodendra van der Walt, van der Klift & D.B. Scott (1971b)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to subglobose, 2–4 μm, and occur singly and in pairs (Fig. 90.118).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present. Aerobic growth is off-white, butyrous, smooth, soft, shiny and has an entire margin.

Fermentation: Absent.

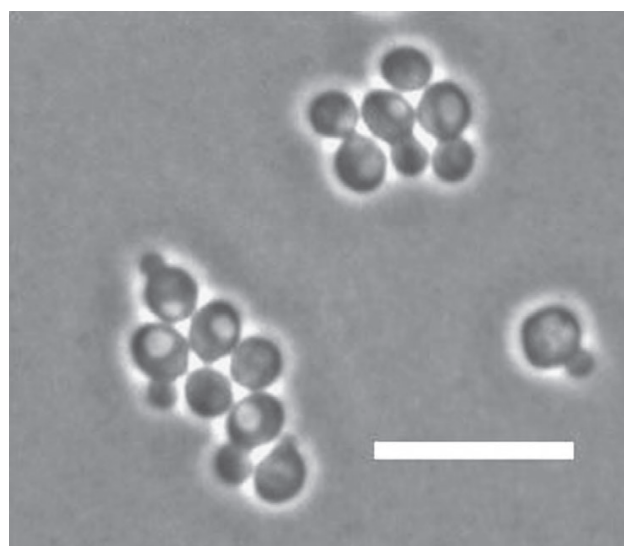


FIGURE 90.118 *Candida nemodendra* CBS 6280. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	+
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	+
Trehalose	+	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl-α-D-glucoside	—	D-Lactate	v
Soluble starch	—	Succinate	+
Cellobiose	v	Citrate	—
Salicin	v	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	+	Hexadecane	w
L-Arabinose	+	Nitrate	—
D-Arabinose	v	Vitamin-free	v

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono-δ-lactone	v	Casein	—
Amino acid-free	+	Lipase	w
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	v
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 7 (J.-D. Lee and Komagata 1980a).

Mol% G + C: 43.2, CBS 6280 (T_m : Stenderup et al. 1972); 39.5, one strain (T_m : J.-D. Lee and Komagata 1980a); 42.4, CBS 6280 (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70246.

Cell carbohydrates: Glucose and mannose are present in cell hydrolysates (Suzuki and Nakase 1998).

Origin of strain studied: CBS 6280, isolated from tunnels of scolytid beetle (*Xyleborus* sp., Coleoptera: Scolytidae) in Cape beech (*Rapanea melanophloeos*, Myrsinaceae), South Africa.

Type strain: CBS 6280.

Systematics: Van der Walt et al. (1971b) described *Torulopsis nemodendra* based on five isolates from beetle tunnels. Some similarity with *C. insectalens* and *C. torresii* was noted. Analysis of rRNA gene sequences places *C. nemodendra* in the methylotroph clade (Kurtzman and Robnett 1998a, Suzuki and Nakase 2002), close to *Ogataea* species, and identifies *C. ortonii* as the nearest relative (Lachance et al. 2001d).

Physiologically, *C. nemodendra* resembles a number of *Ogataea* species, but differs from them by the assimilation of galactitol. At variance with the original description by van der Walt et al. (1971b) and that given by Meyer et al. (1998), the type strain did not utilize galactose or L-arabinose as assessed by replica plating.

Ecology: Like many methylotrophic yeast species, *C. nemodendra* is probably associated with insects involved in tree injury or disease.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.184. *Candida neomexicana* Kurtzman (2007a)

Phylogenetic placement: *Sugiyamaella* clade (Figs 72.1, 90.3). (The description is based on Kurtzman 2007a.)

Growth on 5% malt extract agar: After 3 days at 25°C, yeast cells are spherical, 3.2–4.5 µm, to elongate, 1.5–3 × 2.5–7.5 µm, reproduce by multilateral budding and occur singly or in pairs (Fig. 90.119A). Aerobic growth is tannish-white, glistening, butyrous and with a narrow mycelial fringe. True hyphae formed on various media after a few weeks and often developed denticulate cells that produced blastoconidia. The hyphal cells may disarticulate at the septa.

Growth on the surface of assimilation media: Pellicles do not form on stationary liquid media.

Dalmau plate culture on potato, corn meal or morphology agar: After 7 days at 25°C, pseudohyphae occur and some form denticulate

cells giving rise to blastoconidia (Fig. 90.119B). Aerobic growth is tannish-white, semi-glistening, butyrous and with an entire margin.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	+	Galactitol	+
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D,L-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	+	Starch formation	–
5-Keto-D-gluconate	+	Gelatin liquefaction	–
Saccharate	–	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 37°C	–
10% NaCl/5% glucose	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA = DQ438201, ITS = DQ911447, mitochondrial SSU rRNA = DQ442731, COXII = DQ443055.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL YB-2450 (CBS 10349), isolated in 1950 from frass on ponderosa pine (*Pinus ponderosa*, Pinaceae), Silver City, New Mexico, USA (Kurtzman 2007a).

Type strain: NRRL YB-2450.

Systematics: Phylogenetic analysis of the combined gene sequences from LSU rRNA, mitochondrial SSU rRNA and COXII placed *C. neomexicana* in the *Sugiyamaella* clade. Here it clusters with *Sugiyamaella japonica* as a sister species in a weakly supported clade that comprises *S. americana*, *C. palidigena*, *C. castrensis*, *C. novakii*, *C. marionensis*, *C. grinbergii* and *C. pinicola* (Kurtzman 2007a).

Ecology: *Candida neomexicana* is known from a single strain from insect frass, New Mexico, USA.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

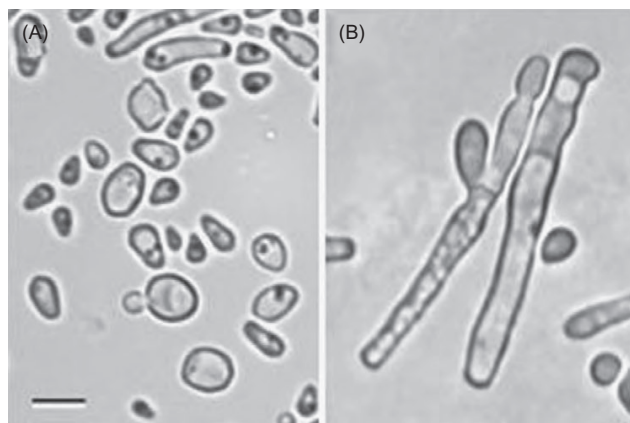


FIGURE 90.119 *Candida neomexicana* NRRL YB-2450. Budding cells after 3 days, 25°C, 5% malt extract agar (A) and hyphal fragments after 7 days, 25°C, yeast morphology agar (B). Bar = 5 µm.

90.185. *Candida nitratophila* (Shifrine & Phaff) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Ogataea* clade (Figs 53.1, 90.4).

Synonym:

Torulopsis nitratophila Shifrine & Phaff (1956)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, $2\text{--}3 \times 3\text{--}6\text{ }\mu\text{m}$, and occur singly and in pairs (Fig. 90.120).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present. Aerobic growth is off-white, butyrous, mostly smooth, soft, glossy and with an entire margin.

Fermentation

Glucose	s	Lactose	–
Galactose	s/–	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	+
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	D,L-Lactate	–
Soluble starch	–	Succinate	s
Cellobiose	–	Citrate	–
Salicin	v	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	+
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	+
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	+	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: 7 (Yamada and Kondo 1972a).

Mol% G + C: 36.6, CBS 2027 (T_m : Nakase and Komagata 1971f).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70180.

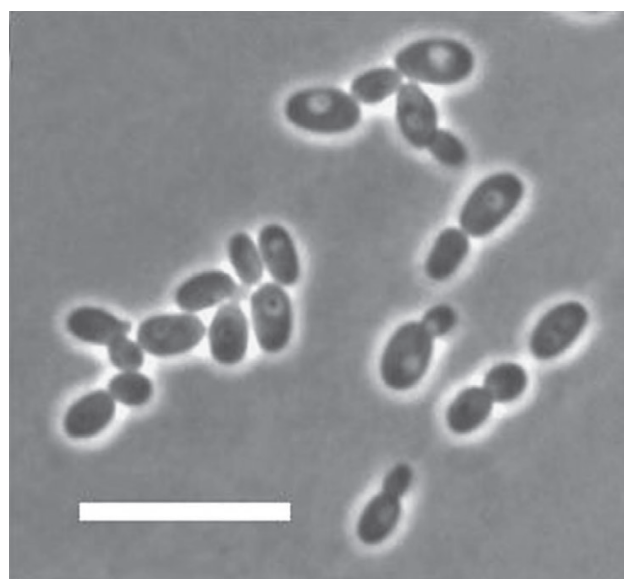


FIGURE 90.120 *Candida nitratophila* CBS 2027. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm .

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 2027, isolated from bark beetle (*Dendroctonus monticolae*, Coleoptera: Scolytidae) in ponderosa pine (*Pinus ponderosa*), California, USA.

Type strain: CBS 2027.

Systematics: In a study of 169 isolates from the scolytid beetles *Ips* spp. and *Dendroctonus* spp., Shifrine and Phaff (1956) described *Torulopsis nitratophila* to accommodate a strain that did not match the description of any known species. *C. nitratophila* is a sister species to *C. nanaspora* and belongs to the *Ogataea* clade of methylotrophic yeasts (Kurtzman and Robnett 1998a, Suzuki and Nakase 2002).

The growth characteristics of *C. nitratophila* resemble those of *C. nanaspora*, but growth on erythritol (negative in the species) can be used to separate the two. The lack of growth on β -glucosides is useful for separation from other similar species. Growth on D-xylose was reported as weak in the original description (Shifrine and Phaff 1956) and positive by Meyer et al. (1998), but in this study the type strain gave a negative response.

Ecology: Although *C. nitratophila* is known from only a single strain, the recovery of a methylotroph from bark beetles is consistent with the growing notion that these yeasts are associated with insects involved in tree injury and decay (Péter et al. 2003).

Biotechnology: Biochemical and regulatory properties of the nitrate reductase of *C. nitratophila* have been the object of some attention (Hipkin et al. 1993 and references therein).

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.186. *Candida nivariensis* Alcoba-Flórez, Méndez-Álvarez, Cano, Guarro, Pérez-Roth & Arévalo (2005)

Phylogenetic placement: Saccharomycetaceae, *Nakaseomyces* clade (Figs 50.1, 90.1).

Growth on yeast morphology agar: After 10 days at 25°C, the colony is 10 mm wide, flat, gray-pale to cream-beige, shiny, butyrous, smooth, toward the margin somewhat striated and with an entire,

somewhat crenulated margin. Cells are ellipsoid, obclavate to cylindrical, $3.5\text{--}5 \times 1.8\text{--}3 \mu\text{m}$, reproduce by polar budding and occur singly or in pairs.

Growth in 3% glucose in yeast nitrogen base: After 10 days at 25°C , cells are ellipsoid, $3\text{--}5 \times 2\text{--}3.8 \mu\text{m}$, reproduce by polar budding and occur singly, in pairs or in small clusters. Sediment is present.

Dalmau plate culture on potato dextrose agar: Pseudohyphae and hyphae are not present.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (in Liquid and on Agar Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	–
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	–
Soluble starch	v	Succinate	–
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	L-Lysine	–
2-Keto-D-gluconate	–	Ethylamine	–
5-Keto-D-gluconate	–	50% Glucose	–
D-Glucuronate	–	10% NaCl/5% glucose	+
L-Arabinitol	–	Starch formation	–
Arbutin	–	Urease	–
Propane-1,2-diol	–	DBB	–
Butane 2,3 diol	–	Cycloheximide 0.01%	–
Nitrite	–	Cycloheximide 0.1%	–
Cadaverine	–	Growth at 37°C	+
Creatinine	–	Growth at 42°C	+

CoQ: Not determined.

Mol% G + C: 33.4, CBS 9983 (T_m : Wahyuningsih et al. 2008).

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY627305, ITS = AY620957 (Alcoba-Flórez et al. 2005).

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9983 (CECT 11998, HC4292-20), isolated in 2001 by J. Alcoba-Flórez from a blood culture of a 69-year-old Spanish woman presenting with biliary pancreatitis and renal failure, Tenerife, Spain; CBS 9984 (HC5937-63), isolated from bronchoalveolar lavage fluid of a 50-year-old woman with anorexia, asthenia, fever, nocturnal swelling, cough with purulent expectoration and moderate dyspnea, Tenerife, Spain; CBS 9985 (HC7609-

30), isolated from a 44-year-old woman complaining of lumbar pain and mild dyspnea after myomectomy (Alcoba-Flórez et al. 2005); CBS 10161, from Indonesian HIV-infected patient with oropharyngeal candidiasis (Wahyuningsih et al. 2008); UWOPS 98-110.4 and UWOPS 98-113.2.2, isolated from flowers of *Hibiscus symonii*, Northern Territory, Australia.

Type strain: CBS 9983.

Systematics: *Candida nivariensis* is closely related to *C. glabrata* and *C. bracarensis* (Alcoba-Flórez et al. 2005, Correia et al. 2006, Wahyuningsih et al. 2008). These three species were found to differ by DNA–DNA reassociation experiments, RAPD-typing, AFLP-typing and D1/D2 and ITS sequence divergence (Alcoba-Flórez et al. 2005, Wahyuningsih et al. 2008). Phenotypically, it has been claimed that the species can be differentiated from *C. glabrata* because it is able to ferment trehalose and on Chromagar plates the colonies remain white and do not turn pink/violet as in *C. glabrata* (Alcoba-Flórez et al. 2005, Bishop et al. 2008). In contrast to the above, Borman et al. (2008) found that isolates of *C. nivariensis* were unable to ferment trehalose, whereas isolates of *C. glabrata* were able to ferment this sugar. Wahyuningsih et al. (2008) observed a delayed trehalose fermentation after 7–8 days for *C. nivariensis*, in contrast to 6–7 days for *C. bracarensis* and 2 days for *C. glabrata* CBS 138. Compared to *C. nivariensis*, isolates of *C. bracarensis*, *C. norvegensis* and *C. inconspicua* produced white colonies on Chromagar (Bishop et al. 2008). Pyrosequencing of the ITS2 region provided a means to rapidly identify isolates of *C. nivariensis* (Borman et al. 2008), as did an ITS-based PCR protocol (Alcoba-Flórez et al. 2005). Growth of the hibiscus isolates on agar media, particularly those based on YNB and YCB, was poor, in contrast with fermentative growth, which was rapid and vigorous.

Ecology: *Candida nivariensis* has been isolated from clinical materials such as HIV-infected and non-HIV infected patients (see also “Origin of the strains studied” and “Clinical importance”). In a large collection of 1598 putative *C. glabrata* strains, 0.2% were found to represent *C. nivariensis* (Lockhart et al. 2009). The only known strains from non-clinical sources came from hibiscus flowers collected in Northern Australia.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: *Candida nivariensis* has been isolated from patients in various countries, such as Spain, Indonesia, the UK and Japan (Alcoba-Flórez et al. 2005, Fujita et al. 2007, Wahyuningsih et al. 2008). Catheter-related infections have been reported (Fujita et al. 2007). Clinically, the species was isolated from bronchoalveolar lavage fluid, blood cultures, urine, lung biopsy, catheter-related infection, peritoneal fluid, pelvic abscess, oropharyngeal candidiasis, mouth and sputum (Alcoba-Flórez et al. 2005, Borman et al. 2008, Fujita et al. 2007, Wahyuningsih et al. 2008). Isolates of the species have reported to be less susceptible to itraconazole, fluconazole, voriconazole and flucytosine than those of *C. glabrata* (Borman et al. 2008). These authors claimed that *C. nivariensis* showed multi-drug resistance to azole antifungals compounds. Another study found no resistance of the species to antifungals (Lockhart et al. 2009) and *C. nivariensis* was found to be susceptible to amphotericin B, 5-flucytosine, fluconazole, voriconazole and itraconazole, and had low MIC values to posaconazole, isavuconazole and caspofungin (Wahyuningsih et al. 2008).

90.187. *Candida norvegica* (Reiersöl)

S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Barnettomyza* clade (Figs 18.1, 90.1).

Synonyms:

Torulopsis norvegica Reiersöl (1958)

Paratorulopsis norvegica (Reiersöl) Novák & Zsolt (1961)

Torulopsis uvae (Pollacci & Nannizzi) Lodder var. *miso* Mogi (1939)¹
Torulopsis vanzylii van der Walt & van Kerken (1961b)¹

¹ Synonymy based on phenotype.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to subglobose, 3–6 µm, and occur singly and in pairs (Fig. 90.121).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, short, branched chains of cells are sometimes present. Aerobic growth is white, butyrous, smooth, shiny and entire.

Fermentation

Glucose	+/s	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	v
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	v
Salicin	+	D-Gluconate	v
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	v	N-Acetyl-D-glucosamine	–
D-Xylose	v	Hexadecane	–
L-Arabinose	–	Nitrate	+
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Gluconate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	+	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	v
L-Lysine	+	Cycloheximide 0.1%	v
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: 41.7, CBS 4239 (BD: Stenderup et al. 1972); 40.7, CBS 4239 (BD: Meyer et al. 1984); 41.2, CBS 4239 (Tengku Zainal Mulok 1988).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U62299.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 2874, type strain of *Torulopsis uvae* var. *miso*, isolated from miso; CBS 4239, from sputum, Norway; UWOPS 81-68 and UWOPS 81-68, from sap flux of sugar maple (*Acer saccharum*, Aceraceae); UWOPS 81-85, UWOPS 03-317a2 and several others, from sap flux of northern red oak (*Quercus rubra*, Fagaceae); Ontario, Canada; UWOPS 85-258.1 and UWOPS 85- 259.1, sap flux of emory oak (*Quercus emoryi*, Fagaceae), Arizona, USA; UWOPS 82-332 and UWOPS 82-338, from *Drosophila* sp., Ontario.

Other strains available: CBS 2669, from dirt from bottle-washing machine; CBS 2670, from washed bottles, brewery, Sweden; CBS 4027, from sputum, The Netherlands; CBS 6575, from seawater.

Type strain: CBS 4239.

Systematics: Reiersöl (1958) described *Torulopsis norvegica* on the basis of an isolate from sputum of a tuberculous patient. Subcultures had been sent to Slooff and Wickerham, who both concluded that it represented a new species. According to the multi-gene study of Kurtzman et al. (2008), *C. norvegica* belongs to the *Barnettozyma* clade. Tengku Zainal Mulok (1988) showed by DNA reassociation studies that CBS 1784, a strain from apple must that was previously identified as *C. norvegica*, was unrelated to the type strain of the species. Kurtzman (2000a) included that strain in the circumscription of *Lindnera* (*Pichia*) *misumaiensis* based on its ability to mate with the type of that species.

A certain amount of variability exists in the growth characteristics of the species. When tested by replica plating, the type strain did not grow on L-rhamnose, D-xylose or D-glucitol, but utilized 2-keto-D-gluconate slowly and grew in the presence of 10% NaCl. Strain CBS 2874 utilized xylose and D-glucitol (weakly) but failed to grow on D-mannitol. Strains UWOPS 82-332 and UWOPS 82-338 differed in the utilization of L-rhamnose, but were otherwise identical and shared the ability to hydrolyze casein. The identity of several of these strains was confirmed by D1/D2 sequencing.

Ecology: *Candida norvegica* has been recovered from a wide variety of substrates, including clinical specimens, food and beverages, insects and plants. A specific habitat has not yet been identified.

Biotechnology: Unknown.

Agriculture and food: Dillon and Board (1990) found that a strain of *C. norvegica* isolated in contaminated lamb products was resistant to 500 µg/ml sulfite, which is above the concentration used in the preparation of meat products such as sausages. Growth in the presence of that inhibitor was possible only at pH values above 4 and was accompanied by the production of acetaldehyde.

Clinical importance: Unknown.

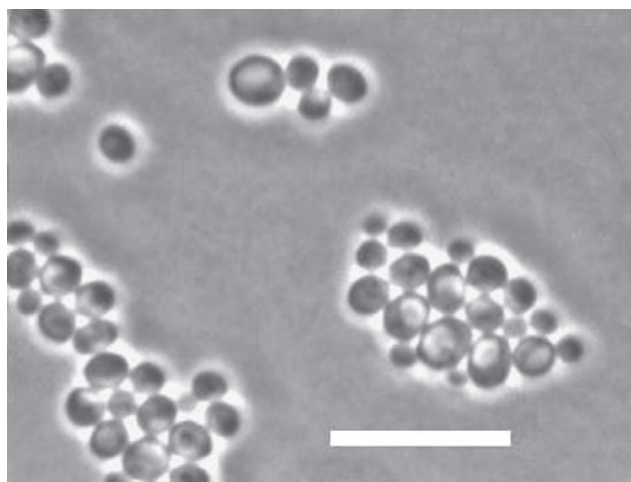


FIGURE 90.121 *Candida norvegica* CBS 4239. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

90.188. *Candida novakii* Péter, Tornai-Lehoczki & Deák (1997)

Phylogenetic placement: *Sugiyamaella* clade (Figs 72.1, 90.3). (Some of the morphological characteristics are based on Péter et al. 1997.)

Growth on malt agar: After 3 days at 25°C the streak culture is butyrous, cream colored, smooth and glistening, and the margin is weakly fringed with hyphae.

Growth in malt extract broth: After 3 days at 25°C, the cells are ellipsoid, subspheroid or elongated, $2.5\text{--}5 \times 3.5\text{--}10\text{ }\mu\text{m}$, and occur singly, in pairs or in short chains (Fig. 90.122 left). Budding is multi-lateral. A pellicle is not formed.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, septate hyphae, rudimentary pseudohyphae and chains of cells are present (Fig. 90.122 right).

Fermentation

Glucose	w	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	s
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	+
Soluble starch	—	Succinate	+
Cellulobiose	+	Citrate	+
Salicin	s	D-Gluconate	s
L-Sorbose	+	D-Glucosamine	s
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	w
L-Arabinose	+	Nitrate	+
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	s	Gelatin	—
Glucono- δ -lactone	+	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	+	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 9 (Péter et al. 1997).

Mol% G + C: 37.5, type strain (T_m : Péter et al. 1997).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY618511, mitochondrial SSU rRNA = DQ442726, cytochrome oxidase II = DQ443054.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 8402 (NCAIM Y 00986, NRRL Y-27346), isolated from decaying wood of oak (*Quercus* sp., Fagaceae), Hungary.

Other strain available: NCAIM Y 00987, from decaying wood of *Quercus* sp., Hungary.

Type strain: CBS 8402.

Systematics: Péter et al. (1997) isolated two strains from decaying oak wood. A similarity with *C. wickerhamii* was noted, but with some differences in physiology and morphology. *C. novakii* was described based on a DNA reassociation value of 14% with *C. wickerhamii*. Multi-gene sequence analysis placed the species close to *C. castrensis* and *C. paludigena* in the *Sugiyamaella* clade (Kurtzman and Robnett 2007).

Growth characteristics determined by replica plating agreed well with those in the original description with the exception of utilization of ribitol and citric acid, which were reported as negative. The species differs from *C. wickerhamii* by the assimilation of L-sorbose, erythritol and glucuronic acid, and the lack of growth on L-rhamnose.

Ecology: An association with decaying wood and associated insects is suspected in view of the isolation sources of this and related species.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

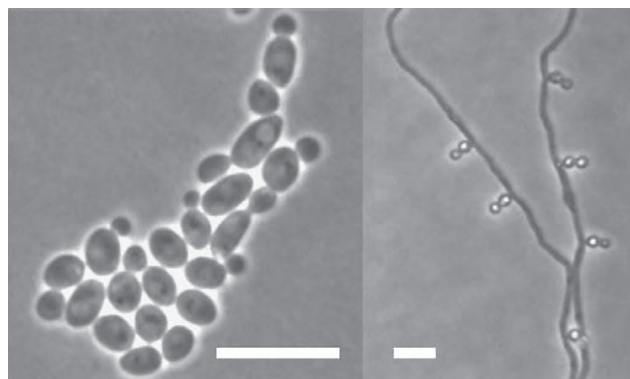


FIGURE 90.122 *Candida novakii* CBS 8402. Budding cells after 3 days, 25°C, YM agar (left) and hyphae with blastoconidia after 14 days, 25°C, YCBAS agar (right). Bars = 10 μm .

90.189. *Candida odintsovae* Bab'eva, Reshetova, Blagodatskaya & Galimova (1989)

Phylogenetic placement: *Wickerhamomyces* clade (Figs 80.1, 90.4).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, long ovoid to cylindroid, $2\text{--}4.5 \times 2.5\text{--}11\text{ }\mu\text{m}$, and occur singly or with buds (Fig. 90.123). Some cells are slightly curved while others appear claviform, somewhat triangular or teardrop shaped.

Growth in yeast nitrogen base + 0.5% glucose: After 3 days at 25°C, a thick, folded pellicle is present and growth adheres to the walls of the tube.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, abundant, entwined pseudohyphal growth is present. Some cells are curved and some of the growth appears “bushy” or “feathery” and does not extend far from the streak. Aerobic growth is white

to off-white, smooth and dull to somewhat chalky, with a mycelial margin.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	+
Sucrose	+	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	v	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	v	Ribitol	v
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	D-Lactate	v
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	v
Salicin	+	D-Gluconate	+
L-Sorbose	v	D-Glucosamine	—
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	+	Nitrate	—
D-Arabinose	—	Vitamin-free	v

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	v
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	v	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	+

CoQ: 7 (Bab'eva et al. 1989).

Mol% G + C: 36.0–36.6, five strains (HPLC: Bab'eva et al. 1989); 38.3, CBS 6025 (T_m : S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70182.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 1951, isolated from washed bottle in a brewery, Sweden; CBS 6025, CBS 6026, from sap of birch (*Betula verrucosa*), Russia.

Type strain: CBS 6026.

Systematics: Bab'eva et al. (1989) described *C. odintsovii* (spelling corrected to *odintsovae* by Meyer et al. 1998) after isolating eight strains from various substrates associated with birch trees. They noted a similarity with *C. maritima* and *Wickerhamomyces* (*Pichia*) *rabaulensis*, although some differences were observed, including the fermentation of several sugars and a lower DNA base composition. Kurtzman and Robnett (1998a) reported that *C. odintsovae* differs

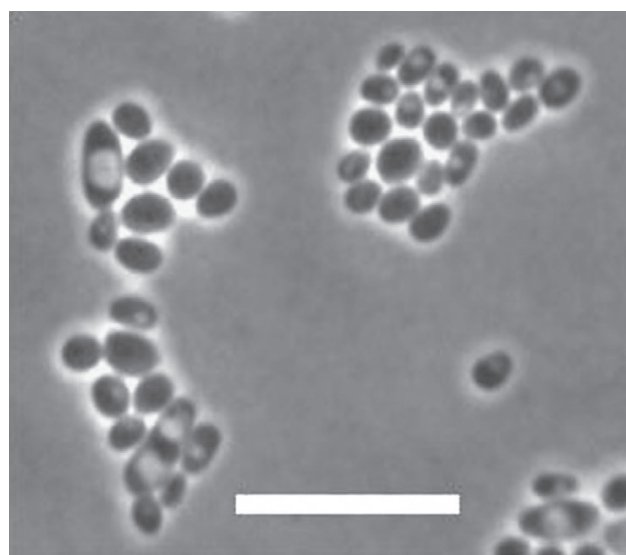


FIGURE 90.123 *Candida odintsovae* CBS 6026. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

from *W. rabaulensis* by three substitutions in the D1/D2 LSU rRNA gene sequences and suggested that they may be conspecific. In view of the differences noted above and in the absence of mating or DNA reassociation data, the species is tentatively recognized as distinct from *W. rabaulensis*.

The nutritional profile of *C. odintsovae* is typical of species in the *Lindnera* and *Wickerhamomyces* (Kurtzman et al. 2008). The highest degree of similarity is with *Lindnera rhodanensis*, *W. onychis*, *C. maritima*, *C. mycetangii* and the close relative, *W. rabaulensis*. At variance with the responses given by Meyer et al. (1998), when tested on agar, the strains were variable for growth on galactose, 2-keto-D-gluconate, and N-acetyl-D-glucosamine or growth in the presence of 10% NaCl, and did not utilize lactic or citric acid.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.190. *Candida oleophila* Montrocher (1967)

Phylogenetic placement: Kurtzmaniella clade (Figs 40.1, 90.2).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, a few cells are spherical, but most are ovoid or long-ovoid to elongate, 3–4 $\times$ 4–6.5 μ m and occur singly, in pairs and in short branched and unbranched chains (Fig. 90.124 left). Slender cylindrical cells, 1.5–4 $\times$ 4–9 μ m, are also present, as well as cells that are slightly curved. A thin, delicately wrinkled pellicle is present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of cylindrical cells, sometimes with verticils of ovoid blastoconidia (Fig. 90.124 right). Aerobic growth is off-white, dull, both smooth and delicately wrinkled and the margin is usually entire with a few tufts of pseudohyphal growth.

Fermentation

Glucose	+	Lactose	—
Galactose	+/s	Raffinose	—
Sucrose	—/l	Trehalose	—/l
Maltose	v		

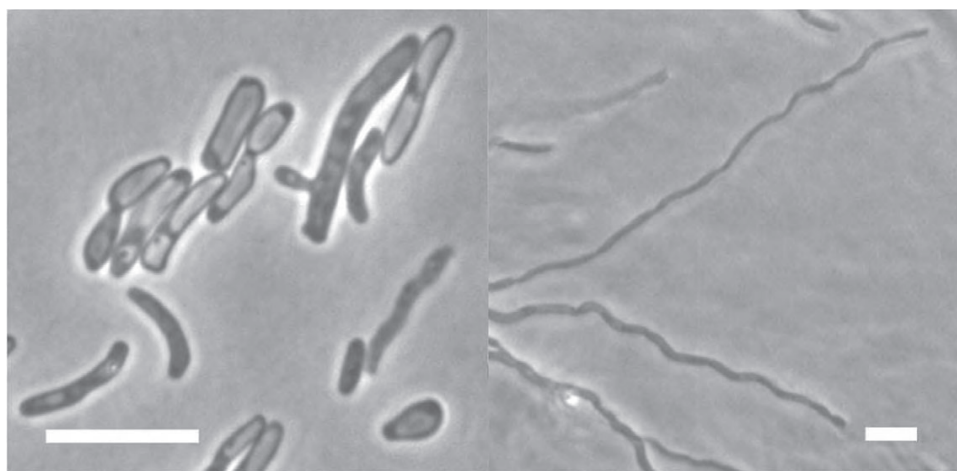


FIGURE 90.124 *Candida oleophila* CBS 2219. Budding cells after 3 days, 25°C, YM agar (left) and pseudohypha after 14 days at 18°C on YCBAS agar (right). Bars = 10 μ m.

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	v
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	v	DL-Lactate	v
Soluble starch	v	Succinate	+
Cellulobiose	+	Citrate	+
Salicin	+	D-Gluconate	v
L-Sorbose	+	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	v
L-Arabinose	–	Nitrate	–
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	v	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	v	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	–

CoQ: 9 (Nakase et al. 1988b).

Mol% G + C: 40.7, CBS 2219; 41.5, CBS 4371 and CBS 6106 (T_m : Meyer et al. 1984); 42.2, NRRL Y-2317 (CBS 2219) (T_m : Nakase and Komagata 1971f); 43.7, UCD-FST 62-4 (CBS 2219, T_m : Meyer and Phaff 1972); 41.7, 40.1, CBS 2219 (T_m and HPCL, respectively: Nakase et al. 1988b).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45793.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 2219, isolated from olives (*Olea europea*, Oleaceae), Italy; SUB 84-665.2, from fruit of *Opuntia stricta*, in O'Hara, Australia; UWOPS 91-603.1 and one other, from fruits of *Solanum* sp. (Solanaceae); UWOPS 91-621.1 and others, from soapberry fruits (*Sapindus saponaria*, Sapindaceae); UWOPS 00-680.2, from sap flux of *Pipturus albidus* (Urticaceae); Hawai'i; UWOPS92-266.1, from rot of *Agave tequilana* (Agavaceae), Mexico.

Other strains available: CBS 2220, from a flower of an herb (*Phacelia* sp., Hydrophyllaceae), confirmed by sequencing (AF178046, H.G. Park and S.A. Meyer, unpublished data); CBS 4371, from cider, UK; CBS 6106, from tonic water, confirmed by sequencing (AF178050, H.G. Park and S.A. Meyer, unpublished data).

Type strain: CBS 2219.

Systematics: Montrocher (1967) examined a strain received from the CBS as *C. parapsilosis* var. *intermedia*, a designation that had apparently been used for strains belonging to at least two species. The strain was compared to the types of *C. parapsilosis* and *C. guilliermondii*, and several differences were noted between the three. The lack of growth on L-arabinose, the utilization of β -glucosides, and the formation of a pellicle on liquid media, among others, were used as the basis for the description of *C. oleophila*. The difficulties associated with the classification and the identification of *C. oleophila* and some of the proposed solutions have been discussed by Meyer et al. (1998). DNA reassociation studies demonstrated that the species is distinct from both *C. railenensis* and *C. sake* (Tengku Zainal Mulok 1988). The type strains of *C. oleophila* and *C. railenensis* differ by only four substitutions in the D1/D2 LSU rRNA gene (Kurtzman and Robnett 1998a) and four in the ITS region (AY528671 and AY528672). The closest ascogenous relative is *Kurtzmaniella clerdarum* (Lachance and Starmer 2008), a haplontic, heterothallic species that forms hat-shaped spores after conjugation, preferably on 5% malt agar. Several strains of *C. oleophila* were mixed in all possible pairs on that medium to see if a similar life cycle could be detected, to no avail.

The physiological profile of *C. oleophila* intergrades with that of *C. railenensis*, so that separation is practically impossible. *C. natalensis*, another relative, may be distinguished by the lack of growth on 50% glucose. Convergence with unrelated species also exists. *C. maltosa* differs by the ability to grow at 37°C. Delimitation from *C. sake* has been reported to be difficult. However, this difficulty is due to a large extent to strain misidentification and the reporting of growth characteristics as "variable" when many strains are considered simultaneously. Resistance to cycloheximide (0.01%) is always positive in *C. oleophila* and negative in *C. sake*.

Ecology: The sparse isolation of the species from plant materials that are frequently visited by *Drosophila* spp. suggests an association with the plant–insect interface.

Biotechnology: Unknown.

Agriculture and food: A strain identified as *C. oleophila* has received considerable attention as a biocontrol agent of postharvest disease of pome and citrus fruit (Mari et al. 2003). An inoculant called Aspire™ is commercially available from Ecogen Inc. (Langhorne, Pennsylvania). The mechanism by which the strain competes with *Penicillium digitatum* to prevent deterioration of fruit is not clear. Yehuda et al. (2003) modified the strain to test the impact of under- and overexpression of a lytic *exo-β*-glucanase, and found no detectable effect on the efficacy of biocontrol.

Clinical importance: Unknown.

90.191. *Candida ontarioensis* Kurtzman & Robnett (1998b)

Phylogenetic placement: unaffiliated clade (Fig. 90.1), *Hyphopichia* clade (Fig. 33.1).

(Some of the morphological characteristics are from Kurtzman and Robnett 1998b.)

Growth on 5% malt extract agar: After 3 days at 25°C, the cells are spherical, 2–5 μm, to ellipsoidal or elongate, 2–5 × 2.5–7.5 μm, and occur singly, in pairs and in short chains (Fig. 90.125A). Budding is multilateral. Growth is tannish-white, dull and butyrous. True hyphae often form abundant endospores after 10 days at 25°C (Fig. 90.125B,C).

Growth on the surface of assimilation media: Pellicles are formed.

Dalmau plate culture on morphology agar: After 7 days at 25°C, pseudohyphae and true hyphae are formed under the coverglass. Aerobic growth is dull, tannish-white, butyrous to mycelial and flat with a slightly raised center. The margin is entire to broadly lobed. The odor is faintly acidic.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	+	Trehalose	+
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	v	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	+	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D,L-Lactate	–
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	+	Nitrate	–
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	v
Glucono-δ-lactone	w	Casein	–
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	v	Growth at 30°C	+
50% Glucose	w	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF017244.

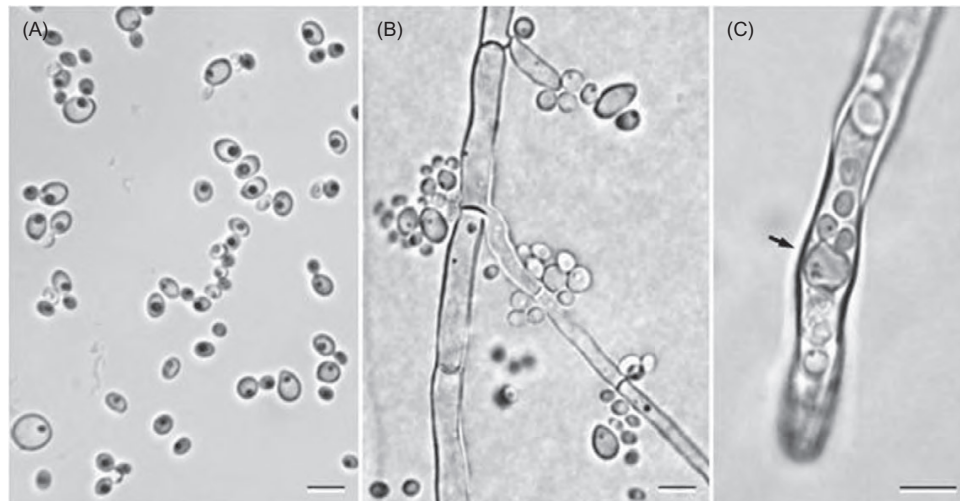


FIGURE 90.125 *Candida ontarioensis*, NRRL YB-1246. Budding cells after 3 days, 25°C, 5% malt extract agar (A). True hyphae with clusters of blastoconidia at septa after 3 weeks at 25°C on YM agar (B). Endospores in a hyphal cell on YM agar after 3 weeks, 25°C (C); note endospore division by budding (arrow). Bars = 5 mm.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 8502 (NRRL YB-1246), NRRL YB-1231 and NRRL YB-1247, isolated from frass in tunnels of an unidentified wood borer, Ontario, Canada; CBS 8503 (NRRL YB-2182), from frass in a tunnel of an unidentified wood borer, Wyoming, USA.

Type strain: CBS 8202.

Systematics: Kurtzman and Robnett (1998b) described *C. ontariensis* on the basis of four isolates from insect frass. Analysis of D1/D2 LSU rRNA gene sequences (Kurtzman 2001a) demonstrated a relationship with *C. litsaeae*, but did not provide a definite placement for the two species. A neighbor-joining analysis prepared in this study suggested a distant connection with *C. entomophila* and *C. silvanorum*, which were linked to *Hyphopichia* (*Pichia*) *burtonii* by Suzuki and Nakase (1999) based on SSU rRNA gene sequences. As *C. ontarioensis* and *C. litsaeae* were not included in their analysis, the SSU sequences of the type cultures were determined (*C. ontarioensis* = AY500849). The analysis supported the view that they are sister species that form a sister clade with *C. entomophila* and *C. silvanorum*, which also occupy basal positions in Fig. 90.1. However, Kurtzman and Robnett (2007), using a multi-gene approach, placed the two species in a sister clade to *Sporopachydermia* species.

Candida ontarioensis has a broad spectrum of carbon assimilations, similar to that of *C. litsaeae*. The two differ in the assimilation of D-glucuronic acid (positive in the species) and growth at 37°C (negative in the species). As assessed by replica plating, neither of the strains examined utilized raffinose and the utilization of D-ribose and erythritol varied between strains. These characteristics were reported as positive in the original description.

Ecology: An association with wood-boring insects is likely.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.192. *Candida orba* Starmer, Phaff, Ganter & Lachance (2001)

Phylogenetic placement: *Phaffomyces* clade (Figs 56.1, 90.3). (The description is based on Starmer et al. 2001.)

Growth on malt agar: After 3 weeks at 25°C, the streak culture on malt agar is cream colored, butyrous to soft, convex, non-spreading, smooth with slight radial striations, semi-glossy. The border is smooth to slightly lobulate.

Growth in YM broth: After 3 days at 30°C, the cells are ovoid, elongate or club-shaped, 2–6 × 3–10 µm, occur singly, in pairs and clusters of 6–10 cells, and reproduce by multilateral budding. After 7 days, a glistening, moist pellicle develops.

Dalmau plate culture on corn meal agar: After 2 weeks at 18°C, pseudohyphae are absent.

Sexual reactivity: All isolates are capable of zygote formation with the type of *Phaffomyces antillensis*, indicating that they are haploid, heterothallic strains of mating type *h*⁺.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+

Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	n	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	n
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: 33.4–34.0, five strains, including the type (BD: Starmer et al. 2001).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF229034.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 8782 (UCD-FST 84-833.1), isolated from necrotic cladodes of erect prickly pear (*Opuntia stricta*, Cactaceae), Australia.

Other strains available: UCD-FST 78-529.3 and others, from necrotic cladodes of *Opuntia stricta*; UCD-FST 84-837.1, from fruit fly (*Drosophila buzzati*, Diptera: Drosophilidae) from a necrotic prickly pear; UCD-FST 99-2 and others, from necrotic cladodes of *Opuntia tomentosa*, all from Australia.

Type strain: CBS 8782.

Systematics: Starmer et al. (2001) described *C. orba* on the basis of 14 strains recovered from decaying tissue of prickly pears and from drosophilid flies that breed and feed on these materials. The first isolates had been referred to as "*Pichia opuntiae* variety Hemmant" in earlier publications (e.g., Starmer et al. 1990). The species is a close relative to *Phaffomyces thermotolerans* as evidenced by a DNA reassociation value of 52%. Values of 27 and 24% were obtained with *Phaffomyces opuntiae* and *Phaffomyces antillensis*, respectively, indicating a more distant, but nonetheless significant relationship. These were consistent with D1/D2 LSU rRNA gene sequence analysis (Kurtzman and Robnett 1998a), which indicated that the four species form a distinct clade, also identified by Yamada et al. (1999). Sisterhood of *C. orba* with *Phaffomyces thermotolerans* was confirmed (Starmer et al. 2001), although the two differ by 53 substitutions in the D1/D2 region. All strains of *C. orba* produce zygotes when mixed with mating type *h*⁺ of *Phaffomyces antillensis*, indicating that the species should be reassigned to the genus *Phaffomyces* following Article 57.9 of the Vienna Code (McNeill et al. 2006).

The species is physiologically similar to the three species of *Phaffomyces*, but separation can be based on the assimilation of L-rhamnose by *C. orba*. Other features such as the utilization of citric acid and growth at 37°C (negative in the species) are useful.

Ecology: The entire *Phaffomyces* clade has a strong association with necrotic cactus tissue and the drosophilids that breed and feed on that material (Starmer et al. 1990). Of special interest is the geographic and host plant distribution of the species in the clade. *Phaffomyces antillensis* has been isolated almost exclusively in columnar cacti in the West Indies, whereas *Phaffomyces thermotolerans* appears to be confined to columnar cacti in the Sonoran Desert of Arizona and Mexico. *Phaffomyces opuntiae* and *C. orba* have been isolated in Australia, although the former may occur also in Mexico and Hawai'i.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.193. *Candida oregonensis* Phaff & do Carmo-Sousa (1962)

Phylogenetic placement: *Metschnikowia* clade (Fig. 90.1).

Synonym:

Candida obtusa Dietrichson ex van Uden & H.R. Buckley var. *oregonensis* (Phaff & do Carmo-Sousa) Montrocher (1967)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, $2\text{--}3.5 \times 2.5\text{--}5\ \mu\text{m}$, and occur singly and in chains (Fig. 90.126 top).

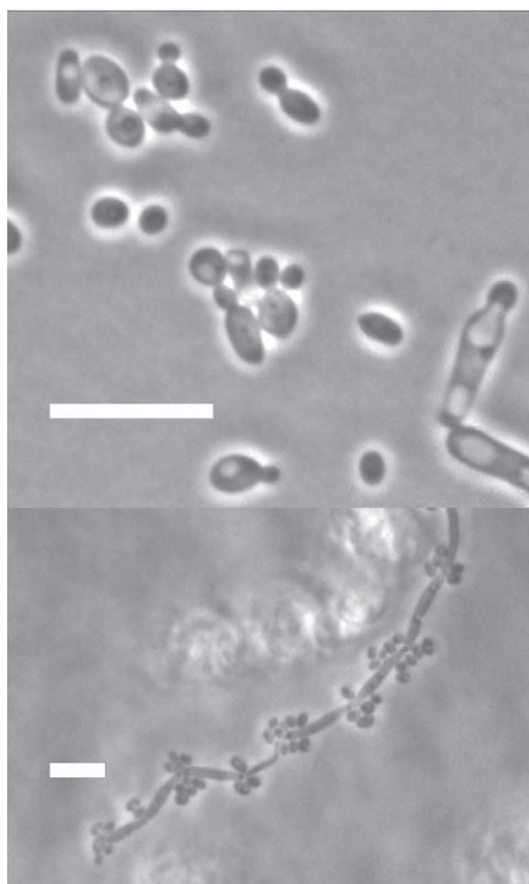


FIGURE 90.126 *Candida oregonensis* CBS 5036. Budding cells after 3 days, 25°C, YM agar (top) and pseudohypha with blastoconidia after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μm .

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of elongate cells, often with dense verticils of ovoid blastoconidia (Fig. 90.126 bottom). Aerobic growth is white to cream colored, butyrous, smooth, glistening and with an entire margin.

Fermentation

Glucose	s	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	s		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	v	Glycerol	—
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	v
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	D-Lactate	—
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	+
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	—	Nitrate	—
D-Arabinose	v	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	v	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	v
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 48.1, 48.0, type strain (T_m : Meyer and Phaff 1972; T_m : Nakase and Komagata 1971f, respectively).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U44815.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5036, isolated from insect frass in western hemlock (*Tsuga heterophylla*), Oregon, USA; CBS 5623, from alpechin.

Type strain: CBS 5036.

Systematics: *Candida oregonensis* was described to accommodate five isolates recovered from insect frass in hemlocks (Phaff and do

Carmo-Sousa 1962). A similarity with *C. obtusa*, *C. lusitaniae* and *C. parapsilosis* was noted, but diagnostic differences were found in carbon assimilation and fermentation as well as maximum growth temperature. Montrocher (1967) considered the species to be a variety of *C. obtusa*, which was later shown to be a haploid mating type of *Clavispora lusitaniae* (Rodrigues de Miranda 1979). Sequencing of the D1/D2 LSU (Kurtzman and Robnett 1998a) and SSU (Sugita and Nakase 1999) rRNA genes showed that *C. oregonensis* is a distinct member of the Metschnikowiaceae clade, although a significant relatedness to *Clavispora lusitaniae* exists. *C. parapsilosis* is unrelated.

The two strains examined by replica plating differed in the utilization of raffinose (negative in the type) and are distinguishable from any other known species by a number of growth responses, including growth on L-rhamnose and the absence of growth on galactose or glycerol.

Ecology: Phaff and do Carmo-Sousa (1962) noted that *C. oregonensis* was particularly abundant in frass generated by the bark beetle *Scolytus tsugae* (Coleoptera: Scolytidae).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

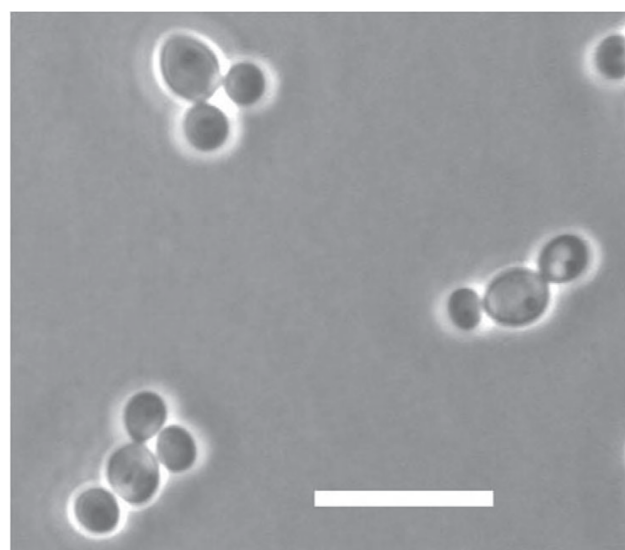


FIGURE 90.127 *Candida orthopsilosis* CBS 8548. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

90.194. *Candida orthopsilosis* Tavanti, Davidson, Gow, Maiden & Odds (2005a)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Fig. 90.5).

Growth on yeast morphology agar: After 10 days at 25°C, the colony is flat, 13 mm wide, pale cream, shiny, butyrous, smooth in the center, toward the margin weakly furrowed and with an eroded margin. Cells are ellipsoid to subglobose, 2–5 × 3–7 μm, and reproduce by multilateral budding (Fig. 90.127).

Growth in 3% glucose in yeast nitrogen base: Cells are subglobose to ellipsoid, 2–5 × 3–6 μm, reproduce by multilateral budding and form branched pseudohyphae. Filaments that measure 10–18 × 1.5–2.3 μm are present. A patchy ring and sediment are present.

Dalmeu plate culture on potato dextrose agar: Well-developed pseudohyphae occur. The colony produces a somewhat ester-like smell.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	n
Maltose	–		

Growth (in Liquid and on Agar Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	v
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	v	Succinate	+

Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	+	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	L-Lysine	+
2-Keto-D-gluconate	+	Ethylamine	+
5-Keto-D-gluconate	n	50% Glucose	+
D-Glucuronate	–	10% NaCl/5% glucose	+
L-Arabinitol	n	Starch formation	–
Arbutin	–	Urease	–
Propane 1,2 diol	+	DBB	–
Butane 2,3 diol	–	Cycloheximide 0.01%	+
Isopropyl alcohol	–	Cycloheximide 0.1%	–
Nitrite	–	Growth at 37°C	+
Cadaverine	+	Growth at 42°C	+
Creatinine	–		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = FJ746056, ITS, 5.8S rRNA and partial LSU rRNA = FJ746064.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 8548, isolated in Antarctica; CBS 10906 (ATCC 96139), from the tip of a catheter, San Antonio, Texas, USA (Tavanti et al. 2005a); UWOPS 83-764.2, from fruit of *Opuntia stricta* (Cactaceae), Bahamas; UWOPS 01-661.1, from flux of guapinol (*Hymenaea courbaril*, Fabales: Caesalpinaceae), Costa Rica.

Type strain: ATCC 96139.

Systematics: *Candida orthopsilosis* represents the former *C. parapsilosis* group II (Tavanti et al. 2005a). The species cannot be distinguished

morphologically from *C. parapsilosis* and *C. orthopsilosis*, but can be separated based on molecular markers such as nucleotide differences in the following genes SYA1, SADH, as well as ITS (Asadzadeh et al. 2009, Borman et al. 2009, Tavanti et al. 2005a). Sequence analysis of the D1/D2 domains of the LSU rRNA gene revealed that *C. hyderabadensis* is a basal species to the *C. parapsilosis*, *C. orthopsilosis* and *C. metapsilosis* cluster (Rao et al. 2007).

Ecology: *Candida orthopsilosis* is known from clinical samples and was found on all continents, but the incidence of infections caused by the species was not evenly distributed (Lockhart et al. 2008b). The highest number (11%) came from Asia and South America (10.9%), followed by North America (5%) and Europe and the Middle East (3.5%, Lockhart et al. 2008b). Seventy-seven percent of the *C. orthopsilosis* isolates with a known origin from the ARTEMIS antifungal surveillance program came from bloodstream infections (Lockhart et al. 2008b). The species was further isolated from vagina, blood, nail, catheter, orbital tissue, ascites fluid, abscesses, cerebrospinal fluid and pulmonary sources (Lockhart et al. 2008b, Tavanti et al. 2005a). The species has also been isolated from plant sources in the Bahamas and Costa Rica as well as Antarctica (see "Origin of the strains studied").

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: *Candida orthopsilosis* is an emerging human pathogen that is known from various clinical materials (see "Ecology"). In a study of 175 isolates belonging to the *C. parapsilosis* species cluster, 2.3% were reidentified as *C. orthopsilosis* (Silva et al. 2009). Five out of 114 isolates belonging to the *C. parapsilosis* complex from Kuwait belonged to *C. orthopsilosis* (Asadzadeh et al. 2009). In Spain, the incidence of *C. orthopsilosis* in candidemia was found to be 1.4% (Gomez-Lopez et al. 2008). From 1929 invasive candidosis isolates from the ARTEMIS antifungal surveillance program, 6.1% belonged to *C. orthopsilosis*, but the incidence increased from 4.5 to 8.3% during the study (Lockhart et al. 2008b). The median age of infection ranged from 40 to 49 years old, and the highest percentage came from the ≥ 60 -year-old age group (Lockhart et al. 2008b). *C. orthopsilosis* has also been involved in some hospital outbreaks on three continents, namely hospitals in the USA, Brazil and Italy (Lin et al. 1995, Lockhart et al. 2008b, Tavanti et al. 2005a, Zancopé-Oliviera et al. 2000) and one possible outbreak in a Malaysian hospital (Yong et al. 2008). In a virulence study using reconstituted human tissue models, *C. orthopsilosis* was found to be as virulent as *C. parapsilosis* (Gácsér et al. 2007).

Isolates of the species are susceptible to amphotericin B, 5-fluorcytosine, fluconazole, itraconazole, ketoconazole and miconazole (Tavanti et al. 2005a). In another study *C. orthopsilosis* isolates were found to be susceptible to fluconazole and amphotericin B and MIC values of caspofungin were lower than those of *C. parapsilosis* (Lockhart et al. 2008b, Silva et al. 2009).

90.195. *Candida ortonii* Lachance (Lachance et al. 2001d)

Phylogenetic placement: *Ogataea* clade (Fig. 90.4).

Growth on malt agar: After 2 weeks at 17°C, colonies are small, high convex and sometimes with a raised margin, dull to semi-glossy, smooth, white and cohesive.

Growth in glucose–yeast extract broth: After 3 days at 25°C, the cells are spherical to ovoid, 4–5 $\times$ 5–6 μ m, and occur singly, in parent-bud pairs, in short chains or in clumps. A pellicle is not formed.

Dalmu plate culture on corn meal agar: After 2 weeks at 18°C, pseudohyphae or true hyphae are not formed.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–	Cellobiose	s

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	s
Raffinose	–	Glycerol	–
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	s
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	s
Maltose	s	D-Glucitol	+
Melezitose	s	myo-Inositol	–
Methyl- α -D-glucoside	–	D-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	s	Citrate	–
Salicin	+	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	s	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	s	Cycloheximide 0.01%	s
L-Lysine	+	Cycloheximide 0.1%	w
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	s
50% Glucose	–	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF313350.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 8843 (UWOPS00-159.3) and others, isolated from flux of old fustic tree (*Maclura tinctoria*, Moraceae); UWOPS 00-226.3, from a stingless bee (*Trigona* sp., Hymenoptera: Apidae) in flower of rock rosemary (*Merremia quinquefolia*, Convolvulaceae); all from Costa Rica.

Type strain: CBS 8843.

Systematics: Lachance et al. (2001d) described *C. ortonii* to accommodate isolates found in sap fluxes of *Maclura tinctoria* in Costa Rica. *C. ortonii*, a close relative of *C. nemodendra* as suggested by D1/D2 LSU rRNA gene sequences, belongs to the methylotroph clade. Another close relative, isolated from sap fluxes of tropical leguminous trees, has been described as *Ogataea falcaomoraisii* (Morais et al. 2004). The carbon assimilation spectrum of the species is unusual for members of the clade, as few compounds are utilized, but methanol is not. Growth is generally slow.

Ecology: An association with tropical sap fluxes and insects that feed on these sources of nutrients is evident.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.196. *Candida oslonensis* Knutsen, V. Robert & M.Th. Smith (Knutsen et al. 2007)

Phylogenetic placement: *Yarrowia* clade (Figs 82.1, 90.3).

(The description is based on Knutsen et al. 2007.)

Growth in YM broth: After 3 days at 25°C, the cells are ovoid to globose, 3–6 × 3–9 µm, reproduce by multilateral budding and occur singly, in pairs and in small clusters.

Dalmau plate culture on YM agar: After 3 days at 25°C, pseudohyphae and true hyphae are produced.

Fermentation: Absent.

Growth (in Microtiter Plates)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	n
Sucrose	–	Ethanol	n
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	v
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	v	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	L-Lysine	+
5-Keto-D-gluconate	–	Ethylamine	+
D-Glucuronate	–	10% NaCl/5% glucose	–
L-Arabinitol	–	Urease	–
Propane 1,2 diol	–	Cycloheximide 0.1%	+
Butane 2,3 diol	–	Growth at 27°C	+
Nitrite	–	Growth at 30°C	+
Cadaverine	+	Growth at 35°C	–
Creatinine	–		

CoQ: Not determined.

Mol% G + C: 45.7–45.9 (T_m : three isolates, Knutsen et al. 2007).

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AM268477, ITS = AM279265.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 10145 (VI 03313), CBS 10146 (NRRL Y-48252, VI03316), CBS 10147 (VI 03320), CBS 10148 (VI 03329), all isolated from yogurt in Norway (Knutsen et al. 2007).

Type strain: CBS 10146.

Systematics: Combined analysis of sequences of the D1/D2 LSU rRNA gene and the ITS 1 and 2 regions (Knutsen et al. 2007) indicated that *C. oslonensis* belongs to the *Yarrowia* clade among *Yarrowia lipolytica*,

C. yakushimensis (nom. inval.), *C. galli*, *C. deformans*, *C. hollandica* and *C. alimentaria* as closely related species. PCR fingerprinting with primer M13 clearly distinguished this species from its relatives in the *Yarrowia* clade. DNA–DNA reassociation values ranged from 93 to 100% among strains, whereas the mean interspecies values ranged from 15 to 50%.

Ecology: *Candida oslonensis* was isolated from yogurt in Norway.

Biotechnology: Unknown.

Agriculture and food: *Candida oslonensis* is known from yogurt and may be a potential spoilage organism of this dairy product.

Clinical importance: Unknown.

90.197. *Candida ovalis* Kumamoto & Yamamoto (Kumamoto et al. 1986)

Phylogenetic placement: *Ogataea* clade (Figs 53.1, 90.4).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to subglobose, 2.5–4 × 3–5 µm, and occur singly and in pairs.

Dalmau plate culture on corn meal agar: After 14 days at 18°C, pseudohyphae are not present. Aerobic growth is white to cream colored, butyrous, moist, soft and entire.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	+
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	w
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	–
D-Arabinose	s	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: 7 (Kumamoto et al. 1986).

Mol% G + C: 35.8, CBS 7298 (T_m : Kumamoto et al. 1986).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70248.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 7298, isolated from soil, Japan.

Type strain: CBS 7298.

Systematics: A collection of 213 yeast isolates recovered from soil was screened for yeasts capable of assimilating methanol (Kumamoto et al. 1986). Among these, two strains could not be identified and were described as *C. ovalis*. A similarity with *C. globata* was noted, but differences were found in the assimilation of galactose, D-arabinose and methanol. The species belongs to the *Ogataea* methylotroph clade. The closest relative is *C. siathepensis*, described from a soil isolate recovered in Thailand by Limtong et al. (2004).

The species is not readily distinguishable from several close relatives, such as *Ogataea pini*, based on growth responses. As the species possesses a general similarity in growth characteristics to *Candida* species in the *Saccharomycopsis* clade, which are capable of necrotrophic parasitism, it was tested for the ability to transport sulfate and to form infection pegs (Lachance et al. 2000b). Although no predacious activity was observed, the yeast was reported not to grow in the absence of organic sulfur. A reassessment of the type culture indicates that the latter was incorrect, as the strain grows well on glucose-YNB without amino acids.

Ecology: Unknown.

Biotechnology: *Candida ovalis* ferments D-xylose and to a lesser extent L-arabinose, but the yields are somewhat lower than those obtained with the related species, *C. arabinofementans* or *Ogataea (Pichia) trehalophila* (Kurtzman and Dien 1998).

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.198. *Candida pallodes* S.-O. Suh, N.H. Nguyen & M. Blackwell (Suh et al. 2006a)

Phylogenetic placement: *Candida kruisii* clade (Fig. 90.5).

(The description is based on Suh et al. 2006a.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, smooth, shiny, butyrous and flat.

Growth in YM broth: After 7 days at 25°C, cells are globose to fusiform, 2–7 × 2–7 μm, mostly ellipsoidal, occur singly, in pairs, in short chains or in clusters and pseudohyphae and hyphae may be present.

Dalmai plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae with blastoconidia are present. Aerobic growth is white to off-white, glistening and smooth.

Fermentation

Glucose	+	Lactose	–
Galactose	d/w	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	d/w		

Growth (in Liquid Media)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	+	Ethanol	v
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–

Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+/d
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D-Lactate	v
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+/d
L-Sorbose	–	D-Glucosamine	+/d
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	d/w	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+/d	Ethylamine	+
2-Keto-D-gluconate	+	50% Glucose	v
D-Glucuronate	–	10% NaCl/5% glucose	+/d/w
L-Arabinitol	–	Starch formation	–
Arbutin	+	Urease	–
Propane 1,2 diol	v	DBB	–
Butane 2,3 diol	–	Cycloheximide 0.01%	–
Nitrite	–	Growth at 30°C	+
Cadaverine	+	Growth at 35°C	+
Creatinine	–	Growth at 40°C	–
L-Lysine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY640194, SSU rRNA = AY640179, ITS and 5.8S rRNA = AY640193.

Cell carbohydrates: Not determined.

Origin of the strains studied: NRRL Y-27653 (CBS 9845), isolated from the gut of a sap beetle (*Pallodes pallidus*) on a basidiocarp of a mushroom (*Lactarius* spp.), Herrick Lake Park, Athens, Georgia; 23 other strains isolated from the guts of *P. pallidus* and *Pallodes* sp. occurring on basidiocarps of various Agaricales (namely, *Amanita bisporigera*, *A. brunnescens*, *Lactarius* sp., *Megacollybia platyphylla*, *Nolanea* sp., *Psathyrella* cf. *larga*, *Russula* sp., *Tricholomopsis decora*) and a gastromycete (*Scleroderma* sp.), at various locations in the USA (Herrick Lake Park, Athens, Georgia; St. Catherine's Creek, Mississippi; Baton Rouge, Louisiana; Blount County, Tennessee; Port Hudson and East Feliciana Parish, Louisiana.); Suh et al. (2006a).

Type strain: NRRL Y-27653.

Systematics: Analysis of combined SSU and LSU rRNA gene sequences indicated that *C. pallodes* belongs to the *Candida kruisii* clade, where it forms a well-supported subclade with *C. tritomae*, *C. panamensis* and *C. lycoperdinae* (Suh et al. 2006a).

Ecology: *Candida pallodes* appears widespread in the guts of the sap beetle *Pallodes* spp. occurring on mushrooms in the south-eastern USA (Suh et al. 2006a).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.199. *Candida palmioleophila* Nakase & M. Itoh (Nakase et al. 1988a)

Phylogenetic placement: *Candida glaebosa* clade (Fig. 90.2).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are primarily globose with some that are slightly

ovoid, $1.5\text{--}4 \times 1.5\text{--}5\text{ }\mu\text{m}$, and occur singly, in pairs, short chains and small clusters (Fig. 90.128). A thin pellicle is present which eventually drops to the bottom of the tube.

Dalmau plate culture on corn meal agar: After 14 days at 18°C , poorly developed pseudohyphae consisting of short, branched chains of ovoid cells are present. Aerobic growth is white, butyrous, smooth, soft and with an entire margin.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	+	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	+
Soluble starch	+	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	+
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	v
Nitrite	+	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	s
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: 9 (Nakase et al. 1988a).

Mol% G + C: 39.4, 39.7, CBS 7418 (T_m and HPLC: Nakase et al. 1988a).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45758.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of strains studied: CBS 7418, isolated from soil, Japan; CBS 8346, from sputum, Belgium; CBS 8109 (received as *C. saitoana*), from soil in tropical greenhouse, The Netherlands.

Type strain: CBS 7418.

Systematics: Nakase et al. (1988a) described *C. palmioleophila* to accommodate a strain found to utilize crude palm oil efficiently. They pointed out that the species was similar to *C. famata* and *C. saitoana*, but could be differentiated on the basis of the maximum growth temperature ($41\text{--}42^\circ\text{C}$). DNA reassociation data supported the separation of the three species and further suggested a possible relationship (40%) to *C. parapsilosis*, as did serological analyses. Sequence analyses, however, did not confirm such a relationship

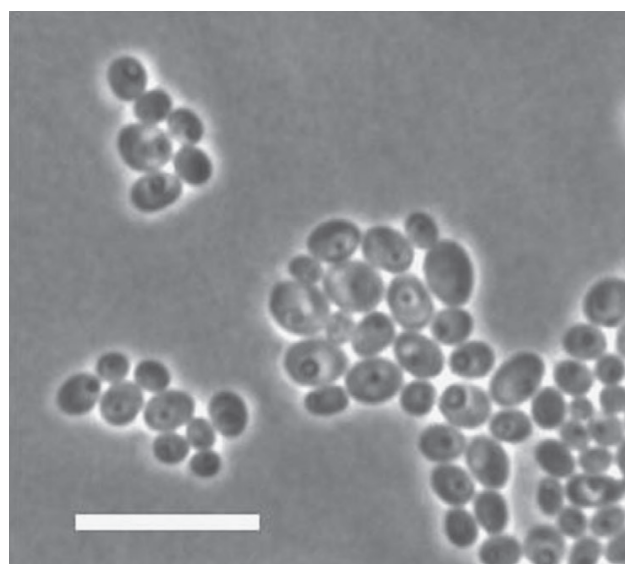


FIGURE 90.128 *Candida palmioleophila* CBS 7418. Budding cells after 3 days, 25°C , YM agar. Bar = $10\text{ }\mu\text{m}$.

(Kurtzman and Robnett 1998a, Sugita and Nakase 1999). *C. palmioleophila* is a sister species to *C. fluvialis* and belongs to a small clade of closely related *Candida* species that includes *C. glabrosa* and exhibits some affinity for the genus *Debaryomyces*.

The species is physiologically similar to other species in the same clade (Fig. 90.2). As assessed by replica plating, both strains exhibited some growth in the presence of 0.01% cycloheximide, and the type grew weakly in the presence of 50% glucose (both reported as negative in the original description). Distinction from *Debaryomyces hansenii* and *C. saitoana* is difficult because of the high variability observed in these two species. The growth characteristics of strain CBS 8109, deposited as *C. saitoana*, were more typical of *C. palmioleophila*. The D1/D2 sequence was determined and found to be identical to that of *C. palmioleophila*. The strain differs from the type strain by the absence of growth on xylitol.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Sugita et al. (1999a) reported the isolation of a strain of *C. palmioleophila* in a clinical specimen and considered the species to be the causative agent of an intravenous catheter-associated fungemia.

90.200. *Candida paludigena* Golubev & Blagodatskaya (Golubev et al. 1981)

Phylogenetic placement: *Sugiyamaella* clade (Figs 72.1, 90.3).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C , the cells are ovoid, $2\text{--}3.5 \times 4\text{--}7\text{ }\mu\text{m}$, and occur singly and in pairs (Fig. 90.129 top). Pseudohyphae may be present.

Dalmau plate culture on corn meal agar: After 14 days at 18°C , well-developed pseudohyphae and septate hyphae are present (Fig. 90.129 bottom). Aerobic growth is white, butyrous, glistening and smooth with a fringed border.

Fermentation

Glucose	s/–	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

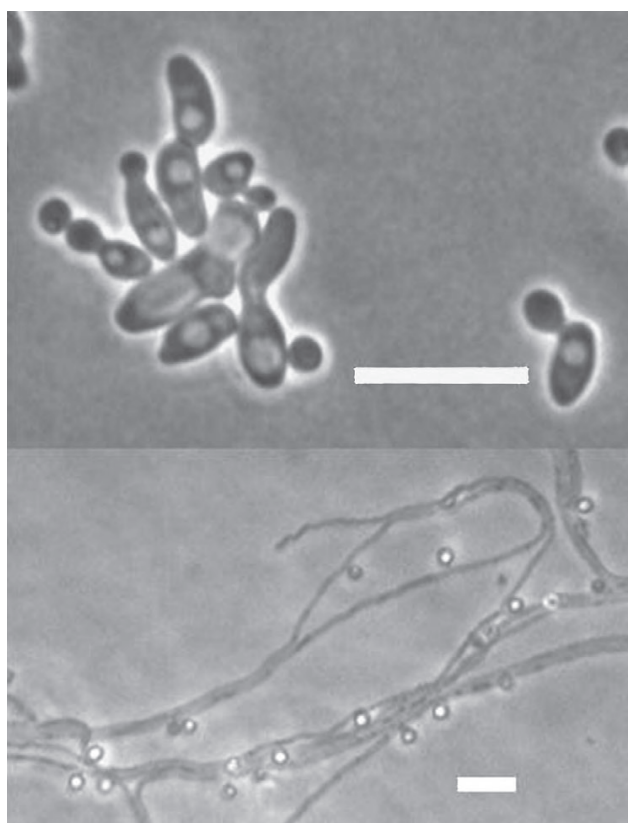


FIGURE 90.129 *Candida paludigena* CBS 8005. Budding cells after 3 days, 25°C, YM agar (top) and hyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 µm.

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	v	Glycerol	—
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	—
Lactose	+	Galactitol	—
Trehalose	+	D-Mannitol	v
Maltose	+	D-Glucitol	—
Melezitose	+	myo-Inositol	+
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	—
L-Arabinose	+	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	+	Gelatin	—
Glucono- δ -lactone	+	Casein	—
Amino acid-free	+	Lipase	—

Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 41.5, CBS 8005 (T_m : S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45826.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 8005, isolated from high-moor peat near Moscow, Russia.

Type strain: CBS 8005.

Systematics: Golubev et al. (1981) described *C. paludigena* on the basis of 15 strains from peat. They noted the formation of single spherical conidia on denticles, and contrasted these features with those of other species, in particular some that were later assigned to the *Sugiyamaella* clade by Kurtzman and Robnett (2007). Although *C. paludigena* and *C. castrensis* differ by only one substitution in the D1/D2 domains of the LSU rRNA gene, the two are reported to differ by 40 substitutions and 4 indels in the SSU rRNA gene (Suzuki et al. 1999), which would argue against synonymy. Significant differences in growth characteristics also exist. The two species belong to the *Sugiyamaella* clade (Kurtzman and Robnett 2007).

The combination of growth responses of *C. paludigena* is unique and can be used for identification, as few ascomycetous species combine growth on myo-inositol and high cycloheximide resistance with the absence of growth on D-mannitol. The utilization of organic acids is particularly strong.

Ecology: According to the original description (Golubev et al. 1981), *C. paludigena* is the predominant species found in high-moor peat in the Moscow region. The optimum growth pH of 4 and the low (1%) tolerance to salt were regarded as potentially important in defining the niche of the species. The high-moor peat has a low pH and a low ash concentration.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.201. *Candida panamensis* S.-O. Suh, N.H. Nguyen & M. Blackwell (Suh et al. 2006a)

Phylogenetic placement: *Candida kruisii* clade (Fig. 90.5).

(The description is based on Suh et al. 2006a.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, butyrous and have a membranous margin.

Growth in YM broth: After 7 days at 25°C, cells are ellipsoidal to fusiform, 2–5 $\times$ 4–9 µm, mostly ellipsoidal, occur singly, in pairs, in short chains or in clusters, and pseudohyphae are present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae are present. Aerobic growth is off-white, shiny, smooth and with a filamentous margin.

Fermentation

Glucose	+	Lactose	—
Galactose	d/w	Raffinose	—
Sucrose	—	Trehalose	+
Maltose	—		

Growth (in Liquid Media)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+/d
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	d
L-Sorbose	—	D-Glucosamine	w
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	d/w	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Ethylamine	+/w
2-Keto-D-gluconate	+	50% Glucose	+/w
D-Glucuronate	—	10% NaCl/5% glucose	v
L-Arabinitol	—	Starch formation	—
Arbutin	+	Urease	—
Propane 1,2 diol	—	DBB	—
Butane 2,3 diol	—	Cycloheximide 0.01%	—
Nitrite	—	Cycloheximide 0.1%	—
Cadaverine	+/d	Growth at 30°C	+
Creatinine	—	Growth at 35°C	—
L-Lysine	+/w		

CoQ: Not determined.**Mol% G + C:** Not determined.**Gene sequence accession numbers, type strain:** D1/D2 LSU rRNA = AY520362, SSU rRNA = AY520233, ITS and 5.8 S rRNA = AY640197.**Cell carbohydrates:** Not determined.**Origin of the strains studied:** NRRL Y-27657 (CBS 9849) was isolated from gut of an unidentified nitidulid beetle on a fruiting body of earthstar (*Gaeastrum* sp.), Barro Colorado Island, Panama; three other isolates from nitidulid, tenebrionid and curculionid beetles, all at Barro Colorado Island, Panama (Suh et al. 2006a).**Type strain:** NRRL Y-27657.**Systematics:** Analysis of combined SSU and D1/D2 LSU rRNA gene sequences indicated that *C. panamensis* belongs to the *Candida kruisii* clade, where it forms a well-supported subclade with *C. tritomae*, *C. pallodes* and *C. lycoperdinae* (Suh et al. 2006a).**Ecology:** *Candida panamensis* is known from the gut of a mushroom-inhabiting beetle in Panama (Suh et al. 2006a).**Biotechnology:** Unknown.**Agriculture and food:** Unknown.**Clinical importance:** Unknown.**90.202. *Candida panamericana* S.-O. Suh & M. Blackwell (Suh et al. 2004b)****Phylogenetic placement:** *Candida tanzawaensis* clade (Fig. 90.5). (The description is based on Suh et al. 2004b.)**Growth on YM agar:** After 7 days at 25°C, colonies are white to off-white, smooth, glistening, flat and with a filamentous margin.**Growth in YM broth:** After 7 days at 25°C, cells are globose to ovoid, 3–6.25 $\times$ 3.75–7 μ m, mostly subglobose, occur singly, in pairs, in short chains or in clusters, and pseudohyphae are present.**Dalmau plate culture on corn meal agar:** After 10 days at 25°C, pseudohyphae are present and hyphae may be present. Aerobic growth is white, shiny and smooth with a filamentous margin.**Fermentation**

Glucose	+	Lactose	—
Galactose	d	Raffinose	—
Sucrose	—	Trehalose	+
Maltose	—		

Growth (in Liquid Media)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	—
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	n	D-Glucosamine	+/d
L-Rhamnose	n	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	v

Additional Growth Tests and Other Characteristics

Xylitol	—	50% Glucose	+
2-Keto-D-gluconate	+	10% NaCl/5% glucose	+
D-Glucuronate	—	Starch formation	—
Arbutin	+/d	Urease	—
Propane 1,2 diol	—	DBB	—
Butane 2,3 diol	—	Cycloheximide 0.01%	—
Nitrite	—	Cycloheximide 0.1%	—
Cadaverine	+	Growth at 25°C	+
Creatinine	—	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	+/d
Ethylamine	+	Growth at 40°C	—

CoQ: Not determined.**Mol% G + C:** Not determined.**Gene sequence accession numbers, type strain:** D1/D2 LSU rRNA = AY24273, SSU rRNA = AY242164.**Cell carbohydrates:** Not determined.**Origin of the strains studied:** NRRL Y-27567 (CBS 9834), isolated from the gut of a beetle (*Mycotretus interstitialis*, Erotylidae) on an imbricate basidiocarp, Barro Colorado Island, Panama; NRRL Y-27582, from an unidentified staphylinid beetle (Staphylinidae) on an imbricate basidiocarp, Barro Colorado island, Panama; NRRL Y-27590, from the gut of a beetle (*Bolitotherus cornutus*, Tenebrionidae) on the basidiocarp of *Ganoderma* sp., Baton Rouge, Louisiana, USA (Suh et al. 2004b).**Type strain:** NRRL Y-27567.

Systematics: An analysis of combined sequences of the D1/D2 LSU and SSU rRNA genes placed *C. panamericana* in the *Candida tanzawaensis* clade with *C. atakporum* as closest relative (Suh et al. 2004b).

Ecology: *Candida panamericana* is known from the guts of basidiocarp-feeding beetles in Panama and the south-eastern USA (Suh et al. 2004b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.203. *Candida parapsilosis* (Ashford) Langeron & Talice (1932)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Fig. 90.5).

Synonyms:

Monilia parapsilosis Ashford (1928)

Mycocandida parapsilosis (Ashford) Dodge (1935)

Mycotorula vesica Harrison (1928)

Blastodendron globosum Zach (Wolfram and Zach 1934a)

Schizoblastosporion globosum (Zach) Dodge (1935)

Blastodendron gracile Zach (Wolfram and Zach 1934a)

Schizoblastosporion gracile (Zach) Dodge (1935)

Blastodendron intestinale Mattlet var. *epidermicum* Ciferri & Alfonseca (1931)

Castellania epidermica (Ciferri & Alfonseca) Dodge (1935)

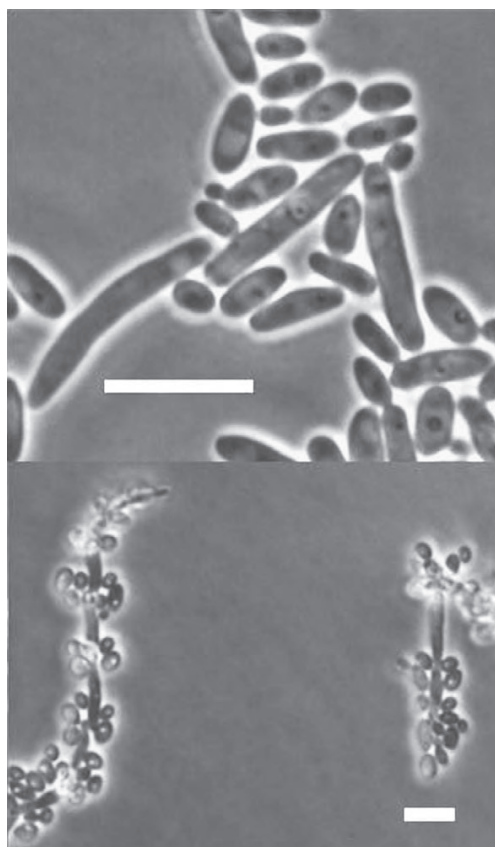


FIGURE 90.130 *Candida parapsilosis* CBS 604. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae with blastoconidia after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 µm.

Mycotoruloides unguis (Emile-Weil & Gaudin) Langeron & Talice (1932)

Saccharomyces vossii Dietrichson (1954)

Zymopichia vossii (Dietrichson) Novák & Zsolt (1961)

Candida parapsilosis (Ashford) Langeron & Talice var. *intermedia* van Rij & Verona (1949)

Brettanomyces petrophilum Takeda, Iguchi, Tsuzuki & Nakano (1972)

Torulopsis larvae Kawano, Kojima, Obosawa & Morinaga (1976) nom. inval.

Candida osornensis C. Ramírez & A. González (1984f)¹

¹ Synonymy based on DNA–DNA reassociation experiments (Roy and Meyer 1998).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, 3–4 × 5–8 µm, and occur singly and in pairs (Fig. 90.130 top). Cylindrical cells up to 20 µm long, as well as pseudohyphae, may be present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of cylindrical cells with clusters or chains of blastoconidia (Fig. 90.130 bottom). Aerobic growth is white, butyrous, soft, smooth and with an entire margin.

Fermentation

Glucose	+	Lactose	–
Galactose	v	Raffinose	–
Sucrose	–/s	Trehalose	–/s
Maltose	–/s		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	v
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	v
L-Sorbose	v	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	s
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	v
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	+

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 40.0, CBS 604 (T_m : Meyer and Phaff 1969); 40.5, CBS 604 (T_m : Meyer and Phaff 1972); 40.8, CBS 604 (T_m : Stenderup and Bak 1968); 40.5, CBS 6318 (T_m : S.A. Meyer, unpublished data); 39.3–40.0, six strains (T_m : Nakase and Komagata 1971f); 40.5–41.7, eight strains (T_m : Su and Meyer 1991).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45754.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 604, isolated from sprue (clinical), Puerto Rico; CBS 617 (received as *C. sake*), from lambic beer, Belgium; CBS 1954, type of *C. parapsilosis* var. *intermedia*, from olive, Italy; A 255, from seawater, Portugal; UWOPS 79-141 and five others, from black knot (*Dibotryon morbosum*, Venturaceae) on apple (*Malus pumila*, Rosaceae), Ontario, Canada; UWOPS 01-213.2, frass of *Myscelus belti* caterpillar (Lepidoptera: Hesperidae) feeding on leaves of a neotropical tree (*Guarea glabra*, Meliaceae), Costa Rica.

Other strains available: CBS 2194, type of *Blastodendron globosum*, from nail, Austria; CBS 2196, type of *Blastodendron intestinale* var. *epidermicum*, from skin; CBS 2197, type of *Mycotorula vesica*, from bladder, Denmark; CBS 2211, received as *Mycotoruloides unguis*, from toenail, Java; CBS 2215, CBS 2216, received as *Candida krusoides*, from pickled cucumber brine; CBS 2915, type of *Saccharomyces vossii*, from exanthematous skin, Norway; CBS 6318, from healthy skin; CBS 8050, origin unknown; CBS 8181, type of *C. osornensis*, from rotten trunk of southern beech (*Nothofagus dombeyi*, Fagaceae), Chile.

Type strain: CBS 604.

Systematics: Meyer and Phaff (1972) reported a low degree of DNA relatedness between the type strains of *C. parapsilosis* and *Lodderomyces elongisporus*, which did not support a proposed anamorphic/teleomorphic relationship of these species. Nakase et al. (1979) demonstrated the presence of two different forms of *C. parapsilosis* with similar properties in physiology, serology and cell wall mannan structure. Strains designated *C. parapsilosis* form I utilized L-arabinose and included the type strain, whereas strains designated *C. parapsilosis* form II did not utilize the sugar and were considered asexual forms of *Lodderomyces elongisporus*. Yamazaki and Komagata (1982a) compared *C. parapsilosis* forms I and II by isoenzyme electrophoresis and supported the conclusions of Nakase and coworkers. Hamajima et al. (1987) showed by DNA reassociation that the strains designated *C. parapsilosis* form II were indeed asporogenous strains of *Lodderomyces elongisporus*. Lin et al. (1995) identified three (independent) groups based on electrophoretic profiles of several enzymes as well as the nucleotide sequences of the ITS1. These groups were confirmed by RFLP analysis and DNA reassociation (Roy and Meyer 1998) and *C. osornensis* was shown to exhibit 100% DNA reassociation with the type strain of *C. parapsilosis*. Strains within each group gave reassociation values of 95% or more and between-group values were 25% or less. Daniel (2002) found that representatives of the three groups have similar amino acid sequences for actin, but she was able to distinguish them on the basis of the DNA sequences of the gene. According to her results, the groups represent sister taxa related to *Lodderomyces elongisporus*, but distinct from that species. The same conclusion could be drawn from LSU rRNA gene sequences, which differ by four to six substitutions between groups, and by 13 to 18 substitutions from *Lodderomyces elongisporus*. The matter was finalized by Tavanti et al. (2005a), who studied several strains of the three groups by multi-gene analysis. They found clear support for recognizing the three groups as distinct genetic populations, and described the new species *C. orthopsilosis* and *C. metapsilosis* to recognize groups II and III, respectively, as distinct species. The proposed diagnosis of the species is based on nucleotides present at certain positions in the genes selected in their studies, which regrettably do not include genes that are commonly

used in yeast systematics. Nonetheless, based on the correspondence between the former groups and the newly described species, it is possible to use rRNA genes to that effect. The small clade centered around *C. parapsilosis* is expected to grow as more ecological investigations are conducted. Rao et al. (2007) added one more species named *C. hyderabadensis* based on a grape isolate.

Candida parapsilosis is generally similar to other species in the *Lodderomyces* clade but can usually be distinguished by growth on L-arabinose (positive) and erythritol (negative), among other tests. Differentiation of the recently described relatives may be more problematic. Lin et al. (1995) reported differences in the assimilation of xylitol in strains reassigned to *C. metapsilosis* and Rao et al. (2007) reported variation in osmotolerance and in the assimilation of a few carbon compounds when *C. hyderabadensis* and *C. parapsilosis* (*sensu stricto*) were compared.

Ecology: The ecology of *C. parapsilosis* is poorly understood. The species has been recovered sporadically from a variety of substrates and localities. The identity of a single isolate recovered as part of a large survey of yeasts in seawater south of Portugal (Gadanhao et al. 2003) was confirmed by sequencing.

Biotechnology: Komagata et al. (1964a) screened several hundred yeast strains for the ability to utilize kerosene. Of these, 26 of 29 strains assigned to *C. parapsilosis* grew on that substrate. One strain was studied further and found to assimilate a broad array of alkanes. Particularly noteworthy was the utilization of *n*-octane, a capability that appears to be unique to the species (*sensu lato*).

Agriculture and food: Suzzi et al. (2003) reported the isolation of *C. parapsilosis* as a dominant species in Manteca, a buttery whey cheese produced in southern Italy. However, as identification was based on physiological test strips and considerable variation was found in cycloheximide resistance and maximum growth temperature, not all of the 33 strains in question may have been correctly assigned to the species.

Clinical importance: *Candida parapsilosis* is frequently isolated from clinical specimens of all sorts (Lin et al. 1995) and is considered by some to be the second most important opportunistic pathogenic yeast, after *C. albicans*. In particular, the species is emerging as an important source of infection in patients undergoing corneal surgery (Bourcier et al. 2003). Gácsér et al. (2007) examined some of the factors that may affect virulence in *C. parapsilosis*. In particular, they were able to show that the reversible deletion of the lipase locus caused an increase in susceptibility to phagocytosis by macrophages and a reduction in the damage caused to human or murine epithelial tissue.

Additional comments: In a study to clarify the distinction between *C. rhagii* and *C. parapsilosis*, Camougrand et al. (1991) compared several strains for certain biochemical properties, including resistance to antibiotics that affect mitochondrial function. With glycerol as the carbon source, *C. parapsilosis* was found capable of growth in the presence of high concentrations (4–5 g/l) of chloramphenicol and erythromycin, as well as other inhibitors of mitochondrial function. This observation was contrasted with the strong inhibition of certain other species, *C. rhagii* being the most sensitive. Recognition of these two taxa was of importance, as a strain originally identified as *C. rhagii*, but in fact a strain of *C. parapsilosis*, was found to possess a linear, and not a circular mitochondrial DNA.

90.204. *Candida pararugosa* Nakase, Komagata & Fukazawa (1978)

Phylogenetic placement: *Wickerhamiella* clade (Fig. 79.1).

Synonym:

Cryptococcus aggregatus Anderson (1917)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are cylindrical, 1.5–3 × 6–23 µm, and occur singly, in

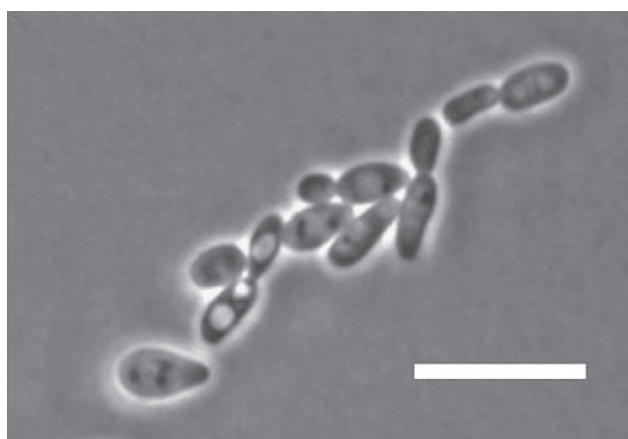


FIGURE 90.131 *Candida pararugosa* CBS 1010. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

pairs and short chains (Fig. 90.131). A white, creeping pellicle composed of tiny, spherical islands like styrofoam discs covers the entire surface. After 1 month the pellicle is complete, folded, rough and thick.

Dalmau plate culture on corn meal agar: After 14 days at 18°C, abundant pseudohyphae occur that consist of long, branched chains of cylindrical cells. Aerobic growth is white, raised and wrinkled to rough with a filamentous border.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	v
Maltose	—	D-Glucitol	v
Melezitose	—	myo-Inositol	—
Methyl-α-D-glucoside	—	D,L-Lactate	s
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	—
Salicin	—	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	v	Hexadecane	—
L-Arabinose	v	Nitrate	—
D-Arabinose	v	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono-δ-lactone	—	Casein	—
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	v

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 48.3, AJ 4645 (CBS 1010) (T_m : Nakase and Komagata 1971f; T_m : Nakase et al. 1978).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U62306.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 1010, isolated from human feces, received by CBS as *Cryptococcus aggregatus*; CBS 2275 (labeled *C. rugosa*), from rancid butter, The Netherlands; CBS 5849, from intestine of a gecko (*Anatolis bartchi*); UWOPS 92-257.4, UWOPS 94-247.4 and others from crushed agave must, and UWOPS 92-323.4, from a *Drosophila* in a tequila distillery, Mexico.

Type strain: CBS 1010.

Systematics: Nakase et al. (1978) separated from *C. rugosa* a strain found to differ in DNA base composition and serology. Galactose was found in the wall mannopolysaccharide and growth occurred at 37 but not 42°C. Utilization of L-sorbose and L-arabinose, and lack of growth on glycerol were also unique to the strain. *C. pararugosa* occupies a basal position with respect to *C. azyma*, *C. drosophilae*, *C. vanderwaltii* and various *Wickerhamiella* species frequently isolated in association with floricolous insects (Fig. 79.1). Strain CBS 2275, deposited as *C. rugosa*, keyed physiologically to *C. pararugosa*. The D1/D2 sequence (AY536215) was found to differ from that of the type of *C. pararugosa* by five substitutions, and the strain may or may not be conspecific. As the species is phylogenetically unique and the rate of sequence divergence in the *Wickerhamiella* clade appears unusually high, the strain is tentatively included in the species.

A high amount of variation in growth characteristics was observed among the strains studied, in spite of the oligophagic nature of the species. Identification based on these criteria is not practical.

Ecology: According to the CBS database, strain CBS 5849 supports the growth of a flagellate protozoan present in the gut isolated from the gecko that was the source of this isolate.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.205. *Candida pattaniensis* Jindamorakot, Duy & Nakase (Jindamorakot et al. 2004)

Phylogenetic placement: *Wickerhamomyces* clade (Fig. 90.4).

(The description is based on Jindamorakot et al. 2004.)

Growth on YM agar: After 1 month at 20°C, the streak culture is grayish-white, smooth, shining, soft and has an entire to ciliate margin.

Growth in YM broth: After 3 days at 25°C, the cells are short ovoid to ovoid, ellipsoidal to long ellipsoidal, sausage-shaped, 1.5–4.5 × 3–10 μm, and occur singly or in pairs.

Growth on the surface of YM broth: After 3 days at 25°C, a trace of a ring and sediment are present. After 1 month at 20°C, a trace of a ring and sediment are present.

Dalmau plate culture on potato dextrose agar: Well-developed, usually tree-like branched pseudohyphae are abundantly produced.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	+	Trehalose	n
Maltose	—		

Growth (in Liquid Media)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	+
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+/w
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	+	N-Acetyl-D-glucosamine	—
D-Xylose	+	Hexadecane	—
L-Arabinose	+/w	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	10% NaCl/5% glucose	—
2-Keto-D-gluconate	—	Starch formation	—
5-Keto-D-gluconate	—	Urease	—
D-Glucuronate	—	DBB	—
Saccharate	—	Gelatin liquefaction	—
L-Arabinitol	w	Cycloheximide 0.1%	—
Propane 1,2 diol	+/w	Growth at 19°C	+
Butane 2,3 diol	—	Growth at 25°C	+
Nitrite	—	Growth at 30°C	+
Cadaverine	+	Growth at 35°C	+
L-Lysine	+	Growth at 37°C	—
Ethylamine	+		

CoQ: 7 (Jindamorakot et al. 2004).

Mol% G + C: 43.2 (ST-311), 43.9 (ST-320) (HPLC: Jindamorakot et al. 2004).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY634568.

Cell carbohydrates: Not determined.

Origin of the strains studied: ST-311 (BCC 11790, JCM 12475, TISTR 5827), isolated from insect frass collected in Kao-Yaow, Pattani Province, southern Thailand; ST-320 (BCC 11799), from insect frass, Thailand (Jindamorakot et al. 2004).

Type strain: ST-311.

Systematics: D1/D2 sequence analysis suggests that *C. pattaniensis* forms a basal lineage to *Lindnera mississippiensis*, *L. amylophila* and *L. veronae* (Jindamorakot et al. 2004).

Ecology: *Candida pattaniensis* is known from insect frass in Thailand (Jindamorakot et al. 2004).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.206. *Candida peltata* (Yarrow) S.A. Meyer & Ahearn (1983)

Phylogenetic placement: *Nakazawaea* clade (Figs 57.1, 90.4).

Synonyms:

Torulopsis peltata Yarrow (1968)

Selenotila peltata (Yarrow) Yarrow (1969b)

Selenozyma peltata (Yarrow) Yarrow (von Arx et al. 1977)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to lunate, 2–3.5 $\times$ 3–5 μ m, singly and in pairs. A pellicle may be present.

Dalmeu plate culture on corn meal agar: After 14 days at 18°C, pseudohyphae are not present. Aerobic growth is white to cream colored, butyrous, smooth and with an entire margin.

Fermentation

Glucose	+	Lactose	—
Galactose	s	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	v
Galactose	+	Ribitol	+
Lactose	—	Galactitol	v
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	s
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	—
L-Arabinose	+	Nitrate	—
D-Arabinose	+	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	+

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U71066.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5564, non-mucoid variant of CBS 5576; CBS 5576, isolated from mastitis milk, UK; CBS 5661 (received as *C. sake*), from sauerkraut, The Netherlands.

Type strain: CBS 5576.

Systematics: Yarrow (1968) described *Torulopsis peltata* from an isolate found in a case of mastitis. The culture segregated into two colony types, one mucoid and one dry. Both were found to produce an extracellular phosphomannan suggesting a relationship with certain

species then assigned to *Hansenula*, but were unusual in the formation of lunate cells. *C. peltata* occupies a basal position with respect to a group of species related to the ascosporic genus *Nakazawaea* (Kurtzman and Robnett 1998a, Suzuki and Nakase 2002). The exact placement varies slightly according to which species are included in the analyses. Strain CBS 5661, received as *C. sake*, gave atypical physiological results and was identified by D1/D2 LSU rRNA gene sequencing as *C. peltata*.

The growth characteristics evaluated by replica plating differed slightly from those given by Meyer et al. (1998). The strains grew well on ethanol (reported as variable in the original description, but did not utilize glucono- δ -lactone. *C. peltata* resembles the related species *Nakazawaea holstii* but the latter utilizes nitrate as a source of nitrogen. A similarity with *C. tenuis*, which is distantly related, is also evident, but the latter utilizes 2-keto-D-gluconic acid and fails to grow at 37°C.

Ecology: Unknown.

Biotechnology: Saha and Bothast (1996) showed that a β -glucosidase produced by *C. peltata* can act synergistically with purified cellulase in the degradation of cellulose. The enzyme was particularly impervious to product inhibition by glucose. In a later paper (1999), the same authors found the species to be an efficient producer of xylitol, a substance used increasingly as an artificial sweetener.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.207. *Candida peoriensis* Kurtzman (2001a)

Phylogenetic placement: *Wickerhamomyces* clade (Figs 90.4, 80.1). (Some of the morphological and physiological characteristics are taken from Kurtzman 2001a.)

Growth on 5% malt extract agar: After 3 days at 25°C, the cells are generally spherical, 2–6 μ m, rarely short ovoid and occur singly, in pairs or in small clusters (Fig. 90.132). Budding is multilateral with 1–5 buds occurring per cell. Growth is tannish-white, glistening and butyrous.

Growth in glucose–yeast extract broth: A thin pellicle is formed.

Dalmau plate culture on morphology agar: After 7 days at 25°C, growth under the coverglass is restricted and devoid of pseudohyphae or true hyphae. Aerobic growth is white, low convex, smooth,

dull to glistening, butyrous and with an irregular to finely denticulate margin.

Fermentation

Glucose	w	Lactose	–
Galactose	–	Raffinose	–
Sucrose	w	Trehalose	w
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	D-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	+	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	+
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	w	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	w	Casein	–
Amino acid-free	+	Lipase	s
Nitrite	+	Acid production	–
Ethylamine	–	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF271084.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 8800 (NRRL YB-1497), isolated from stump of elm (*Ulmus* sp., Ulmaceae), Illinois.

Type strain: CBS 8800.

Systematics: *Candida peoriensis* (orthography corrected from the original epithet *peoriaensis*) was described to accommodate an isolate recovered from the stump of an elm (Kurtzman 2001a). Multi-gene sequence analysis (Kurtzman et al. 2008) placed the species in the *Wickerhamomyces* clade. The growth characteristics of the species form a unique combination that can serve for identification.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

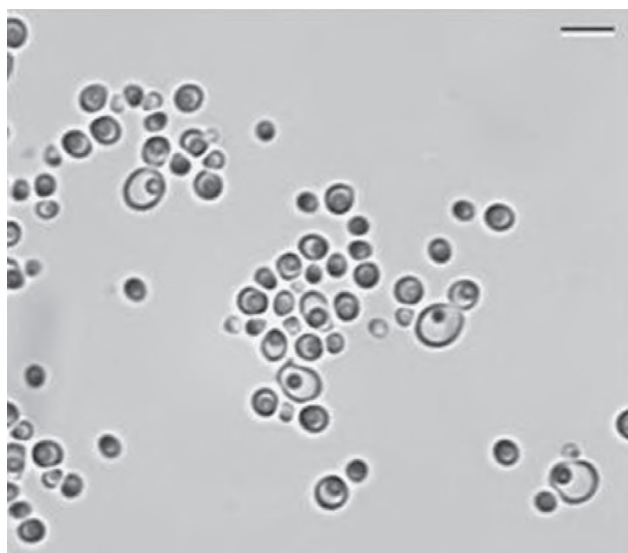


FIGURE 90.132 *Candida peoriensis* NRRL YB-1497. Budding cells after 3 days, 25°C, 5% malt extract agar. Bar = 5 μ m.

90.208. *Candida petrohuensis* C. Ramírez & A. González (1984h)

Phylogenetic placement: *Sugiyamaella* clade (Fig. 90.3).

Synonyms:

Candida ancudensis (C. Ramírez & A. González (1984i))¹

Candida drimydis (C. Ramírez & A. González (1984j))¹

¹ Synonymy based on identical sequences of the D1/D2 domains of the LSU rRNA gene (Kurtzman and Robnett 1998a).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose, ovoid to elongate, 3–6 × 5–8 μm, and occur singly or in pairs (Fig. 90.133 top). After 1 month a ring and a thin pellicle may be present.

Dalmat plate culture on corn meal agar: After 14 days at 25°C, short, dense chains of ovoid cells or poorly developed pseudohyphae may be present (Fig. 90.133 bottom). Aerobic growth is white to cream colored, butyrous to waxy, smooth, soft and with an entire or undulating margin.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	s
Lactose	–	Galactitol	–
Trehalose	v	D-Mannitol	s
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	s	DL-Lactate	v
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	v
Salicin	v	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	v	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	s	Gelatin	–
Glucono-δ-lactone	–	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	–
50% Glucose	–	Growth at 37°C	–

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 46.1, CBS 8173 (*T_m*: Tengku Zainal Mulok 1988); 42.0, CBS 8184 (*T_m*: O'Neill and S.A. Meyer, unpublished data); 43.4, CBS 8185 (*T_m*: Tengku Zainal Mulok 1988).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45819.

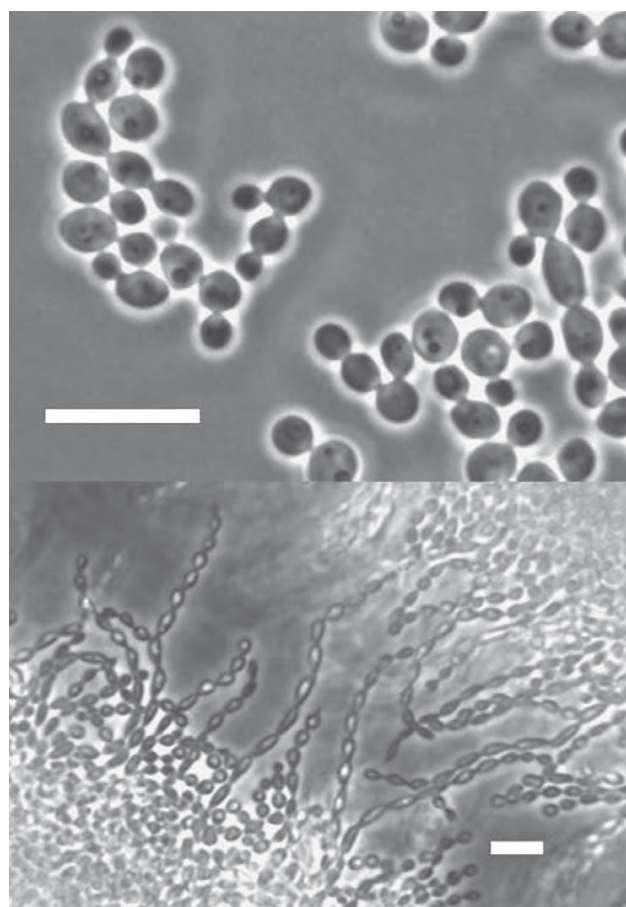


FIGURE 90.133 *Candida petrohuensis* CBS 8173. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μm.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 8173, isolated from rotten trunk of Southern beech (*Nothofagus dombeyi*, Fagaceae); CBS 8184, type strain of *C. ancudensis* and CBS 8185, type strain of *C. drimydis*, from rotten trunk of winter's bark (*Drimys winteri*, Winteraceae), all from Chile.

Type strain: CBS 8173.

Systematics: *Candida petrohuensis* was described by Ramírez and González (1984h) to accommodate isolates obtained from a large collection of yeasts isolated from rotting wood in the Valdivian rainforest of Chile. The isolates differed in physiology from other known species. *C. ancudensis* and *C. drimydis* (correct orthography *drimydis*) were described by the same authors (1984i, j) from similar sources. The authors noted, in *C. drimydis*, the formation of protuberances reminiscent of conjugation tubes, a characteristic shared with *C. santjacobensis*. Kurtzman and Robnett (1998a) found *C. petrohuensis*, *C. ancudensis* and *C. drimydis* to have identical sequences in D1/D2 LSU rRNA gene, suggesting that they might be conspecific. The types exhibit a number of differences in SSU rRNA gene sequences (Suzuki et al. 1999), and intermingle with *C. tepae* and synonyms when analyzed by conventional tree construction. However, a split decomposition analysis (Huson and Bryant 2006) of SSU sequences conducted in this study suggested that the three species form a cohesive clade that is distinct from *C. tepae* and synonyms. To clarify these relationships,

the more sensitive ITS rDNA sequences were determined. *C. petrohuensis* (AY585213) was identical to *C. ancudensis* and *C. drimydis*, but distinct (26 substitutions and 26 gapped positions) from *C. tepae* (AY569004) and synonyms. A multi-gene analysis (Kurtzman and Robnett 2007) positioned the species in a basal position relative to clades that include notably the ascosporic genera *Zygoascus* and *Trichomonascus*.

The growth characteristics of *C. petrohuensis* and synonyms are similar. According to previous descriptions, growth on *N*-acetyl-D-glucosamine can be used to separate *C. drimydis*, but a positive response was obtained by replica plating for all strains examined. The assimilation of L-sorbose and succinic acid as carbon sources or ethylamine, L-lysine and cadaverine as nitrogen sources, and the absence of growth on *myo*-inositol and at 30°C can be useful to distinguish the species from others, including *C. tepae*.

Ecology: The recovery of three biotypes that were previously thought to represent different species all from rotten forest wood, suggests a possible association with some components of that micro-ecosystem.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.209. *Candida picachoensis* S.-O. Suh, Gibson & M. Blackwell (Suh et al. 2004a)

Phylogenetic placement: *Metschnikowia* clade (Fig. 46.1).

(The description is based on Suh et al. 2004a.)

Growth on YM agar: After 7 days at 25°C, colonies are white, viscous and smooth on the surface.

Growth in YM broth: After 7 days at 25°C, yeast cells are globose with a thick cell wall, 5–10 × 5–10 μm, occur mostly singly or in pairs (Fig. 90.134) and pseudohyphae are not present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and true hyphae are absent. Aerobic growth is white to cream and somewhat transparent.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

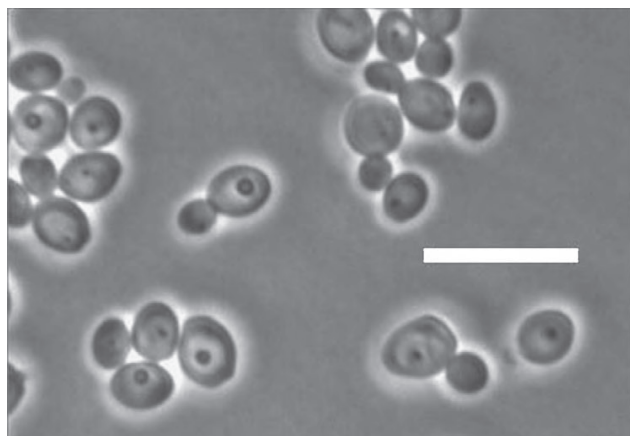


FIGURE 90.134 *Candida picachoensis* NRRL Y-27615. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Growth (in Liquid Media)

Glucose	+	D-Ribose	d/w
Inulin	–	Methanol	–
Sucrose	+	Ethanol	–
Raffinose	–	Glycerol	w
Melibiose	–	Erythritol	–
Galactose	+/d	Ribitol	w
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	d
Maltose	+	D-Glucitol	+/d
Melezitose	+/d	myo-Inositol	–
Methyl-α-D-glucoside	+/d	D-Lactate	–
Soluble starch	–	Succinate	w
Cellobiose	–	Citrate	v
Salicin	w	D-Gluconate	w
L-Sorbose	–	D-Glucosamine	d/w
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	–	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	w	L-Lysine	–
2-Keto-D-gluconate	–	Ethylamine	d/w
D-Glucuronate	–	50% Glucose	+
L-Arabinitol	–	10% NaCl/5% glucose	–
Arbutin	w	Starch formation	–
Propane 1,2 diol	–	Urease	–
Butane 2,3 diol	–	Cycloheximide 0.01%	–
Nitrite	–	Cycloheximide 0.1%	–
Cadaverine	+	Growth at 30°C	+
Creatinine	–	Growth at 35°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY452039.

Cell carbohydrates: Not determined.

Origin of the strains studied: NRRL Y-27607 (CBS 9804), isolated from adult lacewing (*Chrysoperla* sp., Chrysopidae), Picacho Peak, Arizona, USA; NRRL Y-27608, NRRL Y-27609, NRRL Y-27610, isolated from adult *Chrysoperla* sp., Tucson and Picacho Peak, Arizona, USA; NRRL Y-27611, NRRL Y-27612, from male Comanche lacewing (*Chrysoperla comanche*), Tucson, Arizona, USA (Suh et al. 2004a).

Type strain: NRRL Y-27607.

Systematics: Phylogenetic analysis of the D1/D2 domains of the LSU rRNA gene placed *C. picachoensis* in the *Metschnikowia* clade with *C. pimensis* as closest relative. *Metschnikowia chrysoperlae*, *M. pulcherrima* and *M. fructicola* are closely related teleomorph species (Suh et al. 2004a).

Ecology: *Candida picachoensis* is known from lacewings in Arizona, USA (Suh et al. 2004a).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.210. *Candida piceae* Kurtzman (2000b)

Phylogenetic placement: *Ogataea* clade (Figs 53.1, 90.4).

(Some morphological characteristics are taken from Kurtzman 2000b.)

Growth on 5% malt agar: After 3 days at 25°C, the cells are spherical, 2–7 μm, to ellipsoidal or elongate, 1.5–6 × 2–7 μm, and occur singly and in pairs (Fig. 90.135A). Budding is multilateral. Growth is

tannish-white, glistening and mucoid. Older cultures (3–5 weeks) that have been incubated at 15°C show a small number of elongated cells that develop terminal clusters of short, sometimes branched, tubules (Fig. 90.135B).

Growth on the surface of assimilation media: Pellicles are not formed.

Dalmay plate culture on corn meal agar: After 7 days at 25°C, sparingly branched pseudohyphae with few blastoconidia are formed under the coverglass (Fig. 90.135C), but true hyphae are not present. Aerobic growth is tannish-white, glistening, butyrous, low convex with a slightly depressed center and with margins that may be entire or lobed.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	v	Methanol	+
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	v	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	v
Cellulobiose	+	Citrate	–
Salicin	+	D-Gluconate	–
L-Sorbose	v	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	v
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF153672.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 8701 (NRRL YB-2107), isolated from insect frass in Sitka spruce (*Picea sitchensis*, Pinaceae), Alaska, USA; CBS 8702 (NRRL YB-2525), from insect frass, *Picea* sp., Ontario, Canada.

Type strain: CBS 8701.

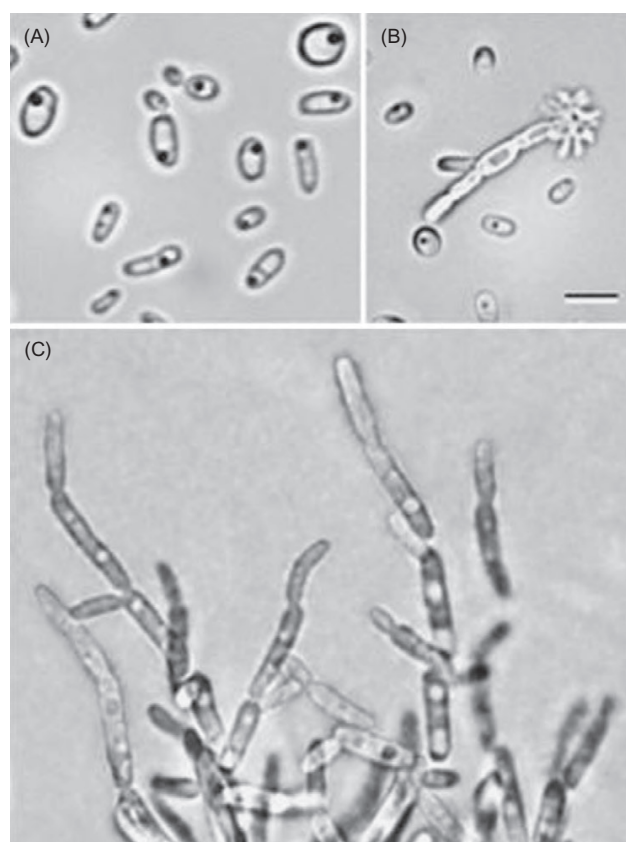


FIGURE 90.135 *Candida piceae* NRRL YB-2107, budding cells after 3 days, 25°C, 5% malt extract agar (A); NRRL YB-2148, "medusa head" outgrowths from the tip of an elongated cell, after 5 weeks, 15°C, 5% malt extract agar (B); NRRL YB-2107, pseudohyphae after 7 days, 25°C, yeast morphology agar (C). Bar = 5 µm.

Systematics: Kurtzman (2000b) described *C. piceae* from several strains isolated mostly from insect frass in spruce trees. The species was defined primarily on the basis of sequence divergence in the D1/D2 LSU rRNA gene. The phylogenetic analysis presented in the original description placed the species in the methylotrophic *Ogataea* clade.

The growth responses of *C. piceae* are similar to those of other methylotrophic yeasts. However, the species can be identified on the basis of the assimilation of trehalose (positive) and erythritol (negative). At variance with the original description, replica plating did not show the two strains examined to be capable of D-arabinose assimilation.

Ecology: An association with insects that infest the wood of spruce trees is evident.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.211. *Candida picinguabensis* Ruivo, Pagnocca, Lachance & Rosa (Ruivo et al. 2006)

Phylogenetic placement: *Metschnikowia* clade (Figs 46.1, 90.1). (The description is based on Ruivo et al. 2006.)

Growth on YM agar: After 4 days at 25°C, colonies are cream colored or white, low-convex, smooth and butyrous.

Growth in 0.5% glucose–2% broth yeast extract broth: After 3 days at 25°C, cells are nearly spherical, 3–7 × 4–8 µm, reproduce by multilateral budding and occur singly or in budding pairs.

Dalmau plate culture on corn meal agar: After 2 weeks, pseudohyphae and hyphae are not formed.

Fermentation

Glucose	+	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (Media not Specified)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	—
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	s
Soluble starch	—	Succinate	w
Cellobiose	—	Citrate	w
Salicin	—	D-Gluconate	v
L-Sorbose	+	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	+	Hexadecane	s
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	+	10% NaCl/5% glucose	—
2-Keto-D-gluconate	+	Urease	—
5-Keto-D-gluconate	—	DBB	—
Nitrite	—	Cycloheximide 0.01%	+
Cadaverine	+	Cycloheximide 0.1%	—
L-Lysine	+	Growth at 35°C	+
Ethylamine	+	Growth at 37°C	—
50% Glucose	s		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY566407.

Cell carbohydrates: Not determined.

Origin of the strain studied: UNESP 00-89 (CBS 9999, NRRL Y-27814) was isolated from water accumulated in flower bracts of *Heliconia velloziana* (Heliconiaceae, Zingiberales) in the Atlantic rainforest, Picinguaba Area, Serro do Mar State Park, São Paulo State, Brazil (Ruivo et al. 2006).

Type strain: UNESP 00-89.

Systematics: Phylogenetic analysis of the D1/D2 domains of the LSU rRNA gene placed *C. picinguabensis* in the Metschnikowiaceae clade with *C. saopaulonensis* as its sister species (Ruivo et al. 2006). The exact placement within the clade is uncertain (Fig. 90.1).

Ecology: *Candida picinguabensis* is known from accumulating water in flower bracts of *Heliconia* in Brazil (Ruivo et al. 2006).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.212. *Candida pignaliae* (F.H. Jacob) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Ogataea* clade (Figs 53.1, 90.4).

Synonym:

Torulopsis pignaliae F.H. Jacob (1970)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose, 3.5–7 μ m, single, in pairs and small groups (Fig. 90.136).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are not present. Aerobic growth is white to cream colored, butyrous, smooth, glistening and entire.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	s
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	+
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	—
Salicin	+	D-Gluconate	+
L-Sorbose	s	D-Glucosamine	—
L-Rhamnose	+	N-Acetyl-D-glucosamine	—
D-Xylose	+	Hexadecane	w
L-Arabinose	+	Nitrate	+
D-Arabinose	—	Vitamin-free	—

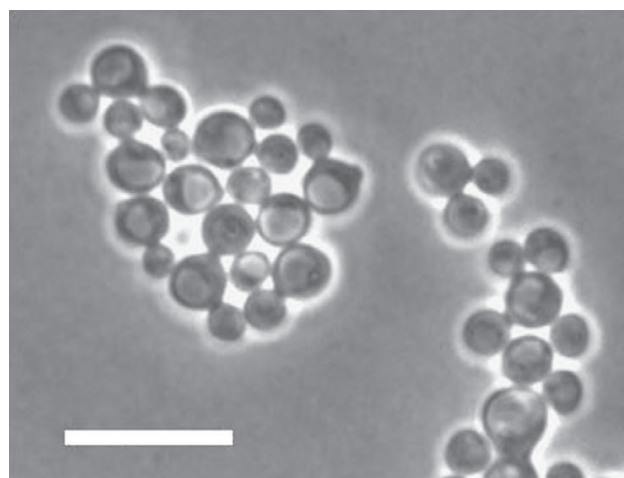


FIGURE 90.136 *Candida pignaliae* CBS 6071. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono-δ-lactone	+	Casein	—
Amino acid-free	+	Lipase	+
Nitrite	+	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	s
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	v
50% Glucose	—	Growth at 37°C	—

CoQ: 7 (C.-F. Lee et al. 1994b).

Mol% G + C: 42.7, CBS 6071 (BD: Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70183.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6071, isolated from tanning fluid, France.

Type strain: CBS 6071.

Systematics: Jacob (1970) described *Torulopsis pignaliae* from six strains isolated from tanning liquors. He noted a similarity with several other *Torulopsis* species, and proposed an affinity with *Hansenula (Ogataea) minuta*. *C. pignaliae* is indeed a member of the methylotroph *Ogataea* clade, but the exact placement varies in different published analyses (Kurtzman 2000b, Kurtzman and Dien 1998, Kurtzman and Robnett 1998a, Suzuki and Nakase 2002) and those performed in this study (Fig. 90.4), which indicates weak phylogenetic resolution.

Growth assessment of the type strain by replica plating resulted in growth on several carbon compounds reported as negative in other descriptions. The new results are given here. *C. pignaliae* produces ethanol from the fermentation of D-xylose, but not L-arabinose (Kurtzman and Dien 1998).

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.213. *Candida pimensis* S.-O. Suh, Gibson & M. Blackwell (Suh et al. 2004a)

Phylogenetic placement: *Metschnikowia* clade (Fig. 46.1).

(The description is based on Suh et al. 2004a.)

Growth on YM agar: After 7 days at 25°C, colonies are white to cream colored, smooth on the surface to somewhat mucoid around the edge.

Growth in YM broth: After 7 days at 25°C, cells are globose to ellipsoidal, 3–7 × 3–9 μm, mostly globose to subglobose, occur singly or in pairs (Fig. 90.137) and pseudohyphae are not present.

Dalman plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae are not present. Aerobic growth is white to cream.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

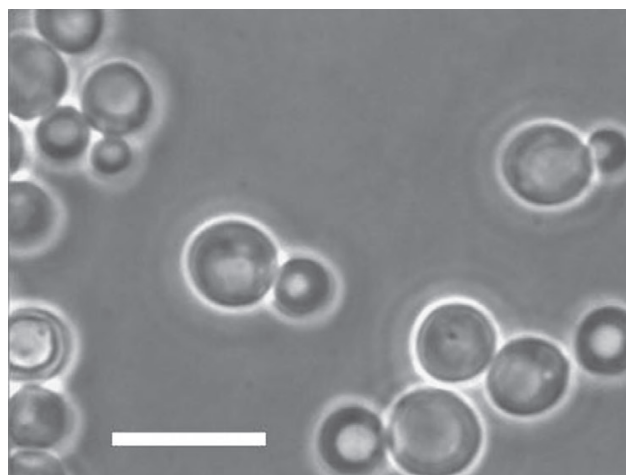


FIGURE 90.137 *Candida pimensis* NRRL Y-27619. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Growth (in Liquid Media)

Glucose	+	D-Ribose	d
Inulin	—	Methanol	—
Sucrose	+	Ethanol	—
Raffinose	—	Glycerol	+/d
Melibiose	—	Erythritol	—
Galactose	d	Ribitol	d/w
Lactose	—	Galactitol	—
Trehalose	+/d	D-Mannitol	+
Maltose	+	D-Glucitol	+/d
Melezitose	+	myo-Inositol	—
Methyl-α-D-glucoside	+/d	DL-Lactate	—
Soluble starch	—	Succinate	w
Cellobiose	—	Citrate	w
Salicin	w	D-Gluconate	+/w
L-Sorbose	—	D-Glucosamine	w
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	—	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	d/w	L-Lysine	—
2-Keto-D-gluconate	—	Ethylamine	+/w
D-Glucuronate	—	50% Glucose	—
L-Arabinitol	—	10% NaCl/5% glucose	—
Arbutin	w	Starch formation	—
Propane 1,2 diol	—	Urease	—
Butane 2,3 diol	—	Cycloheximide 0.01%	—
Cadaverine	+	Cycloheximide 0.1%	—
Nitrite	—	Growth at 30°C	+
Creatinine	—	Growth at 35°C	—

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY452051.

Cell carbohydrates: Not determined.

Origin of the strains studied: NRRL Y-27619 (CBS 9805) and NRRL Y-27620 were both isolated from green lacewing (*Chrysoperla carnea*, Chrysopidae), Tucson, Arizona, USA (Suh et al. 2004a).

Type strain: NRRL Y-27619.

Systematics: Phylogenetic analysis of the D1/D2 domains of the LSU rRNA gene placed *C. pimensis* in the *Metschnikowia* clade with *C. pica-choensis* as closest relative (Suh et al. 2004a). *Metschnikowia chrysoperlae*, *M. pulcherrima* and *M. fruticola* are closely related teleomorph species.

Ecology: *Candida pimensis* is known from green lacewings in Arizona, USA (Suh et al. 2004b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.214. *Candida pini* (Lodder & Kreger-van Rij) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Ogataea* clade (Figs 53.1, 90.4).

Synonyms:

Torulopsis pinus Lodder & Kreger-van Rij (1952)

Paratorulopsis pinus (Lodder & Kreger-van Rij) Novák & Zsolt (1961)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose, 3.5–5 × 3.5–5 μm, and occur singly, in pairs and small groups (Fig. 90.138).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent. Aerobic growth is white to cream colored, soft, mucoid and entire.

Fermentation

Glucose	s	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–/s
Maltose	–		

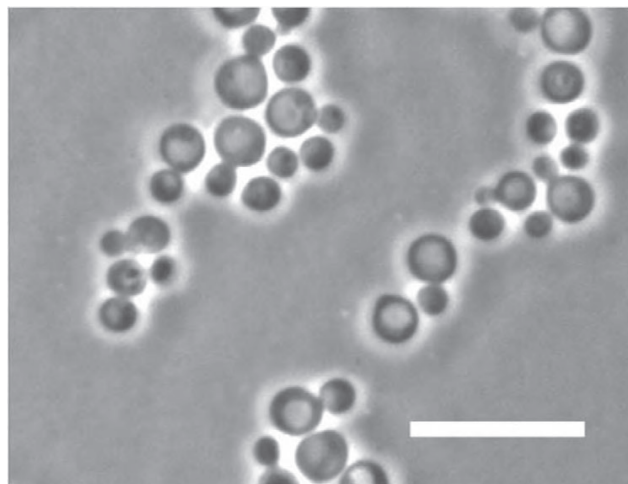


FIGURE 90.138 *Candida pini* CBS 970. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	s
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	–
Melibiose	–	Erythritol	+
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	–	Citrate	s
Salicin	–	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	w
L-Arabinose	s	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	w	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	s
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	–
50% Glucose	–	Growth at 37°C	–

CoQ: 7 (Yamada and Kondo 1972a).

Mol% G + C: 37.3, type strain (T_m : Nakase and Komagata 1971d).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70252.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 970, isolated from water-logged heart of a pine tree, Sweden.

Type strain: CBS 970.

Systematics: Lodder and Kreger-van Rij (1952) described *Torulopsis pinus* to accommodate a capsule-forming isolate. *C. pini* is a basal member of the *Ogataea* clade (Kurtzman and Robnett 1998a, Suzuki and Nakase 2002).

The growth characteristics are typical of those of other methylotrophs, particularly to *Ogataea (Pichia) minuta*, although the two species differ in the utilization of β-glucosides, which is negative in *C. pini*. Characterization by replica plating did not confirm the utilization of L-arabinose or glycerol, as reported previously, but demonstrated resistance to 0.1% cycloheximide.

Ecology: The isolation of the single known strain of *C. pini* from decaying wood is consistent with the frequent recovery of methanol-utilizing yeast species in this kind of material (Péter 2003).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.215. *Candida pinicola* Kurtzman (2007a)

Phylogenetic placement: *Sugiyamaella* clade (Figs 72.1, 90.3).
(The description is based on Kurtzman 2007a.)

Growth on 5% malt extract agar: After 3 days' growth at 25°C, yeast cells are spherical, 3–6 µm, to elongate, 2–2.4 × 6.5–8 µm, form by multilateral budding and occur singly or in pairs (Fig. 90.139A). Aerobic growth is tannish-white, dull-glistening, butyrous and with a narrow hyphal fringe. True hyphae occur abundantly after a week or longer.

Growth on the surface of assimilation media: Pellicles are not formed on stationary liquid media.

Dalmau plate culture on morphology agar: After 7 days at 25°C, pseudohyphae occur that form blastoconidia (Fig. 90.139B). True hyphae are formed on 5% malt extract agar (Fig. 90.139C). Aerobic growth is white, glistening, butyrous and with an irregularly lobed margin.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	v
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	–
Lactose	+	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	+	Starch formation	–
5-Keto-D-gluconate	+	Gelatin liquefaction	–
Saccharate	–	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 37°C	–
10% NaCl/5% glucose	–		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA = DQ438200, ITS = DQ911453, mitochondrial SSU rRNA = DQ442730, COXII = DQ443058.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL YB-2263 (CBS 10348), isolated from frass on lodgepole pine (*Pinus contorta*, Pinaceae), Reno, Nevada, USA.

Type strain: NRRL YB-2263.

Systematics: Phylogenetic analysis of combined gene sequences from LSU rRNA, mitochondrial SSU rRNA and COXII placed *C. pinicola* in the *Sugiyamaella* clade, where it clusters with *Sugiyamaella japonica*, *C. grinbergii* and *C. neomexicana* in a weakly supported clade

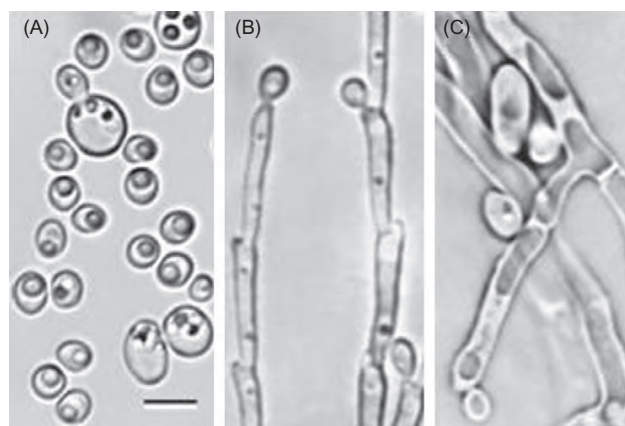


FIGURE 90.139 *Candida pinicola* NRRL YB-2263. Budding cells after 3 days, 25°C, 5% malt extract agar (A); pseudohyphae with blastoconidia after 7 days, 25°C, yeast morphology agar (B); true hyphae after 3 days, 25°C, 5% malt extract agar (C). Bar = 5 µm.

that comprises *S. americana*, *C. palidigena*, *C. castrensis*, *C. novakii* and *C. marionensis* (Kurtzman 2007a).

Ecology: *Candida pinicola* is known only from frass on lodgepole pine, Nevada, USA.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.216. *Candida plutei* S.-O. Suh & M. Blackwell (2005)

Phylogenetic placement: *Kodamaea* clade; see Systematics (Fig. 90.3).
(The description is based on Suh and Blackwell 2005.)

Growth on YM agar: After 7 days at 25°C, colonies are white to cream, membranous, filamentous and rough on the surface with a fuzzy margin.

Growth in YM broth: After 7 days at 25°C, yeast cells are ovoid, elongate, and cylindrical, 2–5 × 4–10 µm, occur singly, in pairs or in short chains, and pseudohyphae are present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, septate hyphae and pseudohyphae with blastoconidia are present. Aerobic growth is white, fuzzy and rough on the surface.

Fermentation: Absent.

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	–
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	w
Salicin	+	D-Gluconate	–
L-Sorbose	w	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	50% Glucose	–
2-Keto-D-gluconate	+	10% NaCl/5% glucose	w
D-Glucuronate	–	Starch formation	–
L-Arabinitol	–	Urease	–
Arbutin	+	DBB	–
Propane 1,2 diol	–	Cycloheximide 0.01%	–
Butane 2,3 diol	–	Cycloheximide 0.1%	–
Cadaverine	+	Growth at 25°C	+
Creatinine	–	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	–
Ethylamine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY520388, SSU rRNA = AY520259.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27715 (CBS 9885), isolated from the gut of an unidentified staphylinid beetle (Staphylinidae) on a deer mushroom (*Pluteus cervinus*), Baton Rouge, Louisiana, USA (Suh and Blackwell 2005).

Type strain: NRRL Y-27715.

Systematics: Phylogenetic analysis of the combined D1/D2 LSU and SSU rRNA gene sequences placed *C. plutei* in the *Kodamaea* clade together with *C. fungicola*, *C. sagamina*, *C. fukazawae*, *C. derodonti*, *C. arcana*, *C. suecica*, *C. mesenterica*, *Kodamaea leatipori* and *K. ohmeri* (Suh and Blackwell 2005).

Ecology: *Candida plutei* is known only from the gut of a staphylinid beetle on deer mushroom in Louisiana, USA (Suh and Blackwell 2005).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.217. *Candida polysorbophila* Kurtzman (2007b)

Phylogenetic placement: *Sugiyamaella* clade (Fig. 90.3).

(The description is based on Kurtzman 2007b.)

Growth on 5% malt extract agar: After 3 days at 25°C, yeast cells form by multilateral budding, are spherical, 2–4 µm, to elongate, 1.9–4 × 2.2–7.1 µm, and occur singly or in pairs (Fig. 90.140A). Many of the larger cells are tapered, often with an elongated rachis-like tip that gives rise to blastoconidia. Colony growth is light tannish-white, smooth, dull-glistening, butyrous and with a hyphal margin.

Dalmeu plate culture on morphology agar: After 7 days at 25°C, pseudohyphae, often with curved cells, are abundantly formed (Fig. 90.140B), but true hyphae do not occur. Aerobic growth is butyrous, white to tannish-white, dull-glistening, flat and with a smooth to irregularly serrate margin circumscribed by a narrow hyphal fringe.

Fermentation

Glucose	+	Lactose	–
Galactose	w	Raffinose	–
Sucrose	w	Trehalose	+
Maltose	+		

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+



FIGURE 90.140 *Candida polysorbophila* NRRL Y-27161. Budding cells including an elongated cell with a rachis-like extension forming a blastoconidium, after 3 days, 25°C, 5% malt extract agar (A). Branching pseudohypha after 7 days, 25°C, yeast morphology agar (B). Bar = 5 µm.

Raffinose	+	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	+
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	+
Methyl-α-D-glucoside	–	D-Lactate	+
Soluble starch	+	Succinate	+
Cellulobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	–	Starch formation	–
5-Keto-D-gluconate	+	Gelatin liquefaction	–
Saccharate	–	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 37°C	–
10% NaCl/5% glucose	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA = DQ438188, ITS = DQ911459, mitochondrial SSU rRNA = DQ442717, COXII = DQ443045.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27161 (CBS 7317), isolated as a contaminant from an emulsion of white oil and polysorbate, South Africa (Kurtzman 2007b).

Type strain: NRRL Y-27161.

Systematics: Phylogenetic analysis of concatenated gene sequences for LSU rRNA, SSU rRNA, mitochondrial SSU rRNA and COXII placed *C. polysorbophila* in the *Zygoascus* clade together with *Zygoascus meyeri*, *Z. hellenicus*, *Z. tannicolus* and *Z. ofunaensis* (Kurtzman 2007b).

Ecology: *Candida polysorbophila* is known only from an emulsion of white oil and polysorbate, South Africa.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

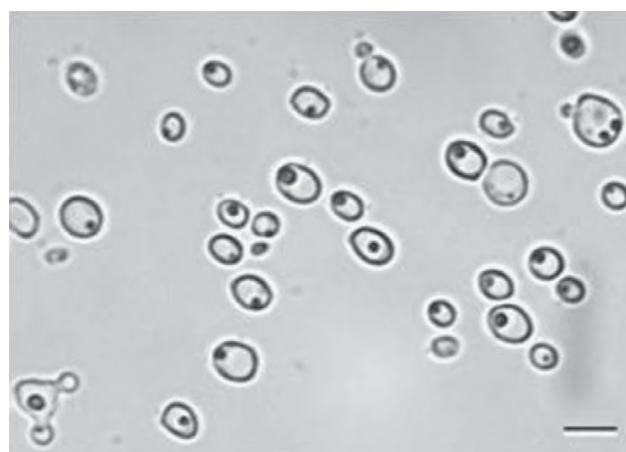


FIGURE 90.141 *Candida pomicola* NRRL Y-27083. Budding cells after 7 hours, 25°C, RG agar. Bar = 5 μm.

90.218. *Candida pomicola* Kurtzman, Robnett & Yarrow (2001a)

Phylogenetic placement: *Nakazawaea* clade (Fig. 90.4).

(Some of the morphological characteristics are taken from Kurtzman et al. 2001a.)

Growth on 5% malt extract agar: After 3 days at 25°C, the cells are spherical to ellipsoidal, 2–4 × 2–6 μm, and occur singly or occasionally in pairs (Fig. 90.141). Budding is multilateral. Growth is tannish-white, glistening and butyrous. A profusion of extracellular polysaccharide is evident.

Dalmau plate culture on morphology agar: After 7 days at 25°C, moderately branched rosettes of undifferentiated cells are seen under the coverglass, but pseudohyphae and true hyphae are not formed.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	v
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	w
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	w
Galactose	s	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	s	DL-Lactate	–
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	v	D-Glucosamine	s
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	s	Nitrate	+
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	+	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	w
50% Glucose	s	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF245400.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 4242 (NRRL Y-27083), isolated from cider, UK.

Type strain: NRRL Y-27083.

Systematics: Kurtzman et al. (2001a) described *C. pomicola* to accommodate an isolate recovered from cider, on the basis of a divergent sequence in the D1/D2 LSU rRNA gene. The species is related to a number of other *Candida* species that exhibit an affinity to the ascosporic genus *Nakazawaea*.

The growth characteristics are similar to those of several related species. The original description (Kurtzman et al. 2001a) indicated that separation from *C. ishiwadae*, *C. ernobii* and *C. wyomingensis* can be based on the fermentation of maltose (negative) and the assimilation of melezitose (positive).

Strain CBS 5808, an isolate from tree bark in Chile, was deposited as *C. conglobata* and was included in that species by Meyer et al. (1998). However, the growth characteristics showed a number of differences from the description of *C. conglobata* and a better match with *C. wickerhamii*, except from nitrate utilization, which is negative in strain CBS 5808. The D1/D2 rRNA gene sequence (AY366526) indicated that the strain is in fact related to *C. pomicola*. The sequences differ by six substitutions. The growth characteristics of the strain differ significantly from those of *C. pomicola* as well. Sucrose is not assimilated. Trehalose is the only α-glucoside utilized and nitrate

does not support growth. The strain also differs by six substitutions in the D1/D2 sequence from strains UWOPS 00-163.1 and UWOPS 01-624.1, recovered from sap fluxes of old fustic (*Maclura tinctoria*) in Costa Rica. One of these strains was reported as a sister species to *C. wyomingensis* by Lachance et al. (2001d).

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.219. *Candida ponderosae* Kurtzman (2001a)

Phylogenetic placement: *Wickerhamomyces* clade (Figs 80.1, 90.4). (Some of the morphological characteristics are taken from Kurtzman 2001a.)

Growth on 5% malt extract agar: After 3 days at 25°C, the cells are ovoid to elongate, 2–5 × 2–7 μm, and occur singly or in pairs (Fig. 90.142A). Budding is multilateral. Growth is tannish-white, glistering and butyrous.

Dalmau plate culture on morphology agar: After 7 days at 25°C, growth under the coverglass is restricted. Rosettes of elongated cells appear (Fig. 90.142B), but there are no differentiated pseudohyphae or true hyphae.

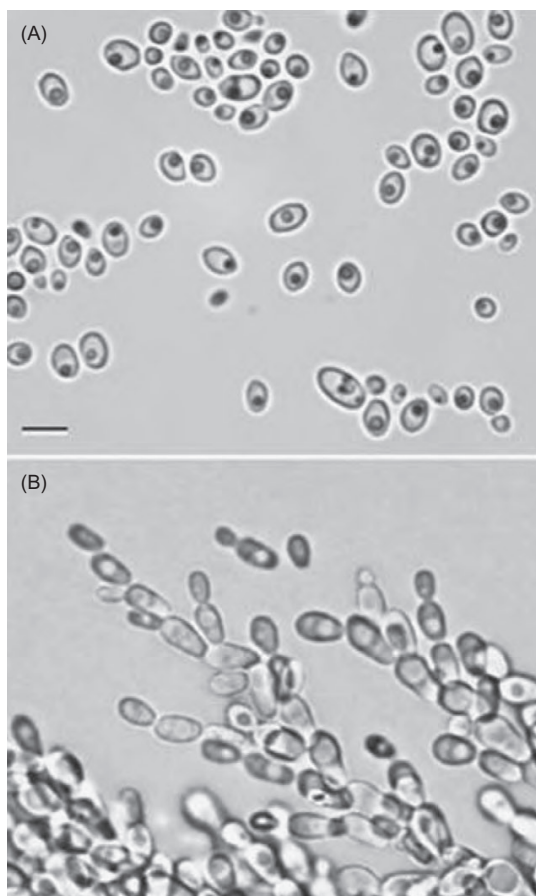


FIGURE 90.142 *Candida ponderosae* NRRL YB-2307. Budding cells after 3 days, 25°C, 5% malt extract agar (A). Simple pseudohyphae after 7 days, 25°C, yeast morphology agar (B). Bar = 5 μm.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	–	D-Glucitol	v
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	s	Casein	–
Amino acid-free	–	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	w	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF271085.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 8801 (NRRL YB-2307), isolated from insect frass in Ponderosa pine (*Pinus ponderosa*, Pinaceae), Washington, USA.

Type strain: CBS 8801.

Systematics: *Candida ponderosae* was described from two insect frass isolates, primarily on the basis of divergence in the D1/D2 LSU rRNA gene (Kurtzman 2001a), which indicates a close relationship with *Wickerhamomyces chambardii* and *W. anomalus* (Kurtzman and Robnett 1998a).

The growth profile of *C. ponderosae* is relatively narrow and bears some similarity to the profiles of *Starmera quercuum* and *Phaffomyces opuntiae*, although growth on D-xylose (positive) is a good discriminatory trait.

Ecology: Like many related species, *C. ponderosae* has been found in association with insects that excavate trees.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.220. *Candida populi* Hagler, Mendonça-Hagler & Phaff (1989)

Phylogenetic placement: *Nakazawaea* clade (Figs 51.1, 90.4).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, 1–2 × 2–3 µm in diameter, occur singly and budding gives rise to short chains and clusters (Fig. 90.143).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent. However, there may be some short chains of cells evident. Aerobic growth is white, butyrous, smooth, soft and entire.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	w/s
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	v	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	s
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	+
D-Arabinose	+	Vitamin-free	–

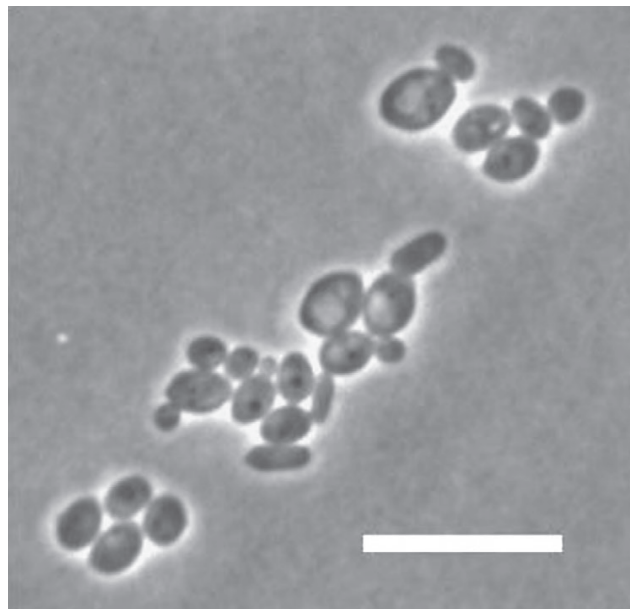


FIGURE 90.143 *Candida populi* CBS 7351. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	+	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: 8 (Hagler et al. 1989).

Mol% G + C: 37.4–38.9, six strains (BD: Hagler et al. 1989).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70249.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 7351, isolated from sap flux of trembling aspen (*Populus tremuloides*, Salicaceae), Alaska; CBS 7352, from sap flux of birch (*Betula* sp., Betulaceae), British Columbia, Canada.

Type strain: CBS 7351.

Systematics: Hagler et al. (1989) described *C. populi* from 24 strains previously recovered from sap fluxes of trembling aspen (*Populus tremuloides*), black cottonwood (*Populus trichocarpa*) and birch (*Betula* sp.) in a large study of this habitat conducted by Phaff et al. (1972) in the Pacific Northwest region of North America. Six strains produced DNA reassociation values ranging from 74 to 100%, and negligible values with *C. molischiana* and similar species that were then assigned to *Pichia*. Sequence analyses later showed that *C. populi* is related to *C. anatomiae* and other species near *Nakazawaea* (*Pichia*) *holstii*. *C. populi* and *C. anatomiae* differ by only two substitutions in the D1/D2 LSU rRNA gene (Kurtzman and Robnett 1998a) and eight substitutions and three gaps in the SSU rRNA gene (Suzuki and Nakase 1999), which indicates a close relationship. However, the two species are different in their physiology.

Physiologically, *C. populi* is similar to several closely related species, including *C. ernobii*, *C. ishiwadae* and *C. wyomingensis*. Distinction from these species is possible based on the lack of growth on maltose, melezitose and starch.

Ecology: The original description (Hagler et al. 1989) noted that *C. populi* occurs sympatrically with *Barnettozyma* (*Pichia*) *populi* but stressed that the two are distinct species. It was also pointed out that the species seemed confined to North American trees and conspicuously absent from similar habitats in Japan.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.221. *Candida powellii* Lachance (Lachance et al. 2001a)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

Growth on malt agar: After 2 weeks at 17°C, colonies are low-convex, glossy, smooth, white and butyrous.

Growth in glucose–yeast extract broth: After 3 days at 25°C, cells are spherical to ovoid, occur singly or in parent–bud pairs and measure 1–3 × 2–4 µm. A thin ring may be formed.

Dalmau plate culture on corn meal agar: After 2 weeks at 18°C, hyphae or pseudohyphae are not formed.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	s		

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	—	Methanol	—
Sucrose	—	Ethanol	—
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	s	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	D,L-Lactate	—
Soluble starch	—	Succinate	s
Cellobiose	—	Citrate	s
Salicin	—	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	s	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	v
10% NaCl	w	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF251554.

Cell carbohydrates: Not determined.

Origin of the strains studied: UWOPS 99-325.3 (CBS 8795), isolated from nitidulid beetle (*Conotelus* sp., Coleoptera: Nitidulidae) from a morning glory (*Ipomoea carnea*, Convolvulaceae); other strains from *Conotelus* sp., unidentified nitidulid beetle, and bees collected on species of morning glory, such as *I. carnea*, *I. trifida* and *I. batatoides*; all from Costa Rica.

Type strain: CBS 8795.

Systematics: *Candida powellii* was described by Lachance et al. (2001a) from several strains isolated from various insects found in flowers of morning glory (Convolvulaceae) in Costa Rica. The species is related to *C. floricola* in the *Starmerella sensu stricto* subclade (Fig. 71.1).

Like several related species, *C. powellii* exhibits a narrow physiological spectrum and is osmotolerant, a pattern that is convergent with that of several *Zygosaccharomyces* species. Some strains grow in the presence of 1% acetic acid. *Z. rouxii* is the most similar species,

but the two can be distinguished on the basis of D-xylose, succinate and citrate, which is positive in *C. powellii*.

Ecology: Although *C. powellii* was recovered from a variety of insects found on flowers in Costa Rica, its absence in samples from similar flowers in other extensively sampled regions is interpreted as evidence of an association with bees that are endemic to Central America. Other species in the clade are often recovered from bees or wasps.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.222. *Candida prunicola* Kurtzman (2001b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5).

(Some of the morphological characteristics are taken from Kurtzman 2001b.)

Growth on 5% malt agar: After 3 days at 25°C, yeast cells are spherical, ellipsoidal, to elongate, 1.4–3.5 $\times$ 2–17 μ m, and occur singly, in pairs or occasionally in small clusters (Fig. 90.144 top). Budding is multilateral. Elongate cells often form short denticles that produce blastoconidia. Occasional elongated cells form a globose inflated terminal cell. Colonies are white, dull, powdery and butyrous in texture.

Dalmau plate culture on yeast morphology agar: After 7 days at 25°C, growth under the coverglass shows sparingly branched pseudohyphae with clusters of blastoconidia at the nodes (Fig. 90.144 bottom). True hyphae are not produced.

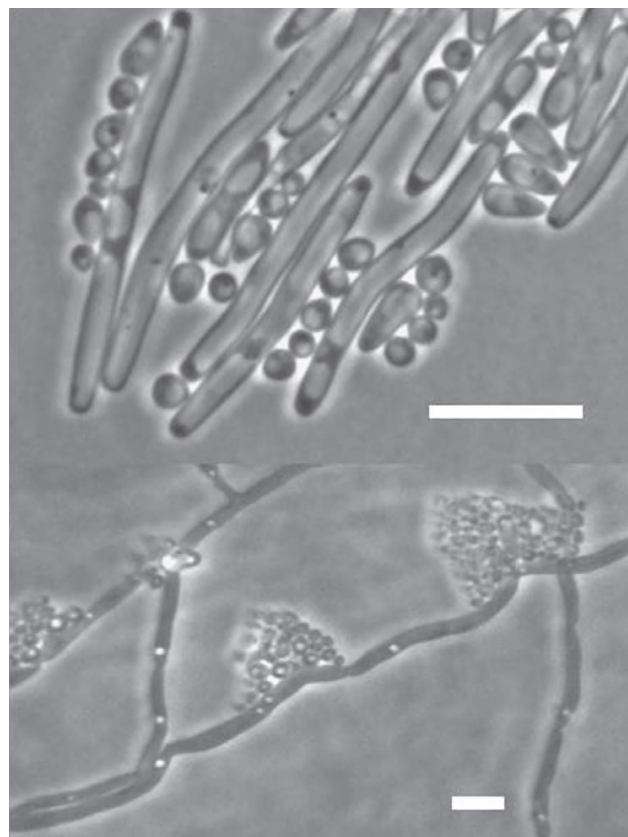


FIGURE 90.144 *Candida prunicola* CBS 8848. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae with blastoconidia after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μ m.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	–
Cellulobiose	–	Citrate	+
Salicin	–	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	+	Acid production	w
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	–	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY488126.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 8848 (NRRL YB-869), isolated from exuded gum from black cherry (*Prunus serotina*, Rosaceae), Illinois, USA.

Type strain: CBS 8848.

Systematics: *Candida prunicola* was described by Kurtzman (2001b) to accommodate an isolate recovered from a gummy exudate of black cherry. The publication included five other species found to be related to *C. tanzawaensis*, which at the time had no known close relatives, as assessed by D1/D2 LSU rRNA gene sequencing. Among these, *C. pyralidae* is the closest relative to the species.

Kurtzman (2001b) commented that the species and its relatives would be difficult to identify on the basis of physiology. However, a computer-based comparison of existing data conducted in this study showed the profile of *C. prunicola* to be unique and characterized by the utilization of several organic acids and few di- or trisaccharides, trehalose being the exception.

Ecology: Most isolates assigned to the six *C. tanzawaensis* relatives described by Kurtzman (2001b) originated from the interface between insects, macrofungi and trees, suggesting a strong association with these habitats.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.223. *Candida pseudoglebosa* Suzuki & Nakase (1993)

Phylogenetic placement: *Candida glabrosa* clade (Fig. 90.2).

(Some of the morphological characteristics are based on Suzuki and Nakase 1993.)

Growth in YM broth: After 3 days at 25°C, the cells are ovoid, ellipsoidal or cylindrical, 3–5 $\times$ 5–12 μ m, and occur singly, in pairs or in short chains (Fig. 90.145 top). A thin pellicle is formed.

Growth on YM agar: After 1 month at 17°C, the streak culture is cream colored, smooth, soft and dull to semi-glossy. The margin is slightly lobed or entire.

Dalmau plate culture on corn meal agar: Poorly developed pseudohyphae are formed (Fig. 90.145 bottom).

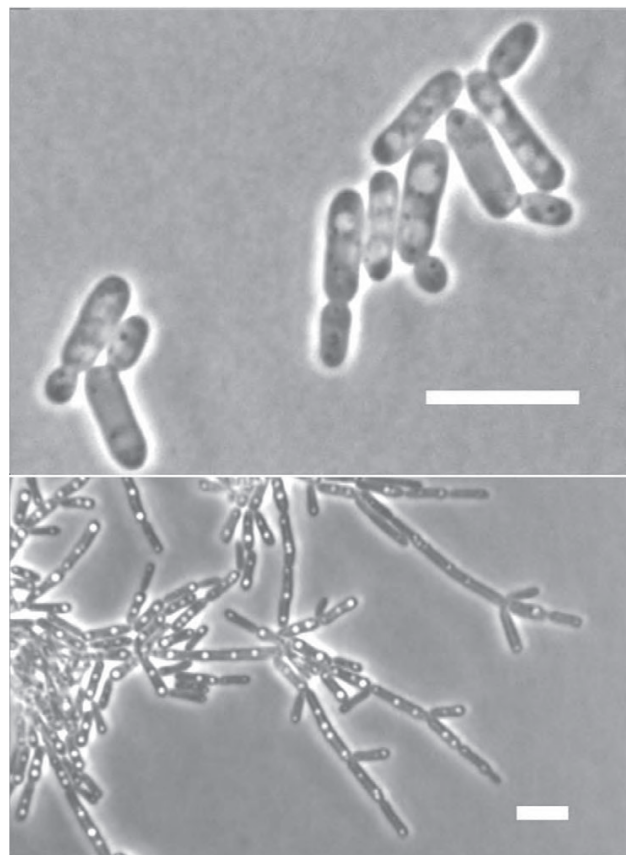


FIGURE 90.145 *Candida pseudoglebosa* CBS 6715. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μ m.

Fermentation

Glucose	w	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	—
Raffinose	+	Glycerol	—
Melibiose	+	Erythritol	—
Galactose	+	Ribitol	—
Lactose	+	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	D,L-Lactate	+
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	w
Salicin	+	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	s
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	—	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	w	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 34.0, type strain (T_m : Suzuki and Nakase 1993).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U71072.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6715 (JCM 2168), isolated from soil in Japan.

Type strain: CBS 6715.

Systematics: In a detailed comparison of strains previously assigned to *C. glabrosa*, *C. saitoana* and *Torulopsis candida*, Suzuki and Nakase (1993) found one strain that could not be assigned to any of these species of the basis of DNA reassociation and other properties. They proposed the name *C. pseudoglabrosa* to accommodate the strain. The species belongs to a small clade of closely related *Candida* species with an affinity for the genus *Debaryomyces* (Kurtzman and Robnett 1998a, Sugita and Nakase 1999). The closest relatives are *C. glabrosa* and *C. saitoana*.

The description indicates that the species can be separated from *C. glabrosa* and *C. saitoana* by the utilization of L-arabinose, D-arabinose and ribitol. Characterization by replica plating could not

confirm the utilization of D-arabinose in any of these species but indicated that assimilation of L-sorbose was an additional character that could be used in distinguishing the species from *C. glabrosa*. The utilization of ethanol and glycerol by the species could not be confirmed.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.224. *Candida pseudointermedia* Nakase, Komagata & Fukazawa (1976)

Phylogenetic placement: *Metschnikowia* clade (Fig. 90.1).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to short ovoid, 4–5 $\times$ 4–6 μ m, and occur singly and in pairs (Fig. 90.146 top). A ring and sediment are present.

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae consist of branched chains of cylindrical cells with verticils of subglobose to ovoid blastoconidia (Fig. 90.146 bottom). Aerobic growth is white to cream colored, butyrous, dull, dry and mostly smooth with some wrinkled areas and fringed margins.

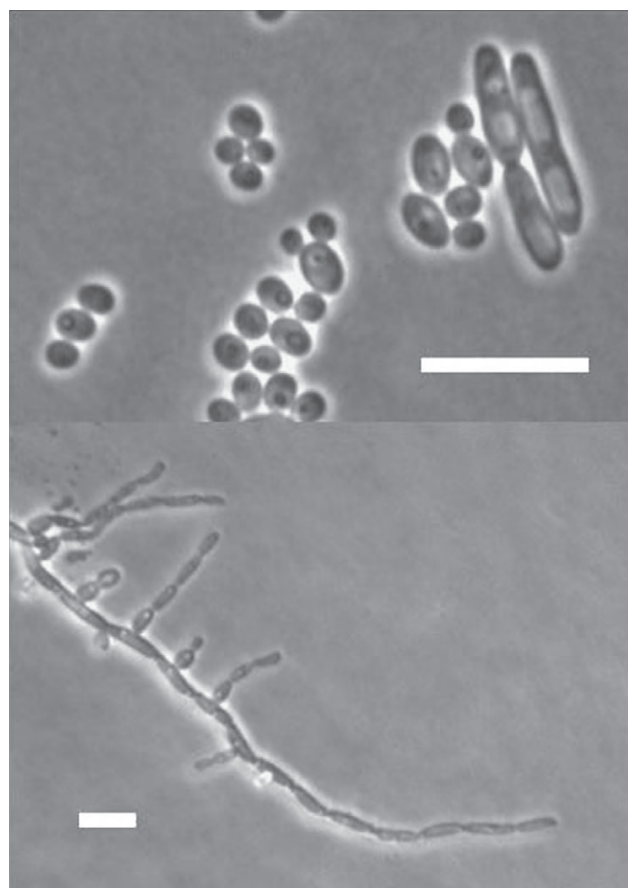


FIGURE 90.146 *Candida pseudointermedia* CBS 6918. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μ m.

Fermentation

Glucose	+	Lactose	—
Galactose	+	Raffinose	—
Sucrose	+	Trehalose	+
Maltose	s		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	v	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	—
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	v	Galactitol	s
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	w
Soluble starch	v	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	v	Nitrate	—
D-Arabinose	v	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	v
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	w/—

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 44.9, CBS 6918 (T_m : Nakase et al. 1976).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U44816.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 6918, isolated from fish paste, Japan; CBS 8603, from flower of bird of paradise (*Strelitzia* sp., Strelitziaceae), French Guyana; UFMG JL29, from flower of *Heliconia* sp. (Heliconiaceae), Brazil.

Type strain: CBS 6918.

Systematics: Nakase et al. (1976) described *C. pseudointermedia* to accommodate three strains recovered from Kamaboko, a popular traditional food made of fish paste in Japan. Similarities with *C. intermedia*, *Meyerozyma* (*Pichia*) *guilliermondii* and *Kodamaea* (*Pichia*) *ohmeri* were noted, but discrimination on the basis of physiology was possible. *C. pseudointermedia* is a close relative of *C. intermedia*. These species belong to the Metschnikowiaceae clade and show affinities to the genus *Clavispora* (Kurtzman and Robnett 1998a, Sugita and Nakase 1999).

The species is polyphagic and the growth characteristics show some variability for utilization of lactose, L-rhamnose, all pentoses and growth in the presence of 50% glucose or 0.01% cycloheximide. In view of the comparable variation found in *C. intermedia* and the physiological similarity between the two species, separation on that basis is impractical.

Ecology: An association with flowers and floricolous insects is possible.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.225. *Candida pseudolambica* M.Th. Smith, Poot & Kull (1989a)

Phylogenetic placement: *Pichia* clade (Figs 57.1, 90.1).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are mostly globose or slightly ovoid, $3\text{--}5 \times 3\text{--}5 \mu\text{m}$, and occur singly, in pairs or in small clusters.

Dalmat plate culture on corn meal agar: After 14 days at 25°C, poorly developed pseudohyphae are present. Aerobic growth is white to cream colored, butyrous, smooth and entire.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	—
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	—
Maltose	—	D-Glucitol	—
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	+
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	—
Salicin	—	D-Gluconate	—
L-Sorbose	—	D-Glucosamine	v
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	v	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	+

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	—	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: 30.8–31.4, 5 strains (T_m : Smith et al. 1989a).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U71063.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 2063, isolated from silage, UK; CBS 7777, from shipworm (*Neoteredo reynei*, Bivalvia: Teredinidae) burrowing in dead wood of mangrove (*Rhizophora mangle*, Rhizophoraceae), Brazil.

Other strains available: CBS 2058, from feces; CBS 2067 (ATCC 4673), CBS 4325 and CBS 4326, from soil, Finland.

Type strain: CBS 2063.

Systematics: Smith et al. (1989a) reviewed the species assignment of 11 strains deposited in the CBS Culture Collection as *C. lambica* and found five strains to differ from the rest. DNA reassociation values from 67 to 97% were found among the strains, and no significant reassociation was found with *Pichia fermentans*, *C. lambica*, *C. ethanolica* and *C. rugopelliculosa*. *C. pseudolambica* belongs to a clade that contains *Pichia membranifaciens* (Kurtzman and Robnett 1998a, Suzuki and Nakase 2002). The affinities suspected by Smith et al. (1989a) were confirmed by sequence analysis, but the exact position of *C. pseudolambica* in the clade varies depending on the species included in the analyses or the method of tree construction.

The physiology is specialized as is that of several related species that utilize ethanol and some organic acids, but little else. Growth on D-xylose, fermentative ability and lack of growth at 37°C can be used to separate the species.

Ecology: Like many related species, *C. pseudolambica* appears to be cosmopolitan in distribution and diverse in habitats, suggesting that in this case, nutritional specialization may lead to a generalistic ecology.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.226. *Candida pseudorhagii* Kurtzman (2005b)

Phylogenetic placement: *Hyphopichia* clade (Figs 33.1, 90.1).

(The description is based on Kurtzman 2005b.)

Growth on 5% malt extract agar: After 3 days at 25°C, yeast cells are spherical, 2–5.2 µm, to elongate, 1.8–5 × 8–20 µm, occur singly or infrequently in pairs and reproduce by multilateral budding (Fig. 90.147A). Moderately branched pseudohyphae are present, but true hyphae were not observed. Colonies are white, semi-glistening, butyrous and have a fine pseudohyphal fringe.

Growth on YM agar: After 1 month at 25°C, true hyphae are formed (Fig. 90.147C).

Dalmau plate culture on yeast morphology agar: After 7 days at 25°C, sparsely or abundantly branched pseudohyphae bearing blastoconidia are formed (Fig. 90.147B). True hyphae were not observed. Aerobic growth is white, dull-glistening, slightly raised with a flat center, butyrous, produces a faint ester-like odor and has finely to moderately lobate margins with a narrow pseudohyphal fringe.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	w
Sucrose	+	Trehalose	+
Maltose	–		

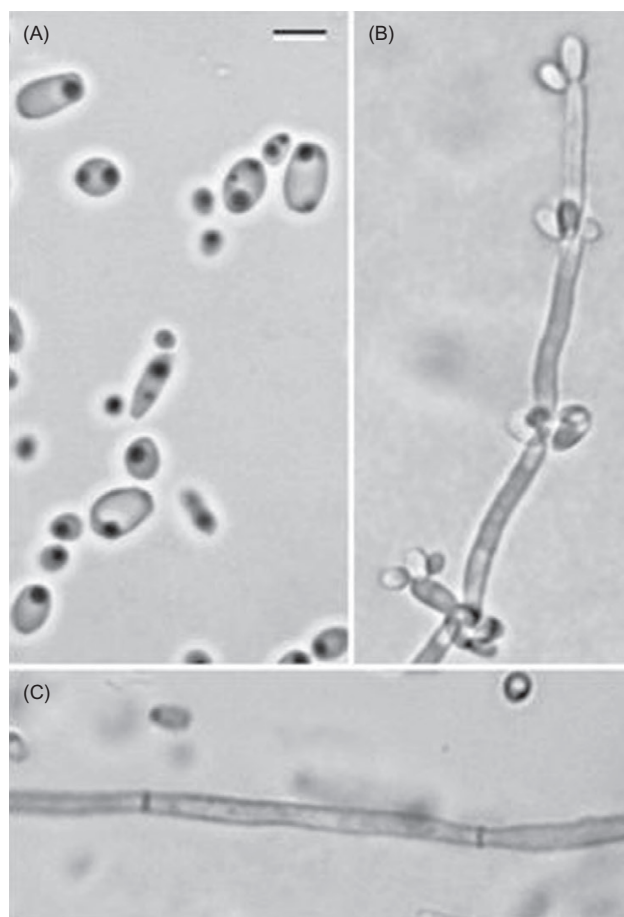


FIGURE 90.147 *Candida pseudorhagii* NRRL YB-2076. Budding cells after 3 days, 25°C, YM agar (A); pseudohypha after 7 days, 25°C, yeast morphology agar (B); septate hypha after 29 days, at 25°C, YM agar (C). Bar = 5 µm.

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D-Lactate	v
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	+
L-Sorbose	v	D-Glucosamine	+
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	–
D-Arabinose	v	Vitamin-free	+

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	+	Starch formation	—
5-Keto-D-gluconate	—	Gelatin liquefaction	w
Saccharate	—	Cycloheximide 0.01%	—
Cadaverine	+	Cycloheximide 0.1%	—
10% NaCl/5% glucose	+	Growth at 37°C	v

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY789656.

Cell carbohydrates: Not determined.

Origin of the strains studied: NRRL YB-1234 (CBS 9997), isolated from insect frass of an unidentified conifer, Lake Wabatonigushi, Ontario, Canada; NRRL YB-1998, from insect frass on jack pine (*Pinus banksiana*), Duluth, Minnesota, USA; NRRL YB-2003, from insect frass on longleaf pine (*P. palustris*), Wilma, Florida, USA; NRRL YB-2076 (CBS 9998), isolated from insect frass in a shortleaf pine (*P. echinata*) growing near Salem, Missouri, USA, by L.J. Wickerham in July 1950; NRRL YB-3075, from insect frass on white pine (*P. strobus*), Big Lake, Wisconsin, USA; NRRL YB-3093, from insect frass on dead fir (*Abies* sp.), Big Lake, Wisconsin, USA (Kurtzman 2005b).

Type strain: NRRL YB-2076.

Systematics: Phylogenetic analysis of the D1/D2 domains of the LSU rRNA gene placed *C. pseudorhagii* in a well-supported clade with *C. gotoi*, *C. rhagii* and *Hyphopichia heimii* (Kurtzman 2005b).

Ecology: The species is known from insect frass on conifer trees at various places in the USA (Kurtzman 2005b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.227. *Candida psychrophila* (S. Goto, Sugiyama & Iizuka) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Debaryomyces* clade (Fig. 24.1).

Synonym:

Torulopsis psychrophila S. Goto, Sugiyama & Iizuka (1969)

Growth in glucose–yeast extract–peptone broth: After 3 days at 15°C, the cells are spherical, 2.5–4.5 µm, and occur singly, in pairs or small clusters.

Dalman plate culture on corn meal agar: After 14 days at 15°C, pseudohyphae are absent. Aerobic growth is white, butyrous, smooth, soft and entire.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+	Ribitol	v
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl-α-D-glucoside	—	DL-Lactate	—

Soluble starch	—	Succinate	—
Cellobiose	—	Citrate	—
Salicin	—	D-Gluconate	—
L-Sorbose	v	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	s	Gelatin	n
Glucono-δ-lactone	—	Casein	n
Amino acid-free	+	Lipase	n
Nitrite	—	Acid production	—
Ethylamine	—	Cycloheximide 0.01%	—
L-Lysine	—	Cycloheximide 0.1%	—
Cadaverine	—	1% Acetic acid	—
10% NaCl	n	Growth at 30°C	—
50% Glucose	s	Growth at 37°C	—

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 36.3, 35.9, CBS 5956 (T_m : Nakase and Komagata 1971d; T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45813.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 5956, isolated from penguin dung, Antarctica.

Type strain: CBS 5956.

Systematics: Goto et al. (1969) examined 123 samples of lake water, soil, moss and penguin dung collected in various localities in Antarctica. These yielded 18 yeast strains, most of which were of basidiomycetous affinity. Two species were obligate psychrophiles. Of these, two strains from penguin dung were assigned to a new species, *Torulopsis psychrophila*. The authors noted a similarity with *Torulopsis (Candida) famata*. In fact, *C. psychrophila* is a close relative of *Debaryomyces hansenii*, the teleomorph of *C. famata* (Kurtzman and Robnett 1998a, Sugita and Nakase 1999).

The species does not grow at temperatures above 17°C. The growth characteristics are those of previous descriptions (Goto et al. 1969, Meyer et al. 1998), determined at 15°C. The assimilation pattern of the species is unique and could be used for identification.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: Watson et al. (1978) determined that *C. psychrophila* and *C. sake* subtype *austromarina* as well as three basidiomycetous species are obligate aerobes in addition to being psychrophiles. Supplementation with lipids that are synthesized under oxidative conditions did not restore the ability of these yeasts to grow in the absence of oxygen. They further observed that these species contain polyunsaturated fatty acids and are unable to form respiratory-deficient mutants. Deegenaars and Watson (1997) further showed that thermotolerance can be induced by subjecting *C. psychrophila* to a heat shock treatment at 25°C. The adapted cells were not rendered able to grow at higher temperature, but resisted a thermal death treatment at 35°C. A unique, 110 kb stress protein was identified in the species.

90.228. *Candida pyralidae* Kurtzman (2001b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5).

(Some of the morphological characteristics are taken from Kurtzman 2001b.)

Growth on 5% malt extract agar: After 3 days at 25°C, cells are spherical elongate, 2–5 × 3–17 μm, occur singly or in pairs and reproduce by multilateral budding (Fig. 90.148 left). Colonies are tanish-white, dull and butyrous.

Growth in liquid media: Thin pellicles occasionally form on stationary liquid media.

Dalmau plate culture on yeast morphology agar: After 7 days at 25°C, growth under the coverglass is restricted with sparse pseudohyphae and limited production of blastoconidia (Fig. 90.148 right). True hyphae were not produced.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D,L-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	–
D-Arabinose	–	Vitamin-free	+

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY013715.

Cell carbohydrates: Not determined.

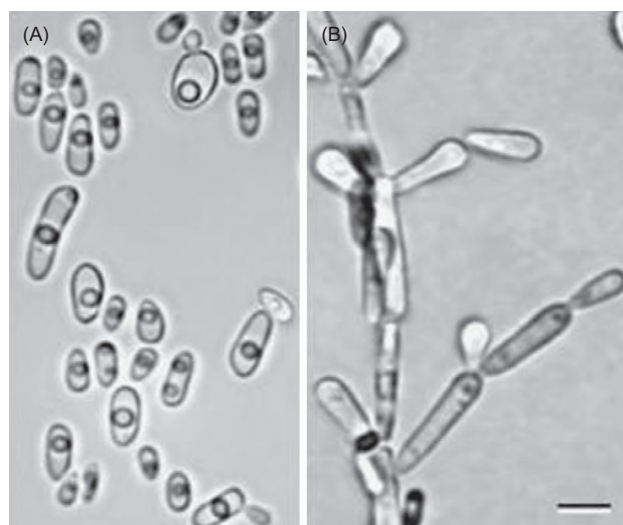


FIGURE 90.148 *Candida pyralidae* NRRL Y-27085. Budding cells after 3 days, 25°C, 5% malt extract agar (A) and pseudohyphae after 7 days, 25°C, yeast morphology agar (B). Bar = 10 μm.

Origin of the strain studied: CBS 5035 (NRRL Y-27085), isolated from frass of moth larva (Lepidoptera: Pyralidae), South Africa.

Type strain: CBS 5035.

Systematics: Kurtzman (2001b) described five species with affinities to *C. tanzawaensis*, which at the time had no known close relatives as assessed by D1/D2 LSU rRNA gene sequencing. Of these species, *C. pyralidae* was described to accommodate an isolate from frass of a moth larva. The species is most closely related to *C. prunicola*. Kurtzman (2001b) commented that the species and its relatives would be difficult to identify on the basis of physiology.

Ecology: *Candida pyralidae* is known from the insect–fungus–tree interface as is the case for most species of the *C. tanzawaensis* clade, which comprises over 20 species (Kurtzman 2001b, Suh et al. 2004b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.229. *Candida qinlingensis* Bai & Lu (Lu et al. 2004a)

Phylogenetic placement: *Barnettozyma* clade (Fig. 90.1).

(The description is based on Lu et al. 2004a.)

Growth on YM agar: After 1 month at 25°C, the colony is butyrous, white to cream, smooth, somewhat dull and with an entire to undulating margin.

Growth in YM broth: After 3 days at 25°C, cells are globose, 1.8–6 μm, to ellipsoidal, 2–5 × 2.5–6.5 μm, occur singly, in pairs or in groups and reproduce by multilateral budding (Fig. 90.149). After 1 month at 25°C, sediment is present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae and true hyphae are absent.

Fermentation

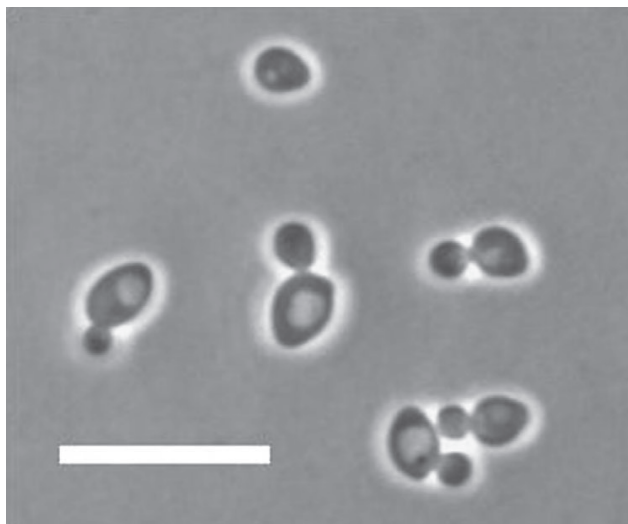
Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	n
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	d
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	d	D-Mannitol	d
Maltose	+	D-Glucitol	d
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	w
Salicin	+	D-Gluconate	n
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	d	Hexadecane	–
L-Arabinose	+	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Nitrite	–	DBB	–
Cadaverine	+	Growth at 19°C	+
L-Lysine	+	Growth at 25°C	+
Ethylamine	+	Growth at 30°C	+
Starch formation	–	Growth at 35°C	–
Urease	–		

CoQ: Not determined.**Mol% G + C:** Not determined.**Gene sequence accession number, type strain:** D1/D2 LSU rRNA = AY450916.**Cell carbohydrates:** Not determined.**Origin of the strain studied:** QL 5-5 (AS 2.2524, CBS 9768), isolated from soil collected in Qinling, Shanxi Province, China (Lu et al. 2004a).**FIGURE 90.149** *Candida qinlingensis* CBS 9768. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.**Type strain:** QL 5-5.**Systematics:** Phylogenetic analysis of sequences of the D1/D2 domains of the LSU rRNA gene placed *C. qinlingensis* close to *Barnettozyma (Williopsis) pratensis* (Lu et al. 2004).**Ecology:** *Candida qinlingensis* is known from soil in China (Lu et al. 2004).**Biotechnology:** Unknown.**Agriculture and food:** Unknown.**Clinical importance:** Unknown.**90.230. *Candida quercitrusa* (van Uden & do Carmo-Sousa) S.A. Meyer & Phaff ex S.A. Meyer & Yarrow (1998)****Phylogenetic placement:** *Kurtzmaniella* clade (Figs 40.1, 90.2).**Synonyms:***Candida parapsilosis* (Ashford) Langeron & Talice var. *querci* van Uden & do Carmo-Sousa (1959)*Candida quercitrusa* (van Uden & do Carmo-Sousa) S.A. Meyer & Phaff (1972) nom. inval.*Candida quercus* (van Uden & do Carmo-Sousa) Montrocher & Claisse (1984) (as *C. querci*) [non *Candida quercuum* Nakase (1971b)]**Growth in glucose-yeast extract-peptone broth:** After 3 days at 25°C, the cells are ovoid, 2–5 $\times$ 4.5–7 μ m, and occur singly, in pairs and small groups (Fig. 90.150 top).**Dalmau plate culture on corn meal agar:** After 7 days at 25°C, pseudohyphae consist of branched chains of cylindrical cells (Fig. 90.150 bottom). Aerobic growth is white, butyrous, soft and smooth to delicately wrinkled.**Fermentation**

Glucose	+	Lactose	–
Galactose	v	Raffinose	–
Sucrose	–/s	Trehalose	–
Maltose	–/s		

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	s
Lactose	–	Galactitol	–
Trehalose	v	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	s
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	v
Salicin	–	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	v	Hexadecane	v
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	s	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono-δ-lactone	v	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	w
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	w	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	—

CoQ: 9 (Yamada and Kondo 1972a).
Mol% G + C: 41.5, CBS 4412 (T_m : Meyer and Phaff 1972); 39.5 (T_m : Nakase and Komagata 1971f); 40.0 (T_m : Su 1990).
Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45831.
Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).
Origin of the strains studied: CBS 4412, isolated from insect frass on an oak tree (*Quercus* sp., Fagaceae); UWOPS 03-190.1, from

nitidulid beetle (*Conotelus* sp., Coleoptera: Nitidulidae) from a flower of morning glory (*Ipomoea batatas*, Convolvulaceae), Costa Rica; UWOPS 91-685.1, from fruit of *Sapindus* sp. (Sapindaceae); UWOPS 04-206.2, from a sap beetle (*Prosopius* sp.) from a flower of holly (*Ilex anomala*, Aquifoliaceae); UWOPS 04-256.4, from nitidulid beetle (*Stelidota geminata*, Coleoptera: Nitidulidae) from a flower of *Hibiscadelphus griffardianus*, Malvaceae); all from Hawai'i, USA.

Type strain: CBS 4412.
Systematics: Van Uden and do Carmo-Sousa described *C. parapsilosis* var. *querc* based on a strain isolated from insect frass in an oak by L.J. Wickerham. The strain had been identified as *C. parapsilosis*, but the authors felt that differences in carbon assimilation and maximum growth temperature were significant. The name *C. quercitrusa* was validated by Meyer and Yarrow (1998), who reviewed the evidence that the species is distinct. The species has affinities for the genus *Kurtzmaniella* (Lachance and Starmer 2008) and is most closely related to *C. natalensis*. However, when nine strains of *C. quercitrusa* were mixed under conditions propitious for conjugation and sporulation in *Kurtzmaniella cleridarum*, mating reactions were not observed.

Physiologically, *C. quercitrusa* is typical of several related (Fig. 90.2) and bears some resemblance to some *Metschnikowia* species, although differentiation on the basis of physiology is possible. Delimitation from the unrelated species *C. sake* was problematic in the past due to strain misidentification and the reporting of growth characteristics as “variable” when considering many strains simultaneously. Resistance to cycloheximide (0.1%) is weak in *C. quercitrusa* and negative in *C. sake*.

Ecology: The exact habitat of the species is not known, although all reported isolates have been found at the plant–insect interface.
Biotechnology: Unknown.
Agriculture and food: Unknown.
Clinical importance: Unknown.

90.231. *Candida quercuum* Nakase (1971b)

Phylogenetic placement: *Wickerhamomyces* clade (Figs 80.1, 90.4).
Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to elongate, 1.5–2.5 × 5–9 μm, and occur singly and in pairs (Fig. 90.151).
Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of elongate cells with globose to ovoid blastoconidia. Aerobic growth is white, butyrous, smooth, dull, dry and entire.

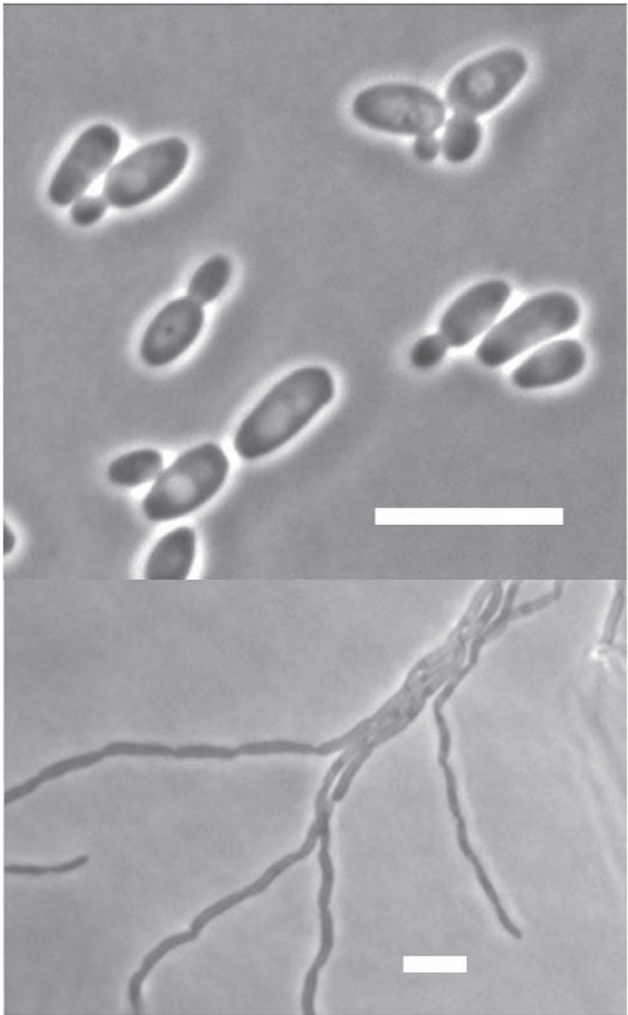


FIGURE 90.150 *Candida quercitrusa* NRRL Y-5392. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μm.

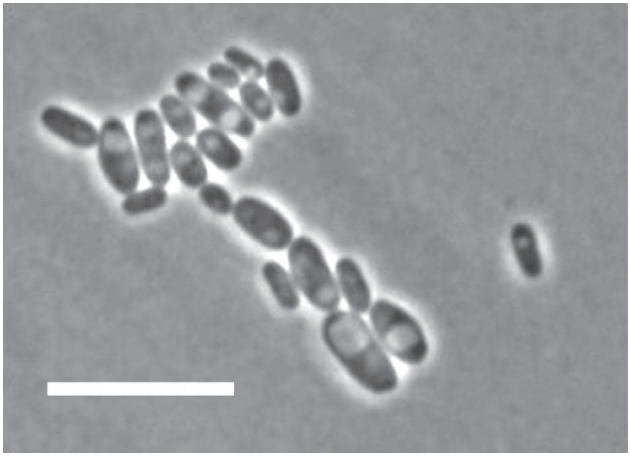


FIGURE 90.151 *Candida quercuum* CBS 6422. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

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Fermentation

Glucose	w	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	+
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	+	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: 38.3, CBS 6422 (T_m : Nakase 1971b); 39.5, CBS 6422 (T_m : S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70184.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6422, exudate of konara oak (*Quercus serrata*, Fagaceae), Japan.

Type strain: CBS 6422.

Systematics: Nakase (1971b) described *C. quercuum* from an oak sap flux isolate. He noted a similarity with *C. oregonensis* and *C. solani*, but also a significant difference in DNA base composition between the three species. Moreover, the assimilation of several carbon sources could be used for separation. The species belongs to the *Wickerhamomyces* clade (Kurtzman et al. 2008).

The growth characteristics determined by replica plating agreed with previous descriptions with minor exceptions. Trehalose assimilation was not confirmed. Galactose utilization was found negative, in agreement with the original description. Separation from distantly related species, such as *Peterozyma* (*Pichia*) *toletana* or *P. xylosa*, would be difficult.

Ecology: Although the species is known from a single isolate, the recovery of moderately related species (some not yet described) in insect frass or tree exudates is consistent with the origin of *C. quercuum* and points to an association with tree-boring insects.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.232. *Candida railenensis* C. Ramírez & A. González (1984c)

Phylogenetic placement: *Kurtzmaniella* clade (Figs 40.1, 90.2)

Synonym:

Apiotrichum osvaldi C. Ramírez & A. González (1984d)¹

¹ Synonymy determined from nuclear DNA reassociation experiments (Tengku Zainal Mulok 1988).

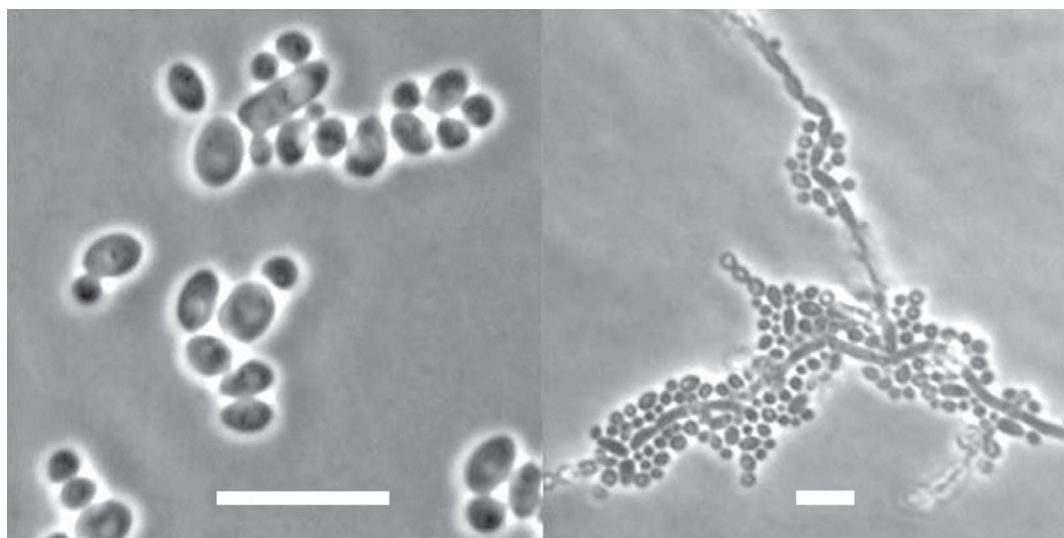


FIGURE 90.152 *Candida railenensis* NRRL Y-17762. Budding cells after 3 days, 25°C, YM agar (left) and pseudohyphae after 14 days, 18°C, YCBAS agar (right). Bars = 10 μ m.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are spherical to ovoid or cylindrical, 2.5–4.5 × 4.5–7.5 μm, and occur singly, in pairs and chains (Fig. 90.152 left). Pseudohyphae are present. A thin, waxy pellicle is evident. After 30 days a thick pellicle is present.

Dalmat plate culture on corn meal agar: After 7 days at 25°C, abundant pseudohyphae with branched chains of cells and ovoid to elongated blastoconidia are present (Fig. 90.152 right). True hyphae are also present. Aerobic growth is cream colored, dull, lacy and raised with a lobed margin.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	s
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	v
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	v	D-Lactate	s
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	s
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	w
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	v	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: 42.0, CBS 8164; 41.5, CBS 8165 (T_m : Tengku Zainal Mulok 1988).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45800.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 8164, isolated from rotten trunk of southern beech (*Nothofagus dombeyi*, Fagaceae); CBS 8165, from rotten trunk of *Nothofagus obliqua*, Chile; CBS 8177, type strain of *Candida rignihuiensis*, from rotten trunk of tepa (*Laurelia philippiana*,

Atherospermataceae); CBS 2223, from rotting carrots, Italy; SUB 84-748.3, from necrotic cladode of prickly pear (*Opuntia stricta*, Cactaceae), Australia; UWOPS 81-24 and four others, from fruit fly (*Drosophila* spp.), Ontario, Canada; UWOPS 82-43, from sap flux of northern red oak (*Quercus rubra*, Fagaceae), Ontario, Canada; UWOPS 79-200, from black knot (*Dibotryon morbosum*, Venturiaceae) on wild cherry (*Prunus avium*, Rosaceae), Ontario, Canada; UWOPS 79-229 and six others, from black knot on choke cherry (*Prunus virginiana*), Ontario, Canada; UFMG 00-32.2 and UFMG 00-172.2, from sap flux of unidentified tree, Mata Atlantica, Brazil.

Type strain: CBS 8164.

Systematics: Ramírez and González (1984c) described *C. railenensis* to accommodate seven isolates from tree trunks in an advanced state of decomposition in the Valdivian rainforest of Chile. The species was treated as a synonym of *C. oleophila* by Barnett et al. (1990). However, DNA reassociation showed that *C. railenensis* and *Apiotrichum osvaldi* are conspecific but distinct from either *C. oleophila* or *C. sake* (Tengku Zainal Mulok 1988). *C. railenensis* and *C. oleophila* are close relatives, differing by only four substitutions in the D1/D2 domains of the LSU rRNA gene (Kurtzman and Robnett 1998a) and four in the ITS region (AY528671 and AY528672). *Kurtzmaniella* is the closest ascosporic genus. As the latter exists in nature in the form of haploid mating types, the 12 available strains of *C. railenensis* were mixed in all possible pairs under conditions that favor ascus formation in *Kurtzmaniella cleridarum*. However, conjugation was not observed.

The physiological profile of *C. railenensis* intergrades perfectly with that of *C. oleophila*, so that separation is not possible on that basis. This is complicated by variation among authentic strains of the species in growth on several carbon compounds and some other growth tests. *C. natalensis*, another relative, may be distinguished only by a combination of lack of growth on 50% glucose and weak or slow growth on 0.01% cycloheximide. Delimitation from *C. sake* can be based on a negative response on the latter test.

The difficulty associated with identification of the species by physiology has resulted in the incorrect assignment of several strains. H.G. Park and S.A. Meyer (unpublished data) determined the sequence of the D1/D2 LSU rRNA gene for several strains that were once assigned to *C. oleophila*. Strain CBS 8177 (AF178052) is identical to the type of *C. railenensis* and strain CBS 2223 (AF178047) differs by one substitution. Other strains examined in this study have identical sequences to the type or differ by one substitution or one substitution and one gap. Most of the strains collected in Ontario had been originally assigned to *C. sake* on the basis of physiology. Strain SUB 84-748.3, originally identified as *Clavispora opuntiae*, was later reassigned to *C. oleophila*, and finally to *C. railenensis* on the basis of the D1/D2 sequence. It contains a 15.1 kb extrachromosomal element (Bogle 1989) thought to be a nuclear plasmid that contains a protein. The element was unstable and could be lost after serial transfer of the strain.

Ecology: Based on the list of isolation sources, the species appears to have an affinity for the tree–fungus–insect interface.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.233. *Candida rancensis* C. Ramírez & A. González (1984h)

Phylogenetic placement: *Metschnikowia* clade (Figs 46.1, 90.1).

(Some of the morphological and growth characteristics are taken from Ramírez & A. González 1984h.)

Growth on glucose–yeast extract–peptone agar: After 1 month at 17°C, the streak culture is white, semi-dull, waxy, smooth, butyrous and with a finely serrulate margin.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose, ovoid or ellipsoidal, 3–6 × 5–10 µm, and occur singly, in pairs or in short chains. Pellicles are not formed. Chlamydospores of the “pulcherrima” type are formed on most agar media.

Dalmau plate culture on corn meal agar: After 2 weeks at 18°C, pseudohyphae are not formed.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	s/–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	s
Raffinose	–	Glycerol	s
Melibiose	–	Erythritol	–
Galactose	w/–	Ribitol	v
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	w	DL-Lactate	–
Soluble starch	–	Succinate	s
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	w	Hexadecane	s
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	s	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Gluconate	–	Gelatin	w
Glucono-δ-lactone	+	Casein	+
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+/w	Growth at 30°C	–/s
50% Glucose	s	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: 4 5.9, type strain (T_m : Daniel 2002).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AJ508580.

Cell carbohydrates: Not determined.

Origin of the strains studied: UWOPS 04-160.3 and one other strain, isolated from a nitidulid beetle (*Prosopeus* cf. *blackburnianus*, Coleoptera: Nitidulidae) from flower of oha wai nui (*Clermontia arborescens*, Campanulaceae), Maui Island; UWOPS 04-206.5, from nitidulid beetle (*Prosopeus* cf. *bidens*) from flower of holly (*Ilex anomala*, Aquifoliaceae); UWOPS 04-233a1, from *Prosopeus subaeneus* from flower of *Hibiscadelphus griffardianus* (Malvaceae); UWOPS 04-235.1, from *Prosopeus inauratus* from flower of smallflower clermontia (*Clermontia parviflora*); all from Hawai'i Island; UWOPS 06-22.1 and one other, from nectar of yellow jessamine (*Gelsemium sempervirens*,

Gelsemiaceae); UWOPS 07-JM105.3, from *Azalea* sp. (Ericaceae); both from Georgia, USA.

Other strains available: CBS 8174 (IJFM 6037), from decayed wood of Chilean laurel (*Laurelia sempervirens*, Atherospermataceae), Valdivian forest, Chile.

Type strain: CBS 8174.

Systematics: *Candida rancensis* was described by Ramírez and Gonzáles (1984h) to accommodate two isolates from rotting wood in the Valdivian rainforest of Chile. Ramírez (1988) later considered the species to be a synonym of *Metschnikowia pulcherrima*, due in part to unspecified technical errors in the original description. Although the two species are similar in many ways, a number of properties attest to the fact that they are separate species, including low similarities in PCR fingerprints, significant differences in LSU and SSU rRNA genes as well as actin gene sequences, differing G+C contents and less than 35% DNA reassociation (Daniel 2002). The closest ascosporic relative is *Metschnikowia reukaufii* (Fig. 46.1).

In reinstating the species, Daniel (2002) suggested that the orthography be changed to *C. rancoensis*, in order to preserve phonetically the name of the location of isolation, Lake Rancho. Manson et al. (2007) followed this recommendation. However, the contraction of the vowels “oe” used by Ramírez and Gonzáles (1984h) is not grammatically incorrect, although the spelling “ranconensis” would have avoided the elision and better preserved the geographic name. To propose another change would not be in line with the spirit of Article 60.3 of the Vienna Code (McNeill et al. 2006), which recommends reserve in correcting the orthography of names. Most importantly, one should be acutely concerned with avoidance of confusion in the literature. Publications that use the original spelling currently outnumber those publications that use the altered spelling. Consequently, the original spelling (*rancensis*) should be retained.

In view of the suggestion by Ramírez (1988) that *C. rancensis* might be conspecific with a *Metschnikowia* species, it comes as no surprise that the species is nearly indistinguishable from *M. reukaufii* based on growth tests. The morphology of chlamydospores, larger and ellipsoidal in *M. reukaufii*, smaller and ovoid in *C. rancensis*, may be of use. The species also exhibits a consistently strong growth on D-gluconic and 2-keto-D-gluconic acids, an intense ability to hydrolyze Tween 80, and a weaker growth in the presence of 50% glucose. The latter trait was noticed in European (Brysch-Herzberg 2004b), North American (Manson et al. 2007) and Hawaiian isolates (M.A. Lachance et al., unpublished data).

Ecology: Brysch-Herzberg (2004b) conducted an intensive study of the yeasts in the digestive tract, mouthparts and body surface of bumblebees as well as the nectar upon which they feed. He found that *C. rancensis* became abundant toward the late part of the summer in the nectar of fireweed (*Epilobium angustifolium*) and great willowherb (*Epilobium hirsutum*, Onagraceae) and in various species in the family Lamiaceae. Manson et al. (2007) found the species in conjunction with *C. gelsemii* in the nectar of the poisonous Carolina gelsamine and of garden Azaleas in Georgia, USA.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.234. *Candida restingae* Rosa, Lachance, Starmer, Barker, Bowles & Schlag-Edler (1999)

Phylogenetic placement: see Systematics.

Growth on YM agar: After 2 weeks at 17°C, colonies are small, low convex, glossy, smooth, white and butyrous.

Growth in glucose–yeast extract broth: After 3 days at 25°C, the cells are ovoid to ellipsoidal, 2–4 × 4–6 µm, and occur singly or in parent-bud pairs (Fig. 90.153). Buds may be formed on a short protuberance. A pellicle is not formed.

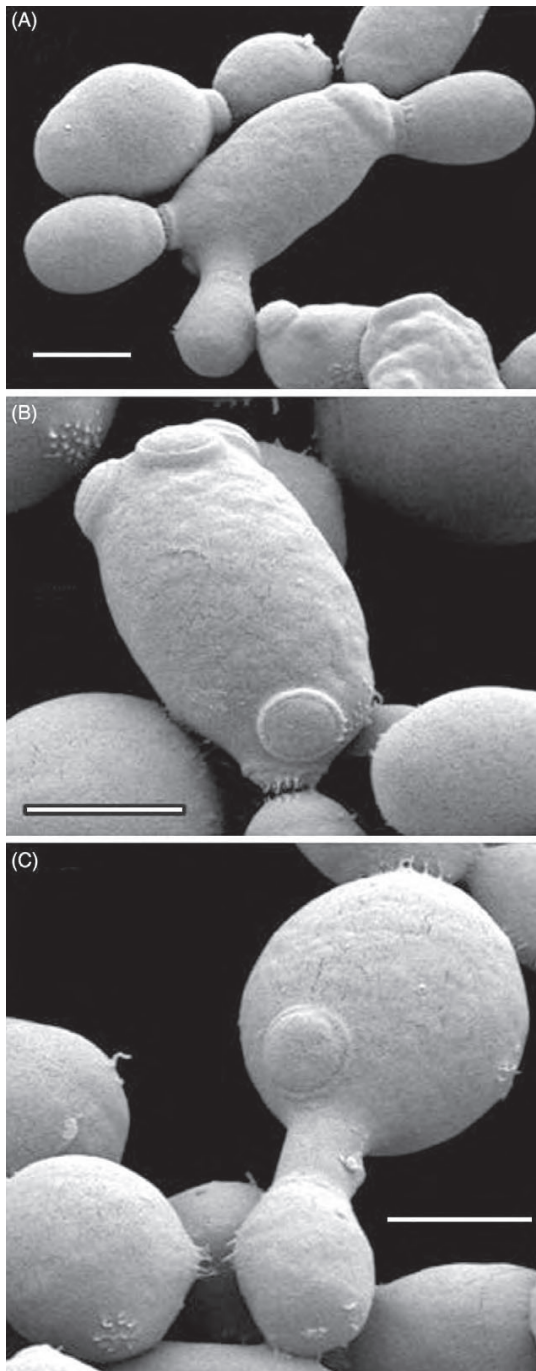


FIGURE 90.153 *Candida restingae* UFMG 96-276. Budding cells after 3 days, 25°C, YM agar. Bars = 2 μm. Scanning electron micrographs reproduced from Rosa et al. (1999) with permission.

Dalmau plate culture on corn meal agar: After 2 weeks at 18°C, occasional true hyphae are formed.

Fermentation

Glucose	s	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	v	Methanol	—
Sucrose	+	Ethanol	s
Raffinose	+	Glycerol	s
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	s	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl-α-D-glucoside	+	D-Lactate	—
Soluble starch	—	Succinate	v
Cellobiose	s	Citrate	v
Salicin	s	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	w
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	s	Hexadecane	w
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono-δ-lactone	s	Casein	—
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	s	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	v

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF059667.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 8493 (UFMG 96-276) and one other isolate from flowers of *Cereus perambucensis* (Cactaceae); UFMG 96-331 and one other isolate from flowers of *Pilosocereus arrabida* (Cactaceae); UFMG 96-308 and two other isolates from tunnels of the pyralid moth *Sigalgaita* sp. in *Pilosocereus arrabida*, all from Brazil. UWOPS 99-336.1 and two other strains from different insects collected on a flower of Costa Rica nightblooming cactus (*Hylocereus costaricensis*, Cactaceae), Costa Rica; UWOPS 05-268.1 and one other strain, from nitidulid beetles from flowers of morning glory (Convolvulaceae), Malaysia.

Type strain: CBS 8493.

Systematics: Rosa et al. (1999) described *C. restingae* on the basis of several strains recovered from cactus flowers in Brazil. They noted the similarity of the species with species of *Kodamaea*, which were shown to be close relatives by D1/D2 LSU rRNA gene. A direct connection with one particular teleomorphic species is not evident (Lanchance et al. 1999).

The growth characteristics are typical of *Kodamaea* species and also resemble those of other unrelated species, including *Candida melibiosica* and some species of *Debaryomyces* and *Metschnikowia*. The utilization of raffinose and xylitol, combined with the absence of growth on melibiose, L-rhamnose and gluconic acid or in the presence of 50% glucose, is useful in distinguishing the species from

others. The cell morphology is distinctive, featuring the production of buds at the end of protuberances.

Ecology: An association with insects that breed and feed on tropical plants is evident. The species appears to be cosmopolitan in distribution, which is somewhat unusual for yeasts that are specific to certain plant insects. However, the recently described sister species, *C. leandrae* (Ruivo et al. 2004), follows a similar pattern, having been recovered from flowers of *Leandra reversa* (Melastomataceae) in Brazil, from an insect of a flower of morning glory (*Ipomoea indica*, Convolvulaceae) on the Island of Oahu, Hawai'i, and from a flower of woodrose (*Merremia tuberosa*, Convolvulaceae) in Costa Rica.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.235. *Candida rhagii* Jurzitza, Kuhlwein & Kreger-van Rij (1960)

Phylogenetic placement: *Hyphopichia* clade (Figs 33.1, 90.1).

Synonym:

Candida tropicalis (Castellani) Berkhout var. *rhagii* Diddens & Lodder (1942)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, 2–4 × 4–6 μm, and occur singly and in pairs.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of cylindrical cells with verticils of ovoid blastoconidia. Aerobic growth is white and wrinkled with a fringed border.

Fermentation

Glucose	+	Lactose	–
Galactose	v	Raffinose	v
Sucrose	+	Trehalose	+
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	–	Erythritol	v
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	v	DL-Lactate	v
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	v
L-Sorbose	v	D-Glucosamine	+
L-Rhamnose	v	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	v	Nitrate	–
D-Arabinose	–	Vitamin-free	v

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–/w
Amino acid-free	+	Lipase	v
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	–

CoQ: 8 (Suzuki and Nakase 1998).

Mol% G + C: 42.4, CBS 4237 (T_m : Meyer and Phaff 1972).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45729.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 618, isolated from longhorn beetle (*Rhagium bifasciatum*, Coleoptera: Cerambycidae); CBS 4237, from longhorn beetle (*Harpium inquisitor*, Coleoptera: Cerambycidae).

Other strain available: CBS 4284, from longhorn beetle (*Gaurotes virginea*, Coleoptera: Cerambycidae).

Type strain: CBS 4237.

Systematics: Jurzitza et al. (1960) examined a number of isolates from several species of cerambycid beetles. Included were newly isolated strains as well as earlier material from the CBS collection. Based on Wickerham's expanded assimilation tests, some of the strains were identified as *C. tenuis* and others could be assigned to *C. tropicalis* var. *rhagii*, which had been transferred to *C. guilliermondii* by Lodder and Kreger van Rij (1952). The variety served as the basis for the description of *C. rhagii*. Kurtzman and Robnett (1997) found *C. rhagii* and *Hyphopichia* (*Pichia*) *heimii* to differ by two nucleotides in the D1/D2 LSU rRNA gene sequence, suggesting that the two taxa might be conspecific. In a recent study of several isolates recovered from insect frass collected in various conifers of eastern and central North America, Kurtzman (2005b) described the close relative *C. pseudorhagii*.

Ecology: *Candida rhagii* is currently known exclusively through isolates recovered from cerambycid (longhorn) beetles and was considered a symbiont of these insects by Jurzitza et al. (1960). Longhorn beetles are notorious for the damage that they may inflict to trees by burrowing through the cambium layer. The closest relatives (Kurtzman 2005), *Hyphopichia heimii*, *C. pseudorhagii*, *C. gotoi*, *C. homilientoma*, *C. fennica* and *Hyphopichia burtonii*, were all isolated in the frass of tree-boring beetles or damaged wood of trees or decaying wood, suggesting that yeasts in that clade have a well-defined niche at the tree–beetle interface.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.236. *Candida riidocensis* Pimentel, Lachance & Rosa (M. Pimentel et al. 2005)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

(The description is based on M. Pimentel et al. 2005.)

Growth on YM agar: After 3 days at room temperature, colonies are white, convex, smooth, opalescent and have an entire edge.

Growth in 0.5% yeast extract–2% glucose broth: After 3 days at 25°C, the cells are ovoid to ellipsoidal, $1\text{--}3 \times 2\text{--}4\text{ }\mu\text{m}$, and reproduce by multilateral budding. Sediment is formed after 1 month.

Dalmau plate culture on corn meal agar: After 2 weeks, neither pseudohyphae nor true hyphae are formed.

Fermentation

Glucose	v	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (Media not Specified)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	–
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	v	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	n	D,L-Lactate	–
Soluble starch	–	Succinate	–
Cellulobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	50% Glucose	–
2-Keto-D-gluconate	–	10% NaCl/5% glucose	+
D-Glucuronate	–	Starch formation	–
Amino acid-free	+	Urease	–
Nitrite	–	DBB	–
Cadaverine	+	Cycloheximide 0.01%	v
L-Lysine	+	Growth at 37°C	+
Ethylamine	+	Growth at 40°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY861674.

Cell carbohydrates: Not determined.

Origin of the strains studied: UFMG-MG02 (CBS 10087, NRRL Y-27859), and 11 other strains, isolated from pollen–nectar provision in a nest of the solitary bee (*Megachile* sp.), Parque Estadual do Rio Doce, Minas Gerais, Brazil (M. Pimentel et al. 2005).

Type strain: UFMG-MG02.

Systematics: Phylogenetic analysis of the D1/D2 domains of the LSU rRNA gene placed *C. riodecensis* in a clade with *C. batistae* and *C. bombicola* (M. Pimentel et al. 2005).

Ecology: *Candida riodecensis* was isolated from a nest with larvae and fecal pellets of a solitary bee in Brazil (M. Pimentel et al. 2005).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.237. *Candida rugopelliculosa* Nakase (1971a)

Phylogenetic placement: *Pichia* clade (Figs 57.1, 90.1).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are mostly ovoid to elongate, $2\text{--}5 \times 6\text{--}11\text{ }\mu\text{m}$, and occur singly, in pairs and short chains (Fig. 90.154 top). Some spherical cells are present. A wrinkled, folded pellicle is present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of cylindrical cells (Fig. 90.154 bottom) with verticils of blastoconidia. Aerobic growth is white to off-white with raised, folded areas and a hyphal border.

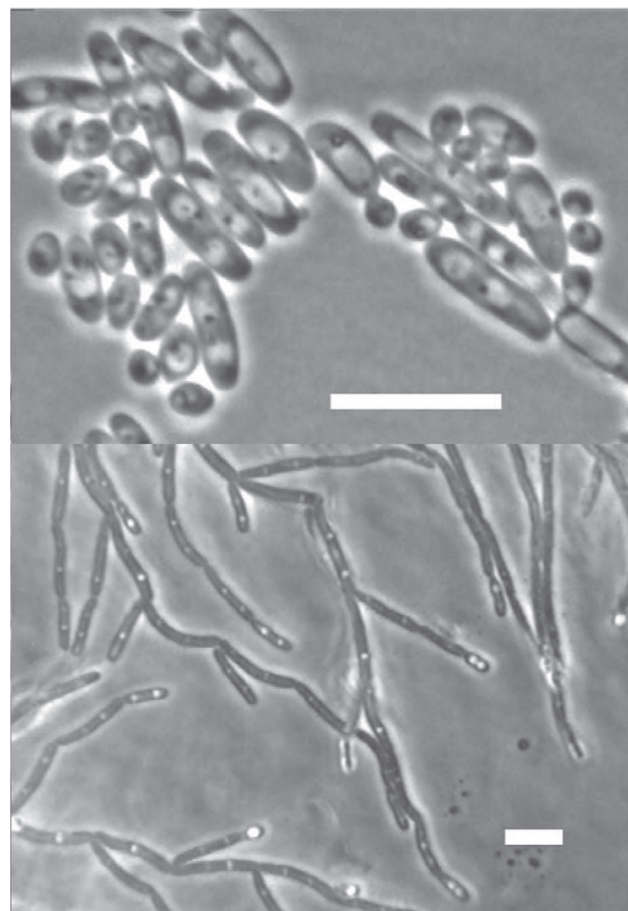


FIGURE 90.154 *Candida rugopelliculosa* CBS 6377. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μm .

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	–
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	+

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Gluconate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: 30.0, CBS 6377 (T_m : Nakase 1971a).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = UJ1069.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6377, isolated from a soybean protein factory in Japan.

Type strain: CBS 6377.

Systematics: Nakase (1971a) examined 76 strains that resembled *C. krusei* in that they utilized few carbon compounds. The strain, which was reassigned to *C. rugopelliculosa*, differed in DNA base composition and fermentative ability from other strains with similar growth characteristics. Sequence analyses link the species to the *Pichia membranifaciens* clade, but the exact placement varies in different analyses (Kurtzman and Robnett 1998a, Suzuki and Nakase 2002, Fig. 57.1, Fig. 90.1).

Assessment of growth characteristics by replica plating agreed with the original description, but some minor differences were found with those given by Meyer et al. (1998), namely in the utilization of D-ribose (negative) and D-glucosamine (positive) as carbon sources, and growth in the presence of sodium chloride (slow at 5%, negative at 10%). Differentiation from related species is difficult, although the utilization of glucono- δ -lactone and D-glucosamine, and the absence of growth on N-acetyl-D-glucosamine may be of utility in some cases.

Ecology: Lim et al. (2003) reported on the use of *C. rugopelliculosa* in combination with the rotifer *Brachionus plicatilis* as a means of reducing the soluble chemical oxygen demand (SCOD) of fish processing effluents. Interestingly, the authors referred to this species as being

proteolytic and commented on its ability to reduce the protein concentration in the effluents. Proteolytic activity against gelatin or casein was not detected in the type strain, although this does not preclude the excretion of proteases active on other substrates by the strain used in that study. Note that a strain number was not given to the specimen used in the study.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.238. *Candida rugosa* (Anderson) Diddens & Lodder (1942)

Phylogenetic placement: unaffiliated clade (Fig. 90.3).

Synonyms:

Monilia rugosa (Castellani) Castellani & Chalmers (1913)

Mycoderma rugosa Anderson (1917)

Mycotorula rugosa (Saito) Harrison (1928)

Azymocandida rugosa (Anderson) Novák & Zsolt (1961)

?*Candida rugosa* (Anderson) Diddens & Lodder var. *elegans* Dietrichson (1954)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are elongate, 1.5–2.5 $\times$ 5–11 μ m, and occur singly and in pairs (Fig. 90.155 top). Islets or a pellicle are present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of densely branched chains of elongate cells (Fig. 90.155 bottom). Aerobic growth is off-white, wrinkled and fringed with pseudohyphae.

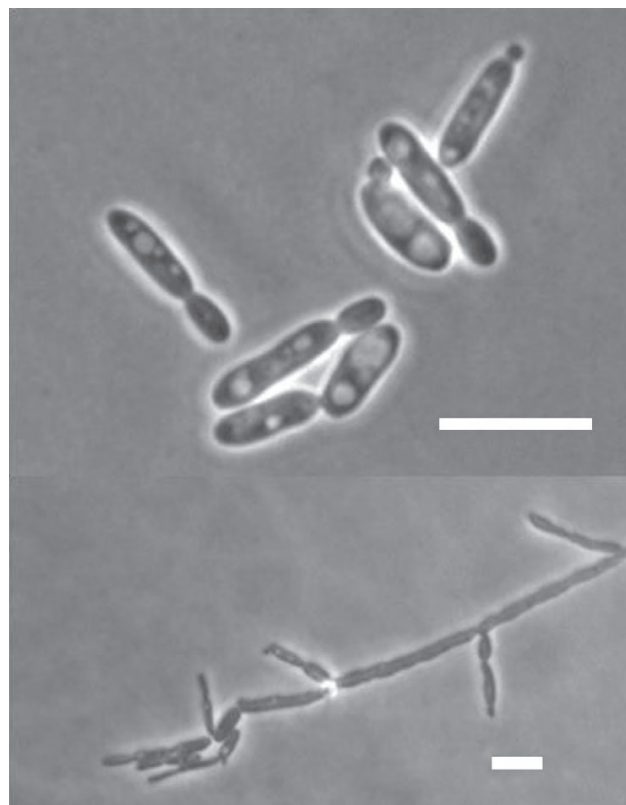


FIGURE 90.155 *Candida rugosa* CBS 613. Budding cells after 3 days, 25°C, YM agar (top) and pseudohypha with blastoconidia after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μ m.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	v	Ribitol	v
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	v
Maltose	—	D-Glucitol	v
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	D,L-Lactate	v
Soluble starch	—	Succinate	v
Cellobiose	—	Citrate	v
Salicin	—	D-Gluconate	v
L-Sorbose	v	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	v	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	v	Casein	w
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	+

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 50.2–50.7, 4 strains (T_m : Nakase et al. 1978).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45727.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 613, isolated from human feces.

Other strains available: CBS 2016, from cow dung, UK; CBS 2274, clinical isolate, from R. Ciferri; CBS 2277, from rancid butter, The Netherlands; CBS 6314, origin unknown, from J.P. van der Walt; CBS 7138, from soil, The Netherlands.

Type strain: CBS 613.

Systematics: Nakase et al. (1978) clarified the taxonomy of *C. rugosa* and transferred one strain previously assigned to the species to the newly created *C. pararugosa*. Ribosomal RNA gene sequences (Kurtzman and Robnett 1998a, Sugita and Nakase 1999) of the species are unique and divergent, precluding the assignment of a credible phylogenetic position. An affinity with the recently described *C. scorzettiae* (Middlehoven and Kurtzman 2007) is possible.

Strain CBS 2275, previously identified as *C. rugosa*, keyed physiologically to *C. pararugosa*. That identification was evaluated by D1/D2 sequencing (AY536215), and a difference of five substitutions was found, indicating that the strain may belong to *C. pararugosa* or to a closely related species.

The growth characteristics of the type strain, as determined by replica plating, agreed with the description except for growth in the presence of 50% glucose, which was found to be negative.

Ecology: Unknown.

Biotechnology: A large amount of literature exists on so-called “*C. rugosa* lipases” (Benjamin and Pandey 1998). Unfortunately, it appears that the strain used in most studies, CBS 6330 (ATCC 14830), is the type of *C. cylindracea*, resulting in considerable confusion. Both names are used extensively, although the two species bear little resemblance and are unrelated. The type strain of *C. rugosa* exhibited no lipase activity when tested by Tween 80 hydrolysis. Ostensibly because of its interest in biotechnology, the strain has been examined by geneticists. For example, because of an early report that *C. rugosa* translates the codon CUG into serine instead of leucine, a special transformation system was constructed (Tang et al. 2003). But again, the strain used was the type of *C. cylindracea*. Both species, incidentally, recognize CUG for serine, which is not as rare as previously thought. Of 78 *Candida* species examined by Sugita and Nakase (1999), 69 translated CUG into serine.

Agriculture and food: Similarly, misidentification of food isolates such as *C. rugosa* is likely, when in fact they belong to *C. cylindracea* or *C. pararugosa*. This said, Suzzi et al. (2003) reported the isolation of 17 strains of *C. rugosa* from Manteca, a buttery whey cheese produced in southern Italy. Identification was based on commercial test strips, and variation was observed in responses to 10% NaCl and maximum growth temperature, suggesting some uncertainty as to their correct identity.

Clinical importance: Misidentification and confusion are also likely to arise in clinical studies, many of which report *C. rugosa* as an emerging opportunistic pathogen.

90.239. *Candida sagamina* Nakase, M. Suzuki, Sugita, S.-O. Suh & Komagata (1999)

Phylogenetic placement: *Kodamaea* clade (Fig. 36.1).

(Some of the morphological characteristics are based on Nakase et al. 1999.)

Growth in YM broth: After 3 days at 25°C, a thin, wrinkled pellicle is produced. The cells are usually elongate, sometimes ellipsoidal or long ellipsoidal, 2.5–5 $\times$ 6–20 μ m (Fig. 90.156). Pseudohyphal cells are often longer. After 1 month at 17°C, a thick pellicle with a cottony surface is present.

Growth on YM agar: After 1 month at 17°C, the streak culture is white to yellowish-white, wrinkled, cottony near the bottom, tough and with a ciliate margin.

Slide culture on potato dextrose agar: Well-developed pseudohyphae with a few blastoconidia are formed.

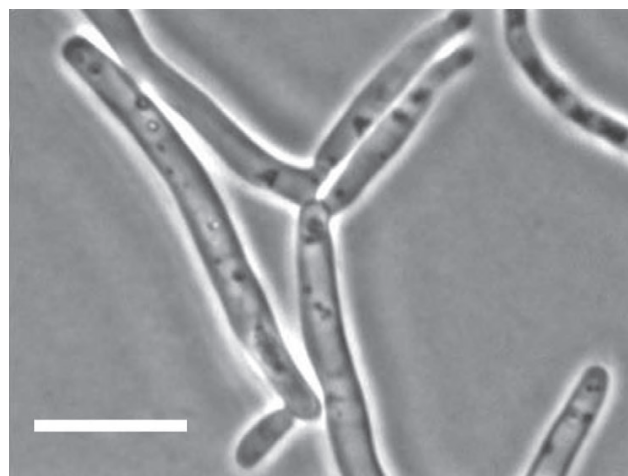


FIGURE 90.156 *Candida sagamina* JCM 10144. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

Fermentation

Glucose	w	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	w
Salicin	+	D-Gluconate	w
L-Sorbose	—	D-Glucosamine	s
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	—	Nitrate	—
D-Arabinose	w	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	—
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	w
50% Glucose	—	Growth at 37°C	—

CoQ: 9 (Nakase et al. 1999).

Mol% G + C: 40.5, type strain (HPLC: Nakase et al. 1999).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY313959.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Nakase et al. 1999).

Origin of the strain studied: JCM 10144 (CBS 9140), isolated from fruiting body of unidentified mushroom, Japan.

Type strain: CBS 9140.

Systematics: Nakase et al. (1999) examined four isolates from mushrooms that resembled *C. mesenterica* but could not be assigned to any known species. DNA reassociation and sequencing of ITS regions, and the 5.8S and SSU rRNA genes showed the strains to represent three distinct species related to *C. mesenterica* and *C. suecica*. Sequencing of the D1/D2 LSU rRNA gene (AY313959) further demonstrated membership of *C. sagamina* and the related species *C. fukazawae* and *C. fungicola* in the *Kodamaea* clade (Fig. 36.1).

The growth characteristics determined by replica plating agreed well with the description. A weak fermentative ability (reported as negative in the description) was also found. Although lipase activity was originally reported as negative, Tween 80 was hydrolyzed. The

species is physiologically similar to *C. oregonensis*, but unlike the latter, does not utilize L-rhamnose and is resistant to 0.1% cycloheximide.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.240. *Candida saitoana* Nakase & M. Suzuki (1985b)

Phylogenetic placement: *Candida glabrosa* clade (Fig. 90.2).

Synonyms:¹

Torula candida Saito (1922)

Torulopsis candida (Saito) Lodder (1934)

Cryptococcus candidum (Saito) Skinner (1950)

Torulopsis candida (Saito) Lodder var. *marina* Kawano, Kojima, Ohosawa & Morinaga (1976)

¹ Synonymy based on phenotype.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 5–8 $\times$ 5–10 μ m, and occur singly and in pairs (Fig. 90.157).

Dalmay plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are either absent or poorly developed. Aerobic growth is off-white, smooth, shiny and entire.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	w
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—
Lactose	+	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	w
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	—
Salicin	—	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	+

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	—	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

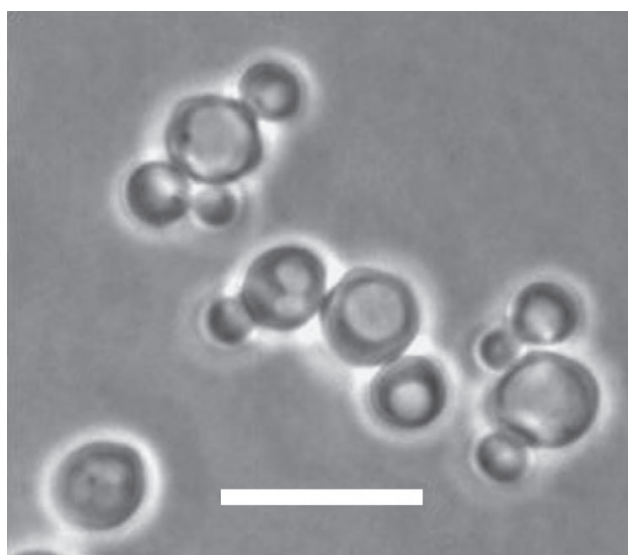


FIGURE 90.157 *Candida saitoana* CBS 940. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

CoQ: 9 (Nakase and Suzuki 1985b).

Mol% G + C: 36.3–37.5, 6 strains (T_m : Nakase and Suzuki 1985b).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45762.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of strains studied: CBS 940, isolated from the atmosphere, Japan.

Other strain available: CBS 8046, from fish food.

Type strain: CBS 940.

Systematics: Nakase and Suzuki (1985b) reviewed the taxonomy of *Debaryomyces hansenii* and related species based on carbohydrate composition, serology, isoenzyme electrophoresis and other characteristics, and concluded that the 52 strains examined could be subdivided into three major groups. Group III consisted of six strains that were serologically unique, had a maximum growth temperature of 34–35°C, assimilated propylene glycol, and were distinct in two isoenzyme profiles. These were assigned to *C. saitoana* and the remaining strains were regarded as members of *Debaryomyces hansenii* and *Debaryomyces nepalensis*. The species is part of a clade that contains a number of *Candida* species with a moderate relationship to *Priceomyces* (*Debaryomyces*) *melissophilus* (Kurtzman and Robnett 1998a). A neighbor-joining analysis of sequences of the D1/D2 domains of the LSU rRNA gene (Fig. 90.2) and the SSU rRNA gene (Sugita and Nakase 1999) identified *C. glabrosa* and *C. pseudoglabrosa* as close relatives. Suzuki and Nakase (1993) noted that distinction between *C. saitoana* and its close relatives on the basis of physiological traits is difficult.

The growth characteristics of strain CBS 8109, deposited as *C. saitoana*, differed from those of the type and keyed to *C. palmioleophila*. The D1/D2 sequence of the LSU rRNA gene was determined and found identical to that of *C. palmioleophila*.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Bovill et al. (2001) evaluated a number of media for the enumeration of probiotic yeasts in animal feeds. Difficulties were experienced with the recognition of *C. saitoana*, apparently due to strain variability.

Clinical importance: Unknown.

90.241. *Candida sake* (Saito & Oda) van Uden & H.R. Buckley ex S.A. Meyer & Ahearn (1983)

Phylogenetic placement: unaffiliated clade (Fig. 90.5).

Synonyms:

Eutorulopsis sake Saito & Oda (1934)

Torulopsis sake (Saito & Oda) Lodder & Kreger-van Rij (1952)

Candida sake (Saito & Oda) van Uden & H.R. Buckley (1970) nom. inval.

Torula lambica Kufferath (1925)

Mycotorula lambica Harrison (1928)

Candida tropicalis (Castellani) Berkhout var. *lambica* (Harrison) Diddens & Lodder (1942)

Candida vanriji Capriotti (1958f)

Candida salmonicola Komagata & Nakase (1965)

Candida australis S. Goto, Sugiyama & Iizuka (1969)

Candida austromarina (Fell & I.L. Hunter) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)¹

¹ Synonymy based on sequence analysis of D1/D2 LSU (Kurtzman and Robnett 1998a) and SSU (Sugita and Nakase 1999) rRNA genes.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are spherical, ovoid, elongate or cylindrical, 2.5–6 $\times$ 3–7 μ m, and occur singly, in pairs, short chains and small clusters (Fig. 90.158). Pseudohyphae may be present. A ring, islets and a thin pellicle may be formed.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae may consist merely of a few short chains of cells or of long, branched chains of cylindrical cells with well-differentiated blastoconidia. Aerobic growth varies from smooth to lacy and wrinkled, white to off-white, creamy and soft. The margin may be entire or irregular.

Fermentation

Glucose	v	Lactose	—
Galactose	v	Raffinose	—
Sucrose	v	Trehalose	v
Maltose	v		

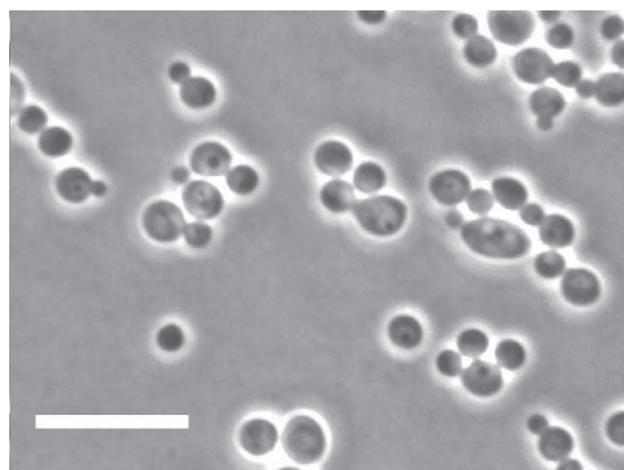


FIGURE 90.158 *Candida sake* CBS 159. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	v	Ethanol	v
Raffinose	—	Glycerol	v
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	v
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	v
Maltose	v	D-Glucitol	v
Melezitose	v	myo-Inositol	—
Methyl- α -D-glucoside	v	DL-Lactate	v
Soluble starch	—	Succinate	+
Cellobiose	v	Citrate	v
Salicin	v	D-Gluconate	v
L-Sorbose	v	D-Glucosamine	v
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	v	Hexadecane	v
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	v

Additional Growth Tests and Other Characteristics

Xylitol	—	DBB	—
2-Keto-D-gluconate	v	Gelatin	—
D-Glucuronate	—	Casein	—
Glucono- δ -lactone	v	Lipase	s/—
Amino acid-free	+	Acid production	—
Nitrite	—	Cycloheximide 0.01%	—
Ethylamine	v	Cycloheximide 0.1%	—
L-Lysine	v	1% Acetic acid	—
Cadaverine	v	Growth at 25°C	v
10% NaCl	v	Growth at 30°C	v
50% Glucose	—	Growth at 37°C	—
Starch production	—		

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 37.8–41.0, 10 strains (T_m : Meyer et al. 1975); 39.3, CBS 159 (T_m : Kaneko et al. 1977); 40.1, CBS 159; 39.7, JMC 1595 (CBS 5690) (T_m : Suzuki and Nakase 1988b); 39.0, CBS 6179, CBS 6588 (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA gene = U45728.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 159, isolated from sake-moto, Japan; CBS 2213, from sap of beech (*Fagus* sp., Fagaceae), The Netherlands; CBS 2920, type strain of *C. vanrijiae*, from soil, Sweden; CBS 4436, sent by A. Capriotti; CBS 5093, from grape juice; CBS 5740, from soil, Chile; CBS 5690, type strain of *C. salmonicola*, from frozen salmon, Japan; (CBS 5957, from water, Antarctica; CBS 6304, type strain of *C. australis*, from water, Antarctica); CBS 6716, from seawater, Chesapeake Bay, between Maryland and Virginia, USA; UWOPS 79-132, from black knot (*Dibotryon morbosum*, Venturiaceae) of sand cherry (*Prunus pumila*, Rosaceae), Ontario, Canada; UWOPS 04-214.1, from nitidulid beetle (*Prosopius* cf. *bidens*, Coleoptera: Nitidulidae) from flower of lava clermontia (*Clermontia calophylla*, Campanulaceae), Hawai'i Island.

Other strains available: CBS 1939, from beer conduit in brewery, Sweden; CBS 2882, CBS 2883, from egg yolk (received as *C. parapsilosis*); CBS 2921, from soil, Sweden; CBS 6717 and CBS 6718, all from seawater, Chesapeake Bay, USA; CBS 6179, type strain of *C. austromarina* and CBS 6588, from Antarctic Ocean.

Type strain: CBS 159.

Systematics: Meyer et al. (1998) and Kaneko et al. (1977) demonstrated low DNA reassociation values between *C. sake*, *C. maltosa* and *C. tropicalis*, confirming their status as distinct species. Separation has been suggested also by immunological and cell wall composition studies (Fukazawa et al. 1975, Montrocher 1980). Analysis of the D1/D2 domains of the LSU (Kurtzman and Robnett 1998a) and the SSU (Sugita and Nakase 1999) rRNA genes placed *C. sake* in a basal position in proximity to the *Lodderomyces* clade.

The identities of strains CBS 617 (but see below), CBS 2920, CBS 5690, CBS 6716 and CBS 6717 had been established by DNA reassociation (Meyer and Phaff 1972, Meyer et al. 1975, Suzuki and Nakase 1988b). Strains UWOPS 79-132, UWOPS 04-214.1, CBS 2213 and CBS 5093 have been identified by D1/D2 rRNA gene sequencing either in this study or at the CBS. These strains were found to be physiologically homogeneous, except for strain CBS 617, which resembled *Yamadazyma mexicana* in growth characteristics. For this reason, the D1/D2 sequence was determined and found to match exactly that of the type strain of *C. parapsilosis*. This is at variance with the CBS database, which reports for this strain a match with the D1/D2 sequence of *C. tenuis*. The reason for this is not clear. CBS 5740 exhibited minor differences in growth characteristics from other authentic strains. However, the D1/D2 sequence (AY536216) differs by only two substitutions from that of the type strain, which does not, on its own, constitute a compelling reason to exclude it from the species. The physiological profiles of strains CBS 4436, CBS 5957 and CBS 6304 are consistent with their assignment to the species, although their identities have not been verified by DNA-based methods.

Other strains previously assigned to the species were found to differ significantly in growth responses as well as D1/D2 LSU rRNA gene sequences and were reassigned as follows: strain CBS 4076 was transferred to *C. musae*; strain CBS 5661 gave anomalous physiological results and the D1/D2 LSU rRNA gene sequence matched that of *C. peltata*, to which the strain is provisionally reassigned.

Other species that have in the past been misidentified as *C. sake* include members of the *Kurtzmaniella* clade, namely *C. fragi*, *C. natalensis*, *C. oleophila* and *C. railenensis*. As a consequence of these many reassignments, the number of properties previously reported as variable in *C. sake* has decreased considerably and identification based on physiology has become more practical, although not entirely free of problems.

Torulopsis austromarina was described by Fell and Hunter (1974) based on 85 isolates recovered in Antarctic seawater. A trehalose-positive biotype (53 isolates) came from the Indo-Pacific sector; and a trehalose-negative biotype was restricted to the Indian Ocean sector. The isolates only ferment glucose, and the results vary from strain to strain. Notably, the assimilation of sucrose, maltose, melezitose, methyl- α -D-glucoside, cellobiose, salicin, L-sorbose, D-xylose, D-ribose, ribitol, D-mannitol, D-glucitol, DL-lactate, citrate, D-glucosamine, ethylamine, L-lysine and cadaverine, as well as growth in the absence of vitamins, in the presence of 10% NaCl, or at 22°C is negative. Based on the restricted growth capabilities of the yeast, a relationship with *C. inconspicua* was postulated by Fell and Hunter (1974). The D1/D2 LSU (Kurtzman and Robnett 1998a) and SSU (Sugita and Nakase 1999) rRNA gene sequences of *C. sake* and *C. austromarina* were later found to be identical, indicating that the two taxa should be treated as members of the same species. In view of the psychrophilic nature of the many strains previously assigned to *C. austromarina*, it might be desirable to recognize them as members of a separate physiological variety. The tests reported here were conducted at 15–17°C by S.A. Meyer. The maximum temperature for growth of these strains is 18–21°C. Only one of the authentic strains of *C. sake* studied (UWOPS 79-132) grew at 30°C, indicating that the strains previously assigned to *C. sake*, although not strictly psychrophilic, may lie at the lower end of the mesophilic range.

Ecology: Authentic strains of *C. sake* have been recovered sporadically in a broad array of substrates and do not seem to be associated with a particular habitat. The isolates that were formerly assigned to *C. austromarina* were isolated in Antarctic seawater, suggesting an adaptation to cold marine waters.

Biotechnology: *Candida sake* has been used as a postharvest biocontrol agent to prevent the growth of molds in pome fruit. The low temperature profile of the species was noted by Cañamás et al. (2008) who proposed a heat treatment aimed at improving the stability of the yeast during spray drying.

Agriculture and food: See biotechnology, above.

Clinical importance: *Candida sake* has a long history of misidentification due to the similarity of its growth characteristics to those of several other species in the *Lodderomyces*, *Debaryomyces* and *Metschnikowia* clades. For this reason, and in view of the poor growth of the species at temperatures of 30°C or above, it is unlikely that *C. sake* plays much of a role as a mammalian pathogen. This point was made by Hoeg et al. (1998), who examined more closely a number of isolates from patients suffering from HIV-associated oropharyngeal candidosis. Isolates putatively identified as *C. sake* based on growth profiles assessed with commercial test strips were compared by RAPD profiling. The latter indicated that the isolates probably belonged to *C. albicans*.

Additional comments: Deegenaars and Watson (1997) determined that *C. austromarina* and *C. psychrophila* as well as three basidiomycetous species are obligate aerobes in addition to being psychrophiles. Supplementation with lipids that are known to restore fermentative ability in many species did not do so in these yeasts. The authors further observed that these species contain polyunsaturated fatty acids and are unable to form respiratory-deficient mutants.

90.242. *Candida salmanticensis* (Santa María) van Uden & H.R. Buckley ex S.A. Meyer & Ahearn (1983)

Phylogenetic placement: unaffiliated clade (Fig. 90.3).

Synonyms:

Torulopsis salmanticensis Santa María (1963a)

Candida salmanticensis (Santa María) van Uden & H.R. Buckley (1970) nom. inval.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 3–5 × 4–8 μm, and occur singly, in pairs and in clusters (Fig. 90.159).

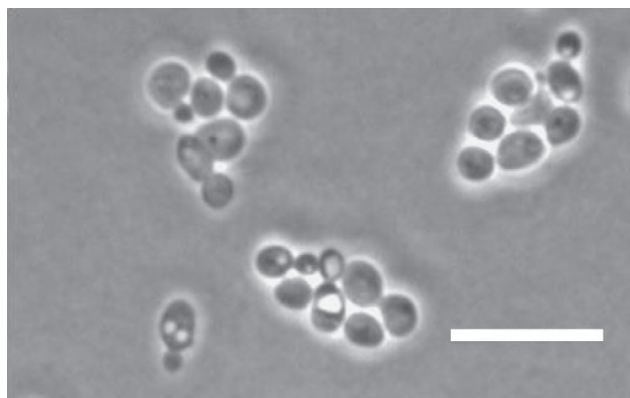


FIGURE 90.159 *Candida salmanticensis* CBS 5121. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of chains of cylindrical cells with verticils of ovoid blastoconidia. Aerobic growth is white to cream colored, dull and smooth with an entire border.

Fermentation

Glucose	+	Lactose	–
Galactose	s	Raffinose	+
Sucrose	+	Trehalose	+
Maltose	+		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	+	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	v
Melibiose	+	Erythritol	–
Galactose	+	Ribitol	s
Lactose	–/w	Galactitol	–
Trehalose	+	D-Mannitol	s
Maltose	+	D-Glucitol	v
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D,L-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	–/w
Salicin	s	D-Gluconate	s
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	–/w	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	s	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	–

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 45.5, CBS 5121 (BD: Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U62308.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5121, isolated from alpechin, a residue from the preparation of olive oil; UWOPS 85-301.1, from *Drosophila carbonaria* (Drosophilidae) collected in a sap flux of mesquite (*Prosopis juliflora*, Fabaceae), Arizona; UWOPS 03-325y3, from sap flux of red oak (*Quercus rubra*, Fagaceae), Ontario, Canada.

Type strain: CBS 5121.

Systematics: Santa María (1963a) isolated four melibiose-utilizing strains from alpechin, an aqueous by-product of olive oil manufacturing. One strain was described as *Torulopsis salmanticensis*. The author was impressed with the large number of compounds utilized by the

species and speculated that a relationship with the genus *Guilliermondella sensu* Boidin et al. (1962) might be anticipated. A connection with known ascogenous species would be difficult, as *C. salmanticensis* forms an isolated clade with *C. auringiensis* (Kurtzman and Robnett 1998a) and *C. tartarivorans* (Fonseca et al. 2000c). Only the SSU rRNA gene sequence (Suzuki et al. 1999) suggests a basal link to the *Trichomonascus/Sugiyamaella* clade.

The growth characteristics of *C. salmanticensis* form a unique profile that combines the utilization of melibiose with a lack of growth on starch. These features are sufficient to separate the species from *Schwanniomyces occidentalis* and related species. The type strain, but not the other isolates, utilized lactose weakly. The type grew weakly on L-arabinose. In contrast to the results given by Meyer et al. (1998), D-glucitol was utilized by all strains when assessed by replica plating. Ethylamine utilization and growth in the presence of 10% NaCl were weak or negative, and growth in the presence of 50% glucose was variable.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: The neighboring species, *C. auringiensis*, has been reported to possess a linear mitochondrial genome and to form, in addition, small circular DNA molecules consisting of mitochondrial telomeric sequences (Tomaska et al. 2000). This feature is apparently shared with *Ogataea philodendra* and *C. parapsilosis* (strain CBS 7157, also reported as *C. rhagii*).

90.243. *Candida santamariae* Montrocher (1967)

Phylogenetic placement: *Kurtzmaniella* clade (Figs 40.1, 90.2).

Synonyms:

Candida krusei (Castellani) Berkhout var. *saccharicola* Santa María (1959b)¹

Candida beechii H.R. Buckley & van Uden (1968)¹

¹ Synonym based on rRNA gene sequences (Kurtzman and Robnett 1998a, Sugita and Nakase 1999).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to elongate, 2–7 × 6.5–22 µm (Fig. 90.160 top). Some single and budding cells are evident, but the growth may be highly pseudohyphal. An incomplete pellicle is present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, the pseudohyphae may be poorly developed or consist of extensively branched chains of cylindrical cells, sometimes with blastoconidia formed singly or in short chains (Fig. 90.160 bottom). Aerobic growth is off-white to beige, creamy, smooth to wrinkled, soft, shiny to dull and with a hyphal border.

Fermentation

Glucose	+/-	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	v
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+



FIGURE 90.160 *Candida santamariae* CBS 4515. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 µm.

Melibiose	–	Erythritol	–
Galactose	v	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D-Lactate	v
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	v	D-Gluconate	+
L-Sorbose	v	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	–/s	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–/s
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	v
L-Lysine	+	Cycloheximide 0.1%	v
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	–

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 36.3, 38.8, 37.3, CBS 4515 (T_m : Nakase and Komagata 1971f; Meyer et al. 1984; S.A. Meyer, unpublished data, respectively); 41.2, CBS 4261 (BD: Meyer et al. 1984); 40.5, CBS 4261 (T_m : Stenderup et al. 1972).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45794.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 4515, isolated from sugar solution, Spain; CBS 5838, type strain of *C. santamariae* var. *membranaefaciens*, isolated from *Hymenochaete rubiginosa*, a bracket fungus; CBS 4261, type strain of *C. beechii*, from cider, UK.

Type strain: CBS 4515.

Systematics: In a study of yeasts recovered from sugar, condensed milk and sugar beet, Santa María (1959b) recovered two strains that were assigned the designation *C. krusei* var. *saccharicola* based on differences in cell size, lack of pellicle formation and formation of rudimentary pseudohyphae. Montrocher (1967) described *C. santamariae* based on one of these strains, having found several physiological differences. He also noted a similarity with *C. brumptii*. Another strain was described as *C. santamariae* var. *membranaefaciens* based on differences in a few growth characteristics. Buckley and van Uden (1968) described *C. beechii* to accommodate an isolate recovered from cider. DNA sequence analysis confirmed the close relationship between *C. santamariae* and *C. santamariae* var. *membranaefaciens*, and further provided evidence that *C. beechii* might be better treated as a member of the species. The D1/D2 LSU rRNA gene sequences (Kurtzman and Robnett 1998a) of *C. santamariae* and *C. beechii* are identical, and their SSU rRNA gene sequences (Sugita and Nakase 1999) differ by only one substitution and one gap. The varieties proposed by Montrocher (1967) differ by two substitutions in the D1/D2 LSU region, and only one gap in the SSU gene. The sequence of the ITS regions and the 5.8S rRNA gene of the type strain of *C. beechii* was found to be identical to that of the type of *C. santamariae* (AY542869) and these differed by one substitution from strain CBS 5838 (AY542870) of the variety *membranaefaciens*. For these reasons, they are considered synonyms of *C. santamariae*, which has priority. *C. zeylanoides* is a sister species and an affinity exists for species in the *Kurtzmaniella* clade.

The three strains studied were physiologically similar as assessed by replica plating. However, some differences were observed for certain tests, including the utilization of L-sorbose, xylitol, glucono- δ -lactone, the hydrolysis of Tween 80 and resistance to cycloheximide, found to be less than 0.01% in the type, and more than 0.1% in the other two strains. Although the species is distinct from most other yeasts separation from *C. zeylanoides* would be problematic.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.244. *Candida santjacobensis* C. Ramírez & A. González (1984i)

Phylogenetic placement: *Sugiyamaella* clade (Fig. 90.3).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, $2\text{--}3.5 \times 2\text{--}5\ \mu\text{m}$, and occur singly and in pairs (Fig. 90.161 top).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, a few, short pseudohyphae are formed outside the coverslip (Fig. 90.161 bottom). Aerobic growth is creamy, off-white, soft and has an entire margin.

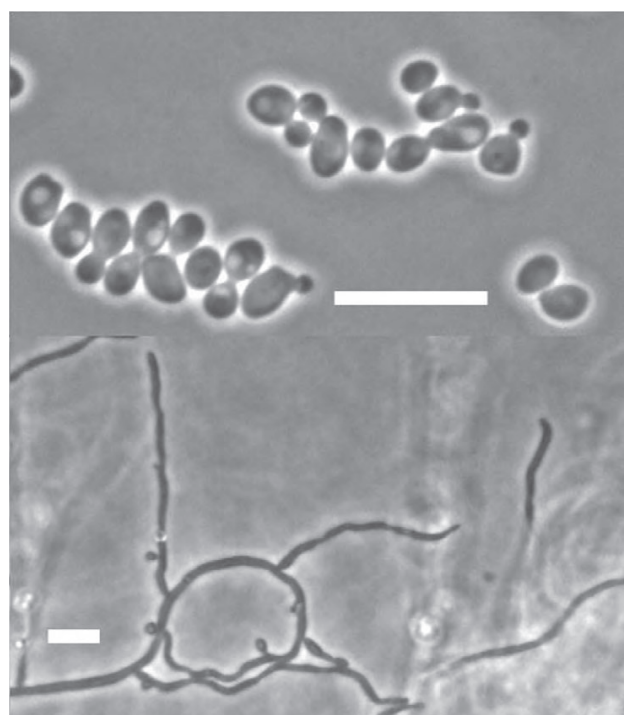


FIGURE 90.161 *Candida santjacobensis* CBS 8183. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μm .

Fermentation

Glucose	s	Lactose	—
Galactose	s	Raffinose	—
Sucrose	—	Trehalose	s
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	+	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	s
Maltose	+	D-Glucitol	s
Melezitose	+	myo-Inositol	+
Methyl- α -D-glucoside	+	D-Lactate	v
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	v	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	—
L-Arabinose	+	Nitrate	—
D-Arabinose	+	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	+	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	w	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	v
50% Glucose	–	Growth at 37°C	–

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 48.5, type strain (T_m : S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45811.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 8183, isolated from fallen trunk of southern beech (*Nothofagus dombeyi*, Fagaceae), Chile; UWOPS 91-780.1, from sap flux of koa (*Acacia koa*, Fabales: Mimosaceae), Hawai'i Island, USA.

Type strain: CBS 8183.

Systematics: Ramírez and González (1984i) described *C. santjacobensis* to accommodate a strain recovered from a fallen tree in advanced decay. They noted a propensity for the formation of protuberances reminiscent of conjugation tubes, also found in *C. ancudensis* (syn. *C. petrohuensis*), which was described at the same time. This property appears to be prevalent in members of the *Trichomonascus* (formerly *Stephanoascus*) clade, to which the species belongs (Kurtzman and Robnett 1998a, Suzuki et al. 1999).

The species is polyphagic and is unusual in the assimilation of myo-inositol and glucuronic acid. The growth characteristics determined by replica plating differed slightly from those given in the original description. No growth was observed on xylitol or gluconic acid. Utilization of ethylamine was weak. Strain UWOPS 91-780.1 was similar to the type, but exhibited weak growth on xylitol and galactitol. A superficial resemblance exists with *C. salmanticensis*, but the latter utilizes inulin, but not erythritol or myo-inositol.

Ecology: *Candida santjacobensis* appears to be associated with trees and possibly insects involved in disease and decay of trees.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.245. *Candida sanyiensis* Lee & Liu (Liu et al. 2008)

Phylogenetic placement: *Barnettozyma* clade; see Systematics (Fig. 90.1). (The description is based on Liu et al. 2008.)

Growth on YM agar: After 7 days at 25°C, the colonies are creamy to brownish, butyrous, smooth, glistening and have an entire margin.

Growth in YM broth: After 3 days at 25°C, cells are globose or ellipsoidal, $2.2\text{--}5.3 \times 3.8\text{--}6.3\text{ }\mu\text{m}$, reproduce by multilateral budding and occur singly or in pairs.

Growth on the surface of YM broth: Sediment is present.

Dalmat plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and true hyphae are absent.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	–
Raffinose	–	Glycerol	–
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	w
Maltose	–	D-Glucitol	w
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	n
L-Arabinose	–	Nitrate	+
D-Arabinose	–	Vitamin-free	n

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	–	50% Glucose	–
5-Keto-D-gluconate	–	10% NaCl/5% glucose	–
D-Glucuronate	–	Starch formation	–
Propane 1,2 diol	+	Urease	–
Butane 2,3 diol	+	DBB	–
Cadaverine	–	Cycloheximide 0.01%	–
Creatinine	–	Growth at 30°C	+
L-Lysine	–	Growth at 35°C	–
Ethylamine	–		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = EF460607.

Cell carbohydrates: Not determined.

Origin of the strain studied: Strain SA 1S06 (BCRC 23094, CBS 10592, NBRC 102654), isolated in 2006 from forest soil in Sanyie, Mioli, Taiwan (Liu et al. 2008).

Type strain: SA 1S06.

Systematics: Phylogenetic analysis of the D1/D2 domains of the LSU rRNA gene placed *C. sanyiensis* in a clade with *Barnettozyma californica*, *B. populi* and *B. hawaiiensis*, and with *C. stellimalicola* as a basal species (Liu et al. 2008).

Ecology: *Candida sanyiensis* is known from forest soil in Taiwan.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.246. *Candida saopaulonensis* Ruivo, Pagnocca, Lachance & Rosa (Ruivo et al. 2006)

Phylogenetic placement: *Metschnikowia* clade (Fig. 90.1). (The description is based on Ruivo et al. 2006.)

Growth on YM agar: After 4 days at 25°C, colonies are cream colored or white, low-convex, smooth and butyrous.

Growth in 0.5% glucose–2% yeast extract broth: After 3 days at 25°C, cells are short ellipsoidal, $3\text{--}6.5 \times 4\text{--}7\text{ }\mu\text{m}$, reproduce by multilateral budding and occur singly or in budding pairs.

Dalmat plate culture on corn meal agar: After 2 weeks, pseudohyphae and true hyphae are not formed.

Fermentation

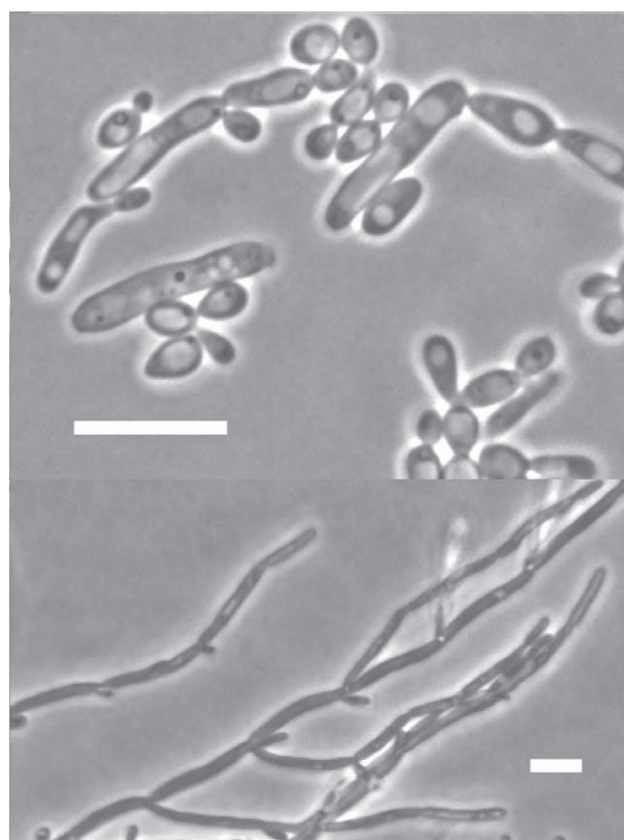
Glucose	+	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (Media not Specified)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	—
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	D-Lactate	+
Soluble starch	—	Succinate	w
Cellobiose	—	Citrate	w
Salicin	—	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	+	Hexadecane	+
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	+	10% NaCl/5% glucose	—
2-Keto-D-gluconate	+	Urease	—
5-Keto-D-gluconate	—	DBB	—
Nitrite	—	Cycloheximide 0.01%	—
Cadaverine	+	Cycloheximide 0.1%	n
L-Lysine	+	Growth at 35°C	+
Ethylamine	+	Growth at 37°C	—
50% Glucose	v		

CoQ: Not determined.**Mol% G + C:** Not determined.**Gene sequence accession number, type strain:** D1/D2 LSU rRNA = AY695398.**Cell carbohydrates:** Not determined.**Origin of the strains studied:** UNESP 00-99 (CBS10001, NRRL Y-27815), and one other strain, both isolated from accumulated water in the flower bracts of *Heliconia velloziana* (Heliconiaceae, Zingiberales), Picinguaba area, an Atlantic rainforest site in "Serra do Mar" State Park, São Paulo State, Brazil (Ruivo et al. 2006).**Type strain:** UNESP 00-99.**Systematics:** Sequence analysis of the D1/D2 domain of the LSU rRNA gene placed *C. saopaulonensis* in a subclade with *C. picinguabensis* within the Metschnikowiaceae clade (Ruivo et al. 2006). The exact placement remains uncertain (Fig. 90.1).**Ecology:** *Candida saopaulonensis* is known only from water in the flower bracts of *Heliconia velloziana* in an Atlantic rainforest in Brazil (Ruivo et al. 2006).**Biotechnology:** Unknown.**Agriculture and food:** Unknown.**Clinical importance:** Unknown.**90.247. *Candida savonica* Sonck (1974)****Phylogenetic placement:** unaffiliated clade (Fig. 90.3).**FIGURE 90.162** *Candida savonica* CBS 6563. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 µm.**Growth in glucose–yeast extract–peptone broth:** After 3 days at 25°C, cells have various shapes, mostly ovoid or ellipsoidal and cylindrical, 2–8 × 6–11 µm, and occur singly, in pairs and in short chains (Fig. 90.162 top). After 1 month thick sediment is evident, that appears clumpy, but on shaking becomes homogeneous.**Dalmat plate culture on corn meal agar:** After 7 days at 25°C, pseudohyphae consist of extensively branched chains of elongate cells with single or short chains of blastoconidia (Fig. 90.162 bottom). Aerobic growth is off-white, smooth, butyrous, flat and exhibits a hyphal border.**Fermentation**

Glucose	+	Lactose	—
Galactose	s	Raffinose	—
Sucrose	—	Trehalose	s
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—

Methyl- α -D-glucoside	—	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	—
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	s	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	s	Vitamin-free	s

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	—	Casein	w
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	w
50% Glucose	—	Growth at 37°C	—

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 48.0, CBS 6563 (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U62307.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6563, isolated from a birch log (*Betula* sp.), Finland.

Type strain: CBS 6563.

Systematics: Sonck (1974) observed white spots on the cut surface of birch logs. From these, a strain was isolated and described as *C. savonica*. The author noted a similarity with *C. cacaioi* teleomorph, (*Milleromyces farinosa*), but the new species differed in the assimilation of pentoses, methanol and erythritol. The phylogenetic position of *C. savonica* cannot be satisfactorily established from currently available rRNA gene sequences (Kurtzman and Robnett 1998a, Sugita and Nakase 1999). The only significant match was reported by Suh et al. (2005a) for an undescribed species isolated from the guts of mushroom-feeding erolytid beetles, but the sequences differed by at least 11%.

The physiological profile determined by replica plating differed from the profile given by Meyer et al. (1998) by a few characteristics, namely the assimilation of glucono- δ -lactone and D-glucosamine, and growth in the presence of 50% glucose and in the presence of 0.1% cycloheximide (all negative in the species). *C. savonica* resembles *C. torresii*, but the two unrelated species can be separated by resistance to 0.01% cycloheximide (positive in the former).

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.248. *Candida schatavii* (Kocková-Kratochvílová & Ondrušová) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Kurtzmaniella* clade (Figs 40.1, 90.2).

Synonym:

Torulopsis schatavii Kocková-Kratochvílová & Ondrušová (1971)

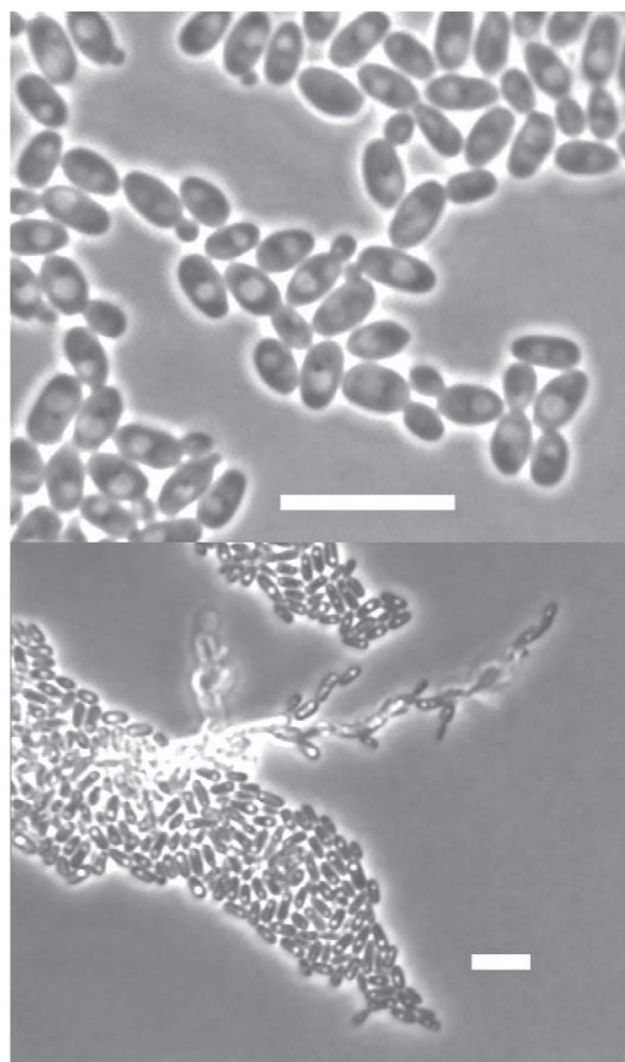


FIGURE 90.163 *Candida schatavii* CBS 6452. Budding cells after 3 days, 25°C, YM agar (top) and pseudohypha after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 µm.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to elongate, $3\text{--}6 \times 4\text{--}7\text{ }\mu\text{m}$, and occur singly and in pairs (Fig. 90.163 top).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of cylindrical cells with a few ovoid blastoconidia (Fig. 90.163 bottom). Aerobic growth is white to cream colored, smooth, moist and glistening and has a fringed margin.

Fermentation

Glucose	s	Lactose	—
Galactose	s	Raffinose	—
Sucrose	—	Trehalose	s
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	s
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	s	Hexadecane	+
L-Arabinose	–	Nitrate	–
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	s	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	v

CoQ: Not determined.

Mol% G + C: 44.6, 43.7, CBS 6452 (T_m : Meyer et al. 1984; T_m : S.A. Meyer, unpublished data, respectively).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45795.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 6452, isolated from basidiocarp of a polypore (*Fomitopsis pinicola*), former Czechoslovakia.

Type strain: CBS 6452.

Systematics: Kocková-Kratochvílová and Ondrušová (1971) described *Torulopsis schatavii* after subjecting a collection of yeasts collected on the fruiting bodies of various mushrooms to phenetic analysis of their growth characteristics. Of these yeasts, 10 strains stood out from the rest of *Torulopsis* species, forming a cluster that shared similar profiles. The strains were also typified by serology. According to analysis of D1/D2 LSU rRNA gene (Fig. 90.2), the species is a close relative of *C. boleticola* in the *Kurtzmaniella* clade. The SSU rRNA gene sequences of *C. schatavii* and *C. boleticola* are identical (Sugita and Nakase 1999). Sequences of the ITS regions and the 5.8S rRNA gene of the two type strains were determined in this study in order to provide additional information on their circumscriptions. Those from the type of *C. schatavii* (AY569006) differed by 21 substitutions and 6 indels from those of the type of *C. boleticola* (AY569005), favoring the retention of these species as separate.

Vitamin independence, reported by Meyer et al. (1998), was not confirmed by replica plating, but other results were in good agreement. The growth characteristics are similar but not identical to

those of several other species, and identification on that basis is possible. The assimilation of erythritol and the lack of growth on β -glucosides are sufficient to separate *C. schatavii* from similar species.

Ecology: Like several related species, *C. schatavii* was recovered from a polyporeaceous mushroom, suggesting an association with fungicolous insects.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.249. *Candida scorzettiae* Middelhoven & Kurtzman (2007)

Phylogenetic placement: unaffiliated clade (Fig. 90.3).

(The description is based on Middelhoven and Kurtzman 2007.)

Growth on 5% yeast extract agar: After 3 days 25°C, the culture is white, almost powdery and with a hyphal fringe consisting of pseudohyphae. Cells are ellipsoidal to elongate, 4–10 $\times$ 2–3 μ m, occur singly, in budded pairs and in short chains and reproduce by multi-lateral budding (Fig. 90.164A).

Growth on the surface of GPYM media: After 3 days at 25°C, cells are ovoid, occur singly or in pairs and hyphae are not present. A thin pellicle and sediment are formed.

Dalmau plate culture on morphology agar: After 7 days at 25°C, well-branched pseudohyphae are present bearing blastoconidia, some of which are spindle-shaped, whereas others are ellipsoidal (Fig. 90.164B). True hyphae do not occur. Aerobic colonies are tanish-white, dull, low convex with numerous cup-like outgrowths and surrounded by a fringed margin consisting of pseudohyphae.

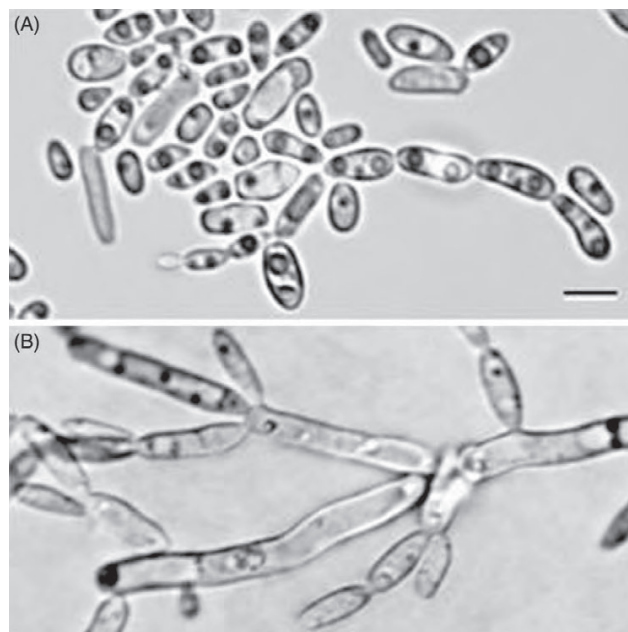


FIGURE 90.164 *Candida scorzettiae* NRRL Y-27665. Budding cells after 3 days, 25°C, 5% malt extract agar (A) and pseudohypha after 7 days, 18°C, yeast morphology agar (B). Bar = 5 μ m.

Fermentation: Absent.

Growth (in Liquid Media)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+/d
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+/d
Lactose	w	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	+
Soluble starch	—	Succinate	+
Cellulobiose	+	Citrate	+/d
Salicin	+	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	—	10% NaCl/5% glucose	—
2-Keto-D-gluconate	+	Extracellular starch-like compounds	—
5-Keto-D-gluconate	—	Urease	—
D-Glucuronate	—	DBB	—
Propane 1,2 diol	d	Cycloheximide 0.01%	+
Butane 2,3 diol	+	Cycloheximide 0.1%	—
Nitrite	—	Growth at 30°C	+
Cadaverine	+	Growth at 32°C	+
Creatinine	—	Growth at 35°C	—
L-Lysine	+		
Ethylamine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = DQ839394.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 10107 (NRRL Y-27665, QuB-82), isolated in August 2002 from rotten oak wood (*Quercus robur*, Fagaceae), Wageningen, The Netherlands (Middelhoven and Kurtzman 2007).

Type strain: CBS 10107.

Systematics: The taxonomic affiliation of *C. scorzettiae* is not clear. Sequence analysis of the D1/D2 domains of the LSU rRNA gene placed the species in a weakly supported lineage with *C. mesenterica* (Middelhoven and Kurtzman 2007). The analysis in Fig. 90.3 places the species near *C. catenulata* also in a poorly supported clade with a loose connection to *C. mesenterica*.

Ecology: *Candida scorzettiae* is known only from rotten oak wood in The Netherlands (Middelhoven and Kurtzman 2007).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.250. *Candida sequanensis* Saëz & Rodrigues de Miranda (1984)

Phylogenetic placement: unaffiliated clade (Fig. 90.5).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, 2.5–8 μ m, and occur singly or in pairs (Fig. 90.165 left).

Dalmau plate culture on YCBAS agar: After 14 days at 18°C, differentiated pseudohyphae with clusters of blastoconidia are formed (Fig. 90.165 right). Aerobic growth is white, flat and glossy and with a lobate margin.

Fermentation

Glucose	+	Lactose	—
Galactose	s	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

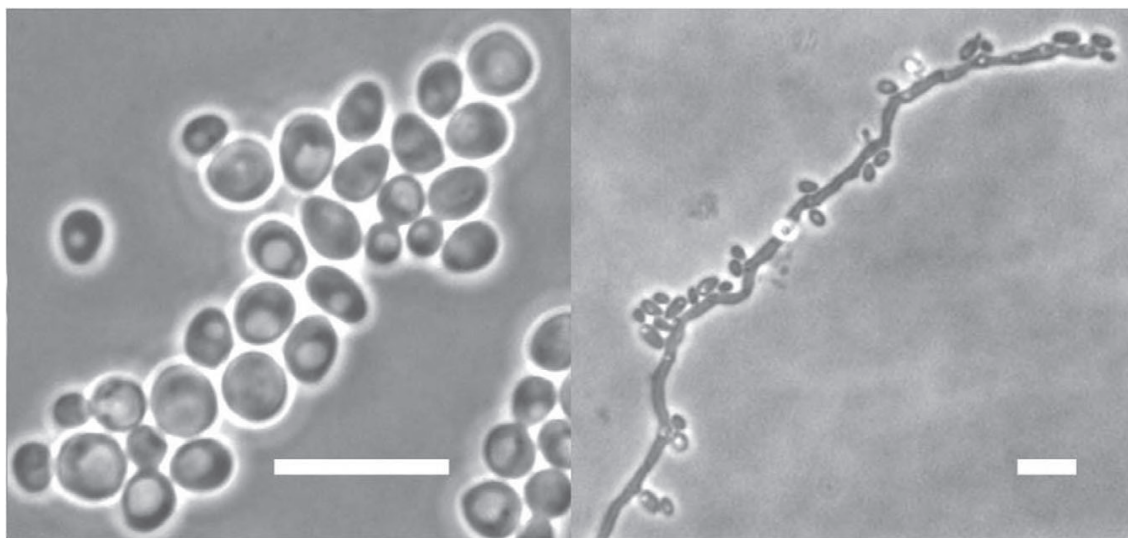


FIGURE 90.165 *Candida sequanensis* CBS 8118. Budding cells after 3 days, 25°C, YM agar (left) and pseudohypha after 14 days, 18°C, YCBAS agar (right). Bars = 10 μ m.

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	s
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	s
Glucono- δ -lactone	s	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	–
50% Glucose	+	Growth at 37°C	–

CoQ: 8 (Suzuki and Nakase 1998).

Mol% G + C: 39.6, type strain (T_m : Saëz and Rodrigues de Miranda 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45711.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 8118, isolated from germinating oat grain (*Avena* sp.) from animal fodder, France.

Type strain: CBS 8118.

Systematics: In a study of the yeasts found in animal fodder, yeasts were isolated from five grains of germinating oat (Saëz and Rodrigues de Miranda 1984). The authors noted a resemblance with *C. boleticola*, but remarked that the latter differs in the assimilation of several sugars, including melibiose. Analyses of D1/D2 LSU rRNA gene sequences (Kurtzman 2001b, Kurtzman and Robnett 1998a) placed *C. sequanensis* in a basal position with respect to a large clade containing several *Debaryomyces* species, the *Lodderomyces* clade, as well as *C. caryicola*. In describing the sister species *C. linzhienensis*, Wu and Bai (2006) suggested a closer affinity to *C. caryicola* as well as another new species, *C. tibetensis*. These four species were thought to form a sister clade to the *C. tanzawaensis* clade, which is also suggested in Fig. 90.5. A phylogeny based on SSU rRNA gene sequences (Suzuki and Nakase 1999) suggested a closer relationship with a group of species related to *Hyphopichia burtonii*, in proximity to *C. rhagii* and *C. gotoi*.

The strain grew poorly when examined by replica plating, but the growth characteristics matched the description given by Meyer et al. (1998), with the exception of the utilization of starch and citric acid. The assimilation of raffinose, melibiose and L-sorbose as well as

the ability to grow in the absence of vitamins and at 33°C, reported in the original description, were not confirmed. The profile resembled that of *Debaryomyces coudertii*, although separation is possible on the basis of the assimilation of lactose and L-rhamnose (negative) and the presence of fermentative activity.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.251. *Candida sergipensis* Trindade, Resende, Lachance & Rosa (Trindade et al. 2004)

Phylogenetic placement: *Wickerhamiella* clade (Fig. 79.1).

(The description is based on Trindade et al. 2004.)

Growth on malt agar: After 2 weeks at 22°C, colonies are small, low convex, glabrous, rugose, white and butyrous.

Growth in 0.5% yeast extract–2% glucose broth: After 3 days at 25°C, the cells are ovoid to ellipsoidal, and occur singly and in parent–bud pairs. Sediment is formed after a month.

Dalmau plate culture on corn meal agar: After 2 weeks, pseudohyphae occur.

Fermentation

Glucose	v	Lactose	n
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	n
Maltose	n		

Growth (Media not Indicated)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	v	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	+
Trehalose	–	D-Mannitol	+
Maltose	v	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	n	DL-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	–	Citrate	–
Salicin	+	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	v	Nitrate	–
D-Arabinose	–	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	+	Urease	–
Nitrite	–	DBB	–
Cadaverine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Ethylamine	+	Growth at 30°C	+
50% Glucose	–	Growth at 35°C	+
10% NaCl/5% glucose	v	Growth at 37°C	n
Extracellular starch-like compounds	–		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF397405.

Cell carbohydrates: Not determined.

Origin of the strains studied: UFMG-R188 (CBS 9567), isolated from frozen pulp of mangaba fruit (*Hanconia speciosa*, Apocynaceae), State of Sergipe, Brazil; two additional isolates from mangaba fruit and 14 strains from umbu fruit (*Spondias tuberosa*, Anacardiaceae), all in the State of Sergipe, Brazil (Trindade et al. 2004).

Type strain: UFMG-R188.

Systematics: *Candida sergipensis* was described from several strains isolated from tropical frozen fruit pulps (Trindade et al. 2004). Sequence analyses demonstrated a close relationship with *C. spandovensis* in the *Wickerhamiella* clade (Fig. 79.1).

Ecology: *Candida sergipensis* is known from fruits in north-eastern Brazil (Trindade et al. 2004).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.252. *Candida shehatae* H.R. Buckley & van Uden (1967)

Phylogenetic placement: *Scheffersomyces* clade (Fig. 90.2).

Synonym:

Candida shehatae H.R. Buckley & van Uden var. *shehatae* (1990)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, $2\text{--}4.5 \times 3.5\text{--}6\text{ }\mu\text{m}$, and occur singly, in pairs and short chains (Fig. 90.166 top). Pseudohyphae are also present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of elongated cells with globose to ovoid blastoconidia (Fig. 90.166 bottom). Aerobic growth is white to cream colored, glistening and smooth with a reticulated margin.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	+/s	D-Xylose	+

Growth (in Liquid Media and on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	v	Glycerol	+
Melibiose	–	Erythritol	v
Galactose	+	Ribitol	+
Lactose	v	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	–
Soluble starch	+	Succinate	+
Cellulobiose	+	Citrate	+
Salicin	+	D-Gluconate	v
L-Sorbose	v	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	v	Nitrate	–
D-Arabinose	v	Vitamin-free	–

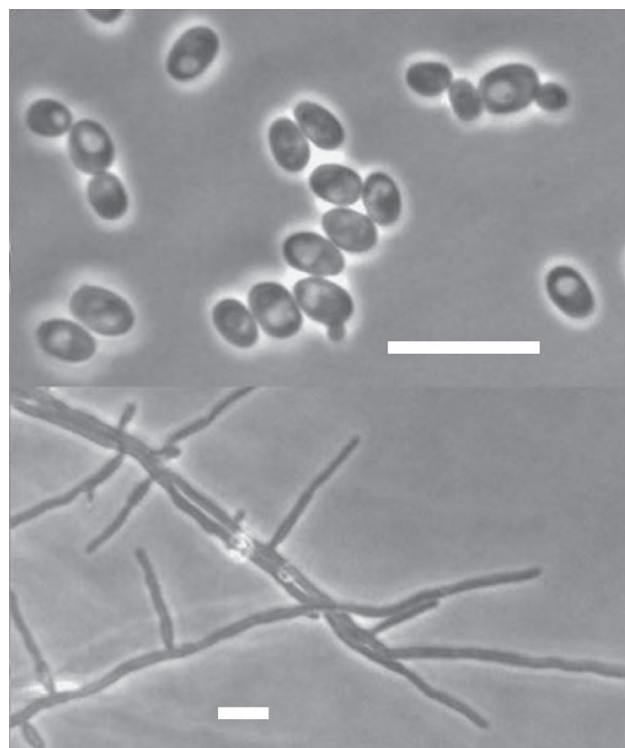


FIGURE 90.166 *Candida shehatae* CBS 5813. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μm .

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	v	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	v
L-Lysine	+	Cycloheximide 0.1%	v
Cadaverine	+	1% Acetic acid	–
10% NaCl	v	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 41.2, one strain (T_m : Nakase and Komagata 1971f); 41.2, one strain (T_m : Vaughan-Martini 1984); 41.2–43.4, four strains (T_m : Tengku Zainal Mulok 1988); 43.5–43.7, three strains (BD: Kurtzman 1990b).

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = U45761, SSU rRNA = AB013582.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5813 (NRRL Y-12858, NRRL Y-17029), isolated from insect-infested pine wood (*Pinus* sp., Pinaceae); CBS 2779 (NRRL Y-17024), from soil, South Africa, J.P. van der Walt; CBS 5712 (NRRL Y-12857), from a rose hip, British Columbia, Canada, R.E. Simard.

Type strain: CBS 5813.

Systematics: Buckley and van Uden (1967) examined six strains that could not be assigned to any known species. Two had been isolated from dead pines and were thought to be related to *C. clausenii*; one

came from the cerambycid beetle *Leptura cerambyciformis* and had previously been assigned to *C. parapsilosis* var. *intermedia*; two originated from insect-infested wood in Chile; one was a soil isolate. Differences between these strains and *C. clausenii* or *C. parapsilosis* were considered sufficient to warrant description of a new species. Some variability was reported in the utilization of D-arabinose, erythritol and organic acids. Kreger-van Rij (1970c) noted a resemblance with *Scheffersomyces* (*Pichia*) *stipitis* and suggested that *C. shehatae* might represent the anamorph of that species. However, DNA reassociation experiments (Tengku Zainal Mulok 1988, Vaughan-Martini 1984) demonstrated that *C. shehatae* is genetically distinct from *S. stipitis*. Kurtzman (1990b) further showed by DNA reassociation that strains assigned to *C. shehatae* comprised three genetic groups, which he designated as varieties. Among these varieties, *C. shehatae* var. *insectosa* was the only variety that was distinguishable on the basis of D1/D2 LSU rRNA gene sequences (one substitution). The species differs from *S. stipitis* by 11–12 substitutions. The analysis of Kurtzman and Robnett (1998a) and Kurtzman and Suzuki (2010) placed these species in the *Scheffersomyces* clade along with the anamorphic species *C. ergatensis* and *C. coipomoensis*. The genera *Scheffersomyces*, *Spathaspora* and *Lodderomyces* appear closely related (Kurtzman and Suzuki 2010). Kurtzman elevated the varieties of *C. shehatae* to the rank of species on the basis of their diminished (ca. 50%) DNA relatedness (Kurtzman and Suzuki 2010).

The D1/D2 sequences (AF178048 and AF178049, deposited by H.G. Park and S.A. Meyer) of two strains previously identified as *C. oleophila* suggest the strains may represent a new variety of *C. shehatae* or even a new, closely related species. CBS 4410 was isolated from the cerambycid beetle *Spondylis buprestoides* (Coleoptera: Cerambycidae) and CBS 4704 from rotten wood in Chile. The sequences of the two strains are identical and differ by one substitution from those of *C. shehatae* and *C. lignosa* and by two substitutions from the sequence of *C. insectosa*.

Kurtzman (1990b) indicated that the former varieties of *C. shehatae* can be separated on the basis of galactitol and lactic acid assimilation and gelatin liquefaction. Meyer et al. (1998) reported that galactitol utilization was variable for *C. lignosa*, but attributed the difference to the length of the incubation period. *C. insectosa* does not assimilate L-sorbose (as reported by Meyer et al. 1998) and assimilation of L-sorbose by *C. shehatae* appears variable.

Ecology: Suh et al. (2003) examined the gut microbiota of the wood-ingesting beetles *Odontotaenius disjunctus* and *Verres sternbergianus* (Coleoptera: Passalidae). Species related to *C. shehatae* were repeatedly found over a broad geographical range, leading the authors to postulate that these species are symbionts that contribute to the insects' nutrition through D-xylose fermentation. Although *C. shehatae* itself was not found in that study, the implication is that the species may also be a symbiont that fulfills a similar function in other beetles such as the Cerambycidae. Nout et al. (1997) isolated *C. shehatae* in samples of milled maize. The species was the third in importance after *C. guilliermondii* and *C. zeylanoides*. However, *C. shehatae* was found to surpass these two species in the production of volatiles that attract the corn pest nitidulid beetle, *Carpophilus humeralis* (Nout and Bartelt 1998).

Biotechnology: *Candida shehatae* is probably best known for the ability to ferment D-xylose. Some of the relevant literature was reviewed by Kastner et al. (1999). Contrary to early expectations, the species has not been used extensively in industry because ethanol production from lignocellulosic substrates has poor yields and requires a careful control of oxygen concentration in the medium. Previous work had shown that excessive oxygen causes the yeast to metabolize D-xylose for biomass production at the expense of ethanol. The authors showed that the species has an absolute requirement for oxygen when D-xylose is the substrate. Anoxic conditions cause rapid and extensive cell death.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.253. *Candida silvae* Vidal-Leiria & van Uden (1963)

Phylogenetic placement: *Saturnispora* clade (Figs 64.1, 90.1).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, 2–4 × 3–6 µm, and occur singly and in pairs. Islets and a ring may be present (Fig. 90.167 top).

Dalmat plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of elongate cells with verticils of ovoid blastoconidia (Fig. 90.167 bottom). Aerobic growth is white, butyrous, soft, mostly smooth, somewhat glistening and entire.

Fermentation

Glucose	s	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

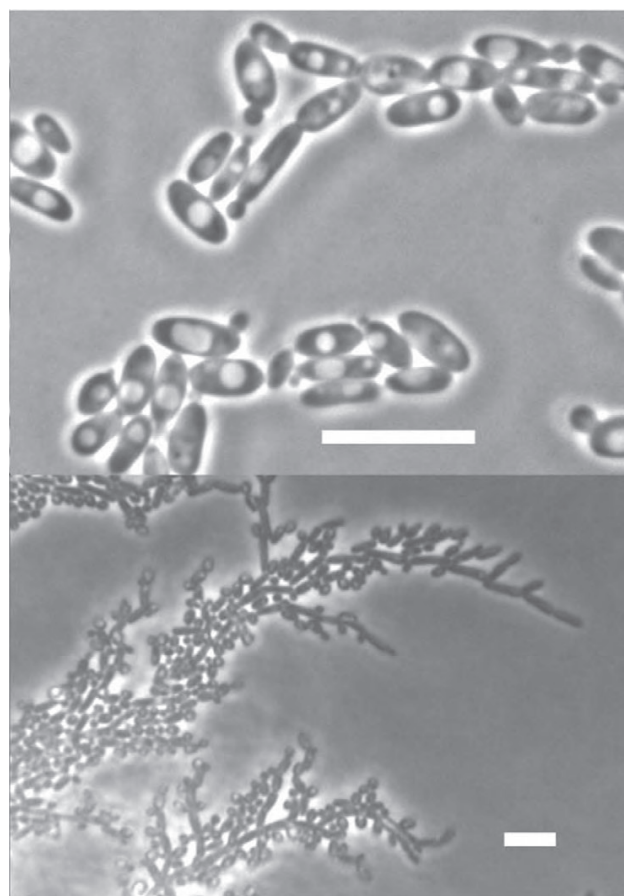


FIGURE 90.167 *Candida silvae* CBS 5498. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 µm.

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	v
Melibiose	—	Erythritol	—
Galactose	v	Ribitol	v
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	v
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	v
Salicin	—	D-Gluconate	v
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	v	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	v

CoQ: 7 (Suzuki et al. 1994).

Mol% G + C: 39.5, CBS 5498 (T_m : Suzuki et al. 1994); 44.0, CBS 5497 (BD: Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U71065.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 988, isolated from compressed yeast, France; CBS 5498, from horse intestine, Portugal; UWOPS 87-2294.3, from necrotic cladode, *Opuntia ficus-indica* (morph *megacantha*; Cactaceae), Hawai'i Island.

Other strains available: CBS 1520, from vagina, Germany; CBS 2832, from sputum, Germany; CBS 5497, from horse intestine, Portugal.

Type strain: CBS 5498.

Systematics: *Candida silvae* was described (Vidal-Leiria and van Uden 1963) on the basis of six isolates from various sources. A similarity with *C. inconspicua* and *C. norvegensis* was noted, but differences existed in the assimilation of cellobiose, salicin, D-glucosamine, D-mannitol and D-glucitol, as well as in the maximum growth temperatures. The species has distinct rRNA gene sequences that place it in a basal position with respect to *Saturnispora* and related *Candida* species (Kurtzman and Robnett 1998a, Suzuki and Nakase 2002).

Although the species is nutritionally specialized, the growth characteristics show some variation among strains. The type, as assessed by replica plating, matched previous descriptions. Strain CBS 988 did not utilize gluconolactone, and strain UWOPS 87-2294.3 utilized galactose, unlike the other two strains. Separation from *C. diversa* is difficult, as the two species share the inability to utilize any of the standard carbohydrates other than glucose. The profile

resembles those of species in the *Saturnispora* clade as well as several unrelated species. The most useful characters for identification are the assimilation of D-mannitol and citric acid, the fermentation of glucose and the lack of growth on sucrose, trehalose and β -glucosides. Identification based on D1/D2 sequences is preferable.

Ecology: *Candida silvae* has been sporadically reported in miscellaneous substrates. The species is apparently abundant in certain invertebrates in Brazilian mangroves (de Araujo et al. 1995).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.254. *Candida silvanorum* van der Walt, van der Klift & D.B. Scott (van der Walt et al. 1971a)

Phylogenetic placement: unaffiliated clade (Fig. 90.1).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, $2\text{--}3.5 \times 2\text{--}4\ \mu\text{m}$, and occur singly, in pairs, small chains and groups (Fig. 90.168 top).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, well-developed pseudohyphae consist of long chains of slender elongate cells with verticils of usually triangular blastoconidia (Fig. 90.168 bottom). Aerobic growth is white to cream colored, butyrous with a raised, wrinkled central area and an entire or fringed margin.

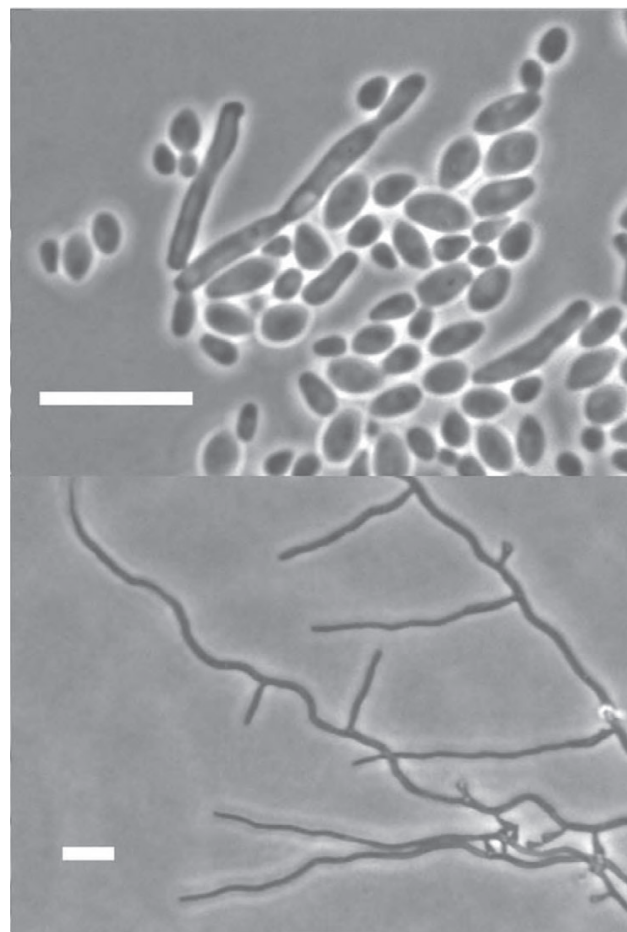


FIGURE 90.168 *Candida silvanorum* CBS 6274. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days at 18°C on YCBAS agar (bottom). Bars = 10 μm .

Fermentation

Glucose	+	Lactose	—
Galactose	s	Raffinose	s
Sucrose	s	Trehalose	s
Maltose	s		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	+	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	+	Nitrate	—
D-Arabinose	—	Vitamin-free	v

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	s	Casein	—
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	s
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	+

CoQ: 8 (Suzuki and Nakase 1998).

Mol% G + C: 40.5, 41.7, CBS 6274 (T_m : van der Walt et al. 1971a; BD: Meyer et al. 1984, respectively).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U71068.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6274, isolated from frass of bostrichid beetle (*Xylion adustus*, Coleoptera: Bostrichidae) in tunnels of African wattle (*Peltophorum africanum*, Fabaceae), South Africa.

Type strain: CBS 6274.

Systematics: Van der Walt et al. (1971a) described *C. silvanorum* from three strains isolated from materials in galleries of tree-infesting beetles. In addition to the type, two strains were recovered from the frass of another bostrichid beetle, *Sinoxylon ruficorne*, in tunnels of red bushwillow (*Combretum apiculatum*, Combretaceae) and from the ambrosia beetle *Xyleborus ferrugineus* (Scolytidae) in wild plum (*Harpephyllum caffrum*, Anacardiaceae). The authors suspected that *C. silvanorum*, *C. entomophila* and other species described at the same time had natural affinities with *C. diddensiae* and *C. shehatae*. Sequence-based phylogenetic placement of *C. silvanorum* using the

D1/D2 LSU rRNA gene is impractical due to the high degree of divergence (20% or more) of the species from any other. The analysis given by Kurtzman and Robnett (1998a) suggested a possible, but unlikely connection to *C. rugosa* and *Cynicomyces guttulatus*. Suzuki and Nakase (1999), on the basis of SSU rRNA gene sequences, suggested a relationship with *C. entomophila* and other *Candida* species that shows affinities to *Hyphopichia burtonii*.

Characterization by replica plating revealed small differences from the description given by Meyer et al. (1998), including the lack of growth on L-sorbose (reported as slow) and D-arabinose (reported as variable in the original description), strong growth on N-acetyl-D-glucosamine, slow growth on hexadecane and positive responses on 10% NaCl and 0.01% cycloheximide. Discrimination from other species may be based on the assimilation of melibiose, starch and growth at 37°C, with absence of growth on 2-keto-D-gluconate.

Ecology: An association with tree-destroying beetles is likely.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.255. *Candida silvatica* (van der Walt, van der Klift & D.B. Scott) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: Basal to the *Pichia* clade (Fig. 90.1).

Synonym:

Torulopsis silvatica van der Walt, van der Klift & D.B. Scott (1971b)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to subglobose, 2–4 μ m, and occur singly and in pairs.

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent. Aerobic growth is white to slightly cream colored, butyrous, smooth and entire.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	—
Salicin	—	D-Gluconate	—
L-Sorbose	—	D-Glucosamine	s
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—

Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 5 5.6, CBS 6277 (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U76201.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6277, frass of platypodid beetle (*Platypus* (syn. *Crossotarsus*) *externedentatus*, Coleoptera: Platypodidae) in tunnels of fig species (*Ficus sycomorus*, Moraceae), South Africa.

Type strain: CBS 6277.

Systematics: Van der Walt et al. (1971b) described *Torulopsis silvatica* to accommodate two strains recovered from beetle frass. Possible affinities with other *Torulopsis* species were discussed. Sequence analysis does not satisfactorily establish a credible phylogenetic placement for *C. silvatica*. Possible affinities with the genus *Dekkera* were suggested (Kurtzman and Robnett 1998a, Sugita and Nakase 1999), but the sequences are divergent and the position of the species varies according to which sequences are included in analyses.

The growth characteristics of the type strain agreed with previous descriptions except for lactic acid utilization which was found to be negative by replica plating. The physiological profile is narrow, but can be used to distinguish *C. silvatica* from other species based on the assimilation of trehalose, ethanol, glycerol and growth at 37°C, or the absence of fermentation.

Ecology: The species is known only from two beetle frass isolates.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.256. *Candida silvicultrix* van der Walt, D.B. Scott & van der Klift (1972)

Phylogenetic placement: *Wickerhamomyces* clade (Figs 80.1, 90.4).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to short-ovoid, 2.5–6 $\times$ 4.5–7 μ m, and occur singly and in pairs (Fig. 90.169).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, abundant development of pseudohyphae is present. Pseudohyphae consist of branched chains of elongate cells with dense verticils of blastoconidia. Aerobic growth is off-white, butyrous, smooth and shiny with both an entire and a fringed border.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	+
Sucrose	+	Trehalose	–
Maltose	s		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+

Raffinose	+	Glycerol	+
Melibiose	+	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	+
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	s
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	+

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	+

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: 36.6, CBS 6269 (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U69879.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6269, isolated from frass of bostriichid beetle (*Sinoxylon ruficorne*, Coleoptera: Bostrichidae) infesting sweet thorn (*Acacia karroo*, Fabaceae), South Africa.

Type strain: CBS 6269.

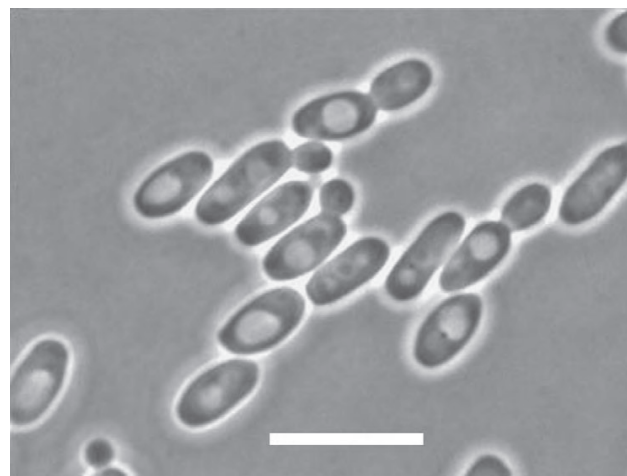


FIGURE 90.169 *Candida silvicultrix* CBS 6269. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

Systematics: Van der Walt et al. (1972) described *C. silvicultrix* from four strains isolated from beetle frass found in tunnels of diseased trees species. Two strains were found in frass of the scolytid beetle *Styracopterix murex* in *Spirostachys africanus*, a medium-sized tree that belongs to the Euphorbiaceae. A similarity with *C. friedrichii* was noted, but the species differed in the utilization of L-sorbose, D-arabinose, galactitol and lactic acid. The closest relative of the species is *Wickerhamomyces (Pichia) ciferrii* (Kurtzman and Robnett 1998a, Suzuki and Nakase 2002).

The growth profile is similar to the profile of *Debaryomyces hansenii*, but this apparent similarity is due to the large number of responses reported as variable for that species. Other similar species can be resolved based on the assimilation of melibiose, which is positive in *C. silvicultrix*.

Ecology: The species is rare, but many close relatives are also isolated from beetle frass in trees, suggesting that the species is associated with the digestive tract of tree-boring beetles.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.257. *Candida sinolaborantium* S.-O. Suh, N.H. Nguyen & M. Blackwell (2005b)

Phylogenetic placement: Unaffiliated clade (Fig. 90.4); see Systematics.

(The description is based on Suh et al. 2005b.)

Growth on YM agar: After 7 days at 25°C, colonies are white to cream colored, smooth and butyrous.

Growth in YM broth: After 7 days at 25°C, cells are globose to ellipsoidal, 2–5 × 3–6 μm, mostly subglobose, occur singly, in pairs, in short chains or in clusters, and pseudohyphae may be present.

Dalmeu plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae are present. Aerobic growth is white and smooth.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	d
Maltose	–	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	w	Galactitol	+
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D,L-Lactate	d
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	+	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	–
D-Arabinose	d	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Ethylamine	+
2-Keto-D-gluconate	+	50% Glucose	+
D-Glucuronate	–	10% NaCl/5% glucose	+
Arbutin	+	Starch formation	–
Propane 1,2 diol	d	Urease	–
Butane 2,3 diol	–	DBB	–
Nitrite	–	Cycloheximide 0.01%	+
Cadaverine	+	Cycloheximide 0.1%	+
Creatinine	–	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY520328, SSU rRNA = AY520198, ITS and 5.8S rRNA = AY964674.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9940 (NRRL Y-27765), isolated from the gut of a handsome fungus beetle (*Amphix laevigatus*, Endomychidae), Barro Colorado Island, Panama; two other strains, one from the gut and the other from the surface of a cerambycid larva (Cerambycidae) on a rotting log, Calcasieu Park, Louisiana, USA (Suh et al. 2005b).

Type strain: CBS 9940.

Systematics: Sequence analysis of the combined SSU and D1/D2 LSU rRNA gene sequences placed *C. sinolaborantium* with *C. temnochilae* as a basal lineage in the *Candida membranifaciens* clade (Suh et al. 2005b).

Ecology: *Candida sinolaborantium* is known from the gut of a handsome fungus beetle and the gut and surface of a larva of a cerambycid beetle, Panama and south-eastern USA (Suh et al. 2005b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.258. *Candida sithepensis* Limtong, Srisuk, Yongmanitchai, Kawasaki, Yurimoto, Nakase & Kato (2004)

Phylogenetic placement: *Ogataea* clade (Fig. 90.4).

(The description is based on Limtong et al. 2004.)

Growth on YM agar: After 3–5 days at 25°C, cells are spherical to ovoid, 2.3–5.5 × 2.3–5.5 μm, and occur singly or in pairs. The streak culture is white to cream, dull-glistening, butyrous and has an entire margin.

Growth on the surface of assimilation media: Pellicles are absent.

Dalmeu plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae or true hyphae are not formed.

Fermentation

Glucose	w	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	w
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	+
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+

Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	DL-Lactate	w
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	w
L-Sorbose	+	D-Glucosamine	n
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

D-Glucuronate	—	DBB	—
Nitrite	—	Gelatin liquefaction	+
Cadaverine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Ethylamine	+	Growth at 25°C	+
50% Glucose	+	Growth at 30°C	+
10% NaCl/5% glucose	+	Growth at 35°C	+
Starch formation	—	Growth at 37°C	+
Urease	—	Growth at 40°C	+

CoQ: 7 (Limtong et al. 2004).

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AB120220.

Cell carbohydrates: Not determined.

Origin of the strain studied: S023 (JCM 12265, TISTR 5821), isolated in 2000 from soil in Sithep Historical Park, Petchabun Province, Thailand.

Type strain: S023.

Systematics: Sequence analysis of the D1/D2 domains of the LSU rRNA gene placed *C. sithepensis* in a clade with *C. ovalis* and *C. arabinofementans* (Limtong et al. 2004).

Ecology: *Candida sithepensis* is known only from soil in Thailand (Limtong et al. 2004).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.259. *Candida smithsonii* S.-O. Suh & M. Blackwell (2004)

Phylogenetic placement: *Meyerozyma* clade (Figs 47.1, 90.2). (The description is based on Suh and Blackwell 2004.)

Growth on YM agar: After 7 days at 25°C, colonies are white, butyrous and with a smooth surface.

Growth in YM broth: After 5 days at 25°C, yeast cells are globose to ellipsoidal, 2–5 $\times$ 2–6 μ m, mostly subglobose, occur singly, in pairs or in short chains and pseudohyphae may be present.

Dalman plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae with blastoconidia are present. Aerobic growth is white, shiny and smooth.

Fermentation

Glucose	+	Lactose	—
Galactose	+	Raffinose	—
Sucrose	—	Trehalose	+
Maltose	—	D-Xylose	—

Growth (in Liquid Media)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	+	Ethanol	—
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	s/w
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	v
L-Sorbose	—	D-Glucosamine	+/s
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Ethylamine	+
2-Keto-D-gluconate	—	50% Glucose	+
D-Glucuronate	—	10% NaCl/5% glucose	+/w
L-Arabinitol	v	Starch formation	—
Arbutin	+	Urease	—
Propane 1,2 diol	v	DBB	—
Butane 2,3 diol	—	Cycloheximide 0.01%	+
Nitrite	—	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 30°C	+
Creatinine	—	Growth at 35°C	—
L-Lysine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY518525, SSU rRNA = AY518520, ITS and 5.8S rRNA = AY553844.

Cell carbohydrates: Not determined.

Origin of the strains studied: NRRL Y-27642 (CBS 9839), isolated from an unidentified endomycid larva; NRRL Y-27643, from the gut of a beetle (*Iphiclus (Megaprotus) pulcher*, Erotylidae), both from Barro Colorado Island, Panama (Suh and Blackwell 2004).

Type strain: NRRL Y-27642.

Systematics: A phylogenetic analysis of the combined sequences of the D1/D2 LSU and SSU rRNA genes placed *C. smithsonii* in the *Meyerozyma (Pichia) guilliermondii* clade (Suh and Blackwell 2004). Closely related species are *C. athensis*, *C. fermentati*, *C. xestobii* and *M. guilliermondii*.

Ecology: *Candida smithsonii* is known from the gut of beetles or their larva in Panama (Suh and Blackwell 2004).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.260. *Candida sojae* Nakase, M. Suzuki, Takashima, Miyakawa, Kagaya, Fukazawa & Komagata (1994b)

Phylogenetic placement: *Lodderomyces–Spathaspora* clade (Fig. 90.5) (Some of the morphological characteristics are based on Nakase et al. 1994b.)

Growth on YM broth: After 3 days at 25°C, the cells are spherical to short-ovoid, $3\text{--}6.5 \times 3.5\text{--}8\ \mu\text{m}$, and occur singly or in pairs (Fig. 90.170 top). A ring is formed.

Growth in YM agar: After 1 month at 17°C, the streak culture is yellowish-white to yellowish-gray, smooth, dull-shining, soft and with an erose to ciliate margin.

Dalmau plate culture on potato dextrose agar: Well-developed pseudohyphae are formed (Fig. 90.170 bottom).

Fermentation

Glucose	+	Lactose	—
Galactose	+	Raffinose	—
Sucrose	w	Trehalose	n
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	v
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	v	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	w
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	s
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	w
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	+

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 30.9–31.2, two strains, including the type (HPLC: Nakase et al. 1994b).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U71070.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 7871 (JCM 1644), isolated from an effluent of a soybean extraction process.

Other strain available: CBS 7419, oil-pipe, food-processing plant, The Netherlands.

Type strain: CBS 7871.

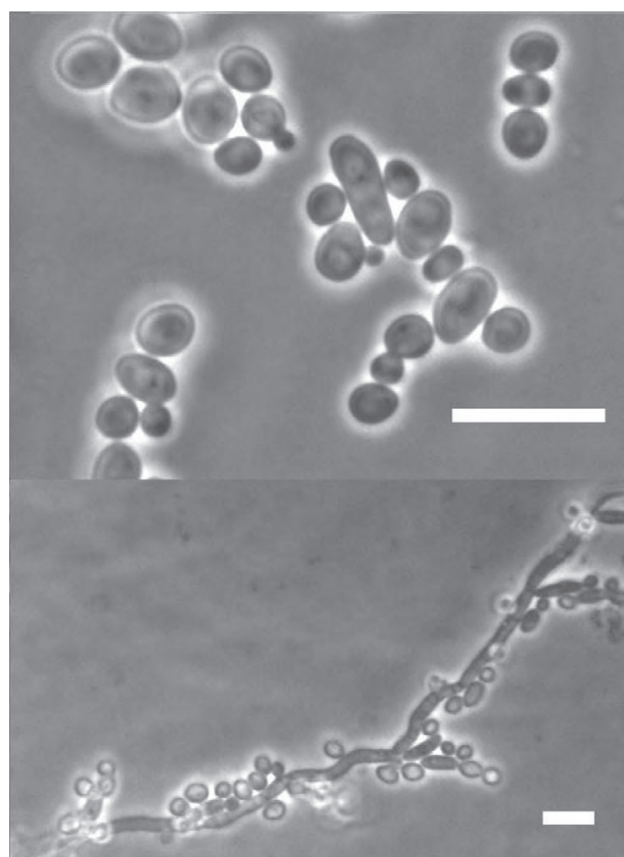


FIGURE 90.170 *Candida sojae* CBS 7871. Budding cells after 3 days, 25°C, YM agar (top) and pseudohypha with blastoconidia after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μm .

Systematics: Nakase et al. (1994b) described *C. sojae* to accommodate two strains isolated from effluents of a soybean extraction process. A strong similarity to *C. tropicalis* and *C. albicans* was noted. The species could be distinguished from other species based on isoenzyme electrophoresis patterns, DNA base composition and data from DNA reassociation experiments. The reassociation experiments gave values ranging from 19 to 40% with other species. Analysis of D1/D2 LSU (Kurtzman and Robnett 1998a) and SSU (Sugita and Nakase 1999) rRNA gene sequences confirmed a close relationship with *C. tropicalis* and other species in the *Lodderomyces* clade, including *C. albicans*, but also supported the distinct nature of the species. The D1/D2 LSU rRNA gene sequence of strain CBS 7419 (AF178051, H. Park and S.A. Meyer), previously identified as *C. oleophila*, is identical to that of *C. sojae*, for which reason the strain is considered a member of the species.

The growth characteristics obtained by replica plating were similar to those characteristics in the original description (Nakase et al. 1994b). According to the latter report, *C. sojae* can only be distinguished from close relatives by maltose fermentation (negative) and the maximum growth temperature (39°C). Mannarelli and Kurtzman (1998) devised a set of species-specific primers to identify rapidly several yeast species that are encountered in clinical specimens. *C. sojae* was included in the study as it is nearly indistinguishable from many prevalent clinical species by physiological identification methods. In the process of devising a set of flow cytometry probes for the identification of clinically important yeasts, Page and Kurtzman (2005) found that the phylogenetic proximity of *C. sojae* to *C. tropicalis* and *Lodderomyces elongisporus* created some challenges.

However, the combination of results from two probes allowed the correct differentiation of these species.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Although *C. sojae* has not been reported in clinical specimens, the possibility exists that it might act as an opportunistic pathogen. In view of the similarity of *C. sojae* to other species that are frequently found in clinical environments, the probability of misidentification based on growth responses is significant.

90.261. *Candida solani* Lodder & Kreger-van Rij (1952)

Phylogenetic placement: Not determined; see Systematics.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, sometimes slightly elongated, 3.5–5.5 × 6–11 µm, and occur singly, in pairs and short chains (Fig. 90.171).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of cylindrical cells with ovoid blastoconidia. Aerobic growth is off-white, butyrous, smooth, soft, flat and dull with a slightly irregular edge.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	–
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

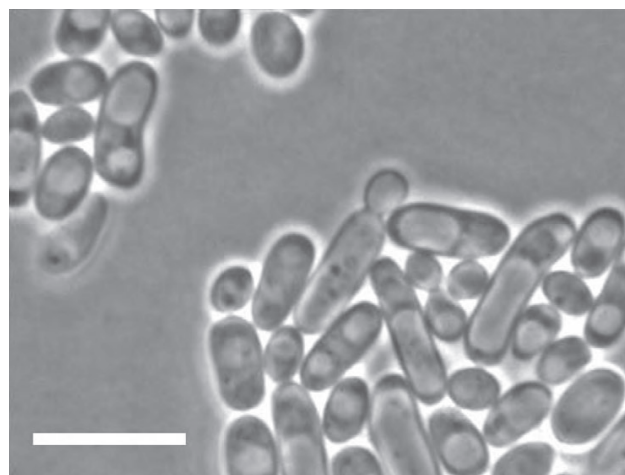


FIGURE 90.171 *Candida solani* CBS 1908. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

CoQ: 7 (Yamada and Kondo 1972a).

Mol% G + C: 41.9, CBS 1908 (T_m : Meyer and Phaff 1972).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70179.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 1908, isolated from a potato-starch mill, The Netherlands.

Type strain: CBS 1908.

Systematics: *Candida solani* was described by Lodder and Kreger-van Rij (1952), primarily on the basis of morphology. The species is related to *Wickerhamomyces pijperi* (Kurtzman and Robnett 1998a) and various other species (Suzuki and Nakase 2002), but the exact position with respect to other yeasts is uncertain. The multi-gene analysis of Kurtzman et al. (2008) suggests a basal position with respect to the *Wickerhamomyces* (Fig. 80.1) and *Lindnera* clades.

Differentiation from similar species can be based on the assimilation of positive reactions on L-sorbose, L-lysine and cadaverine, growth at 30°C and negative reactions on galactose, L-rhamnose and erythritol.

A few other strains are listed in the CBS database with the mention “identification doubtful”. One of these strains, CBS 5303, which was isolated from Pilsener beer in Germany, had an atypical growth profile. The D1/D2 sequence (AY550999) was identical to that of strain UWOPS 92-4.2 isolated from an oak exudate, Ontario, Canada, and differed from *Wickerhamomyces silvicola* by five substitutions and one gap. The strain is therefore not included in *C. solani*.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.262. *Candida sonorensis* (M.W. Miller, Phaff, Miranda, Heed & Starmer) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Ogataea* clade (Figs 53.1, 90.4).

Synonym:

Torulopsis sonorensis M.W. Miller, Phaff, Miranda, Heed & Starmer (1976a)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, 2.5–5 × 4–6 µm, and occur singly and in pairs (Fig. 90.172).

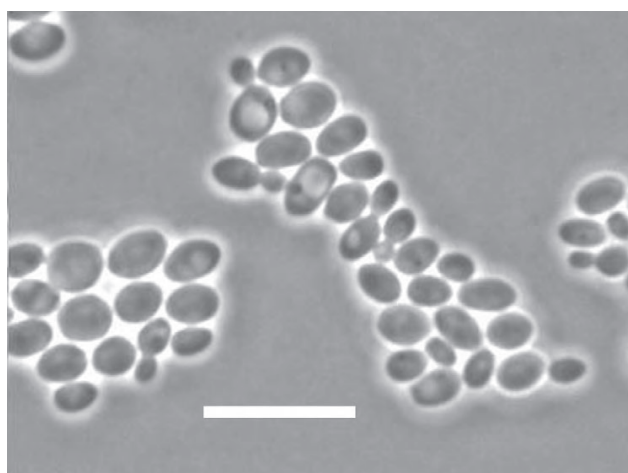


FIGURE 90.172 *Candida sonorensis* CBS 6792. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent. However, small chains of cells occur. Aerobic growth is off-white, butyrous, soft, smooth, shiny and with an entire to slightly lobed margin.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	—	Methanol	+
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	s
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl-α-D-glucoside	—	DL-Lactate	s
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	—
Salicin	+	D-Gluconate	—
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	+	Hexadecane	—
L-Arabinose	+	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Glucuronate	—	Gelatin	—

Glucono-δ-lactone	s	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	+

CoQ: 7 (Lee and Komagata 1980a).

Mol% G + C: 36.0–36.1, 2 strains (BD: Miller et al. 1976a).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70185.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 6792, isolated from tissue of organ-pipe cactus (*Lemaireocereus thurberi*, Cactaceae), Mexico, and many others from cactus tissue or associated *Drosophila* spp. (Diptera: Drosophilidae) or moths (Lepidoptera: Pyralidae) from Arizona and Hawai'i, USA, the Bahamas, the Caribbean, Argentina, Brazil and South Africa.

Other strains available: CBS 6793, isolated from tissue of saguaro cactus (*Carnegiea gigantea*), Arizona, and hundreds of others, from cactus tissue or associated insects, in Mexico, the southern USA and Australia.

Type strain: CBS 6792.

Systematics: Miller et al. (1976a) described *Torulopsis sonorensis* from a collection of 35 isolates recovered from the necrotic tissue of several cactus species collected in the Sonoran desert of Arizona and Mexico. The authors noted a similarity with *Lindnera* (*Pichia*) *sargentensis*, but observed that the two species could be separated by a few growth characteristics. Sequence analysis has shown that *C. sonorensis* is a core member of the methylotroph *Ogataea* clade (Kurtzman and Robnett 1998a, Suzuki and Nakase 2002). Ganter et al. (2004) reported considerable heterogeneity in a number of features including DNA reassociation values and D1/D2 LSU rRNA gene sequences. In some cases, these values were thought to vary beyond the range expected within a species. However, a critical examination of the data suggests that the variation was not as extensive as indicated by the authors.

The growth characteristics of the species are unique. Although some resemblance exists with a few related species, the absence of growth on trehalose is sufficient for separation. The physiological uniformity observed among the many strains examined in this laboratory contrasts with the extensive variation reported by Ganter et al. (2004), who found substantial variation in characteristics such as the utilization of D-xylose, D-ribose, glycerol and glucono-δ-lactone. It may not be entirely coincidental that these tests have in common a particularly high degree of experimental variation from one laboratory to the next.

Ecology: *Candida sonorensis* is one of the most prevalent species in cactus tissues that serve as breeding and feeding sites for numerous *Drosophila* species as well as the moths *Cactoblastis cactorum* (Starmer et al. 1988a) and *Sigalgaita* sp. (Rosa et al. 1992). Starmer et al. (1986) noted that *C. sonorensis* and species in the *Sporopachydermia cereana* complex are able to benefit the insects by consuming 2-propanol present in cactus tissue, and consequently reducing its toxicity. Methanol detoxification may also be of significance.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: In a study of the related species *C. arabinofementans*, Kurtzman and Dien (1998) found *C. sonorensis* capable of ethanol production by fermentation of D-xylose, but not L-arabinose.

90.263. *Candida sophiae-reginae* C. Ramírez & A. González (1984g)

Phylogenetic placement: unaffiliated clade (Fig. 90.2); see Systematics.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are long-ovoid, ellipsoidal or cylindrical, 2–4.5 × 6–10 µm, and occur singly, in pairs and short chains (Fig. 90.173 top).

Dalmay plate culture on corn meal agar: After 7 days at 25°C, well-developed pseudohyphae with branched chains of cells possessing clusters of ovoid blastoconidia are present (fig. 90.173 bottom). Aerobic growth is white, butyrous, glistening and the margin is entire to irregular.

Fermentation

Glucose	+	Lactose	–
Galactose	s	Raffinose	–
Sucrose	–	Trehalose	s
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	s	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	v	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	–
50% Glucose	–	Growth at 37°C	–

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 39.3, CBS 8175 (T_m : Tengku Zainal Mulok 1988).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45817.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 8175, isolated from rotten wood of Chilean laurel (*Laurelia sempervirens*, Atherospermataceae), Chile.

Type strain: CBS 8175.

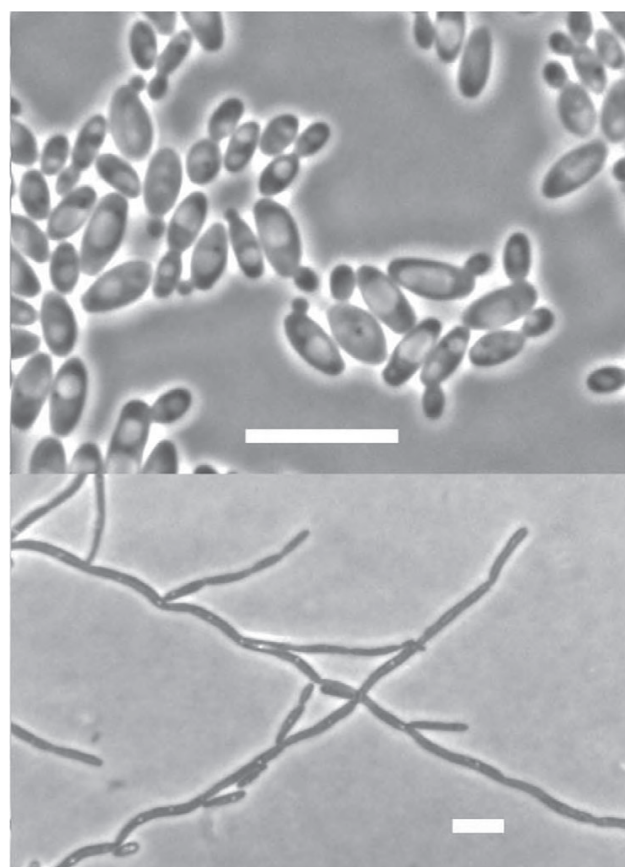


FIGURE 90.173 *Candida sophiae-reginae* CBS 8175. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 µm.

Systematics: Ramírez and González (1984g) described *C. sophiae-reginae* based on nine isolates from fallen tree trunks in a state of advanced decay in the Valdivian rainforest of Chile. The strains were reported to produce extracellular iodophilic material. Analysis of D1/D2 LSU rRNA gene sequences (Fig. 90.2) links the species to *C. aurita* and suggests a weak affinity to species in the genus *Debaryomyces*. The latter is supported by SSU rRNA gene sequences (Sugita and Nakase 1999).

The growth characteristics of the species are distinct. Similar species, including *C. sake*, do not utilize erythritol.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.264. *Candida sorbophila* (Nakase) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Wickerhamiella* clade (Fig. 79.1).

Synonym:

Torulopsis sorbophila Nakase (1975)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, 2–3.5 × 3–4 µm, and occur singly and in pairs (Fig. 90.174).

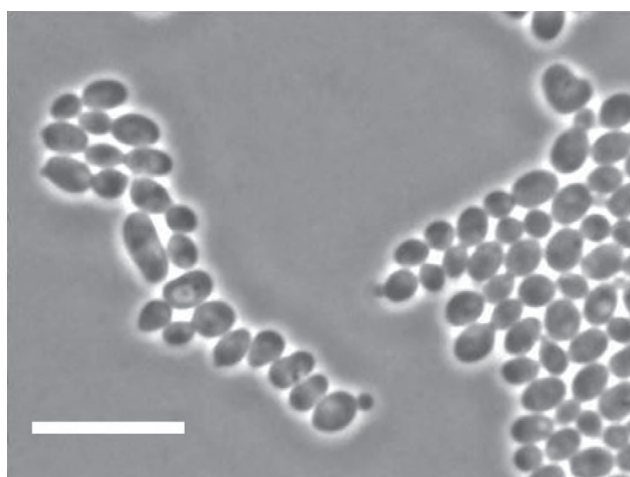


FIGURE 90.174 *Candida sorbophila* CBS 6739. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent or consist of short, branched chains of ovoid cells. Aerobic growth is white, butyrous, smooth, glistening and with an entire margin.

Fermentation

Glucose	w/s	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	v
Raffinose	—	Glycerol	—
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl- α -D-glucoside	—	D,L-Lactate	w/s
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	—
Salicin	—	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	s	Hexadecane	+
L-Arabinose	v	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	s	Starch production	—
2-Keto-D-gluconate	w	DBB	—
D-Glucuronate	—	Gelatin	s
Glucono- δ -lactone	v	Casein	—
Amino acid-free	+	Lipase	+
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+

Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	v

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 50.0, CBS 6739 (T_m : Nakase 1975).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45852.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 2280, isolated as a culture contaminant, UK; CBS 6739, from washings of ion-exchange resin from guanine-monophosphate plant, Japan; CBS 8746, from water from ventilation system of pig sty, The Netherlands.

Other strains available: CBS 7062, origin unknown, Switzerland; CBS 7266, from soil, South Africa.

Type strain: CBS 6739.

Systematics: Nakase (1975) described *Torulopsis sorbophila* from a strain isolated from industrial waste water. He noted a resemblance with *C. maris*, although the species could be separated on assimilation reactions, DNA base composition and the formation of galactomannan by *C. sorbophila*. The species belongs to the *Wickerhamiella* clade (Kurtzman and Robnett 1998a, Suzuki et al. 1999). Kurtzman (2007b) described the sister species *C. infanticola* to accommodate a strain that differed by six substitutions in the D1/D2 LSU rRNA gene sequences, although he noted some incongruences when other genes were examined. In particular, the two types have identical mitochondrial SSU rRNA genes and are indistinguishable by growth responses. Examination by DNA reassociation would be desirable in this case.

The growth characteristics of the three strains examined by replica plating were similar to previously reported results with some minor differences, including weak responses for assimilation of lactic acid (as reported in the original description), 2-keto-D-gluconate and glucose fermentation, which was previously reported as negative. The three strains examined did not assimilate glycerol. Gelatin liquefaction was slow and resistance to 0.1% cycloheximide positive (both reported as negative in the original description). A strong reaction was observed for Tween 80 hydrolysis, which is characteristic of the clade. Some physiological convergence with *Geotrichum fragrans* and various *Dipodascus* species was observed, although separation is easily obtained on the basis of growth habit. Separation from *C. catenulata* can be based on sorbose utilization by the species.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.265. *Candida sorbosivorans* James, Bond & Roberts (2001b)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

Synonym:

Candida hagleri Trindade, Guerra, Resende, Lachance & Rosa (Lachance 2001) nom. nud.

Growth on malt agar: After 2 weeks at 22°C, colonies are small, low convex, glabrous, smooth, white and butyrous.

Growth in glucose-yeast extract broth: After 3 days at 25°C, the cells are spherical, ovoid to ellipsoidal, 2–4 $\times$ 3–5 μ m, and occur singly, in parent–bud pairs or occasionally in short chains (Fig. 90.175). Rings or pellicles are not formed.

Dalmau plate culture on corn meal agar: After 2 weeks at 18°C, pseudohyphae or true hyphae are not formed.

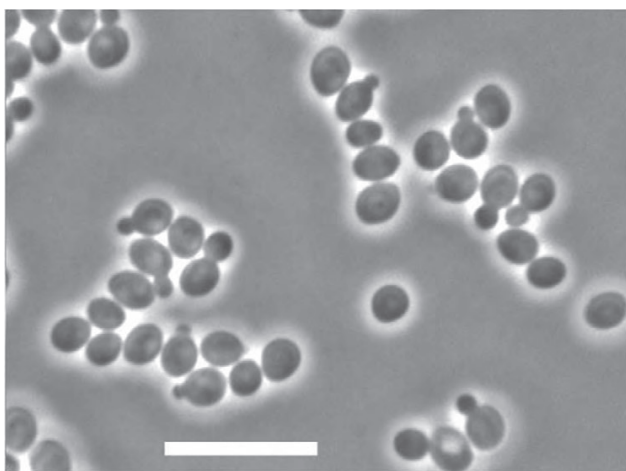


FIGURE 90.175 *Candida sorbosivorans* CBS 8768. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	+	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—/w
Inulin	—	Methanol	—
Sucrose	+	Ethanol	—/w
Raffinose	+	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	s	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl-α-D-glucoside	—	DL-Lactate	v
Soluble starch	—	Succinate	s
Cellulose	v	Citrate	+
Salicin	s	D-Gluconate	v
L-Sorbose	+	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	+
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	v	DBB	—
D-Gluconate	—	Gelatin	v
Glucono-δ-lactone	+	Casein	v
Amino acid-free	+	Lipase	—
Nitrite	+	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	s
L-Lysine	+	Cycloheximide 0.1%	w
Cadaverine	+	1% Acetic acid	—/w
10% NaCl	+	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AJ277846.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 2250, received as *C. magnoliae*, isolated from the gut of a bumblebee (*Bombus* sp., Hymenoptera: Apidae); CBS 3086 (received as *C. magnoliae*), from human sputum, The Netherlands; CBS 6201 (received as *C. magnoliae*), from beak of a dead tern (*Sterna* sp.), Finland; CBS 7444 (received as *C. apicola*), from blackcurrant drink, The Netherlands; CBS 8768 (NCYC 2938), continuous fermentation cascade from sorbitol to sorbose, UK; CBS 8824 (UFMG-R132), type strain of *C. hagleri*, and others, from frozen fruit pulp of umbu (*Spondias tuberosa*, Anacardiaceae); UFMG-R54 and others, from frozen acerola fruit pulp (*Malpighia glabra*, Malpighiaceae); UFMG-R151 and others, from frozen mangabe fruit pulp (*Hancornia speciosa*, Apocynaceae); all from Brazil. UWOPS 00-617.2 and UWOPS 00-619c3, from nitidulid beetle (*Aethina concolor*, Coleoptera, Nitidulidae) from morning glory (*Ipomoea cairica*, Convolvulaceae), Hawai'i, USA.

Type strain: CBS 8768.

Systematics: James et al. (2001b) described *C. sorbosivorans* after isolating a strain from an industrial fermentation where sorbitol is converted to sorbose. An analysis of the D1/D2 LSU rRNA gene sequence showed that the species is closely related to *C. geochares* and *C. magnoliae*, in the *Starmerella sensu lato* subclade (Fig. 71.1). The name *C. hagleri* was proposed almost simultaneously (Trindade et al. 2001, publication withdrawn, reported in *Yeast Newsletter* 2001, 50, 14) for similar strains recovered from frozen pulps of tropical fruit in Brazil. As the D1/D2 sequences were found identical to that deposited by James et al. (2001b), the species were considered synonymous. Some other strains formerly assigned to *C. apicola* and *C. magnoliae* are regarded as representatives of *C. sorbosivorans* on the basis of sequence similarity. Of these strains, CBS 2250 (GenBank AY521567) differs by three substitutions from the type strain. CBS 2250 stands out by a stronger utilization of 2-keto-D-gluconate.

The several strains studied by replica plating exhibited a fair amount of variability, notably in the utilization of cellobiose and xylitol, and resistance to 0.01% cycloheximide, and some strains grew weakly in the presence of 1% acetic acid. Other than the utilization of D-ribitol and erythritol (negative) there was good agreement with the original description. Comparison with authentic strains of *C. magnoliae* showed that the two species are practically indistinguishable on the basis of growth tests. The same observation applies for *C. vaccinii*. *C. gropengiesseri* may be distinguished on the lack of growth on nitrate.

Ecology: In view of the origin of the type strain in industrial sorbitol, James et al. (2001b) examined its growth on glucose, L-sorbose and sorbitol (D-glucitol) in comparison with the related species *C. magnoliae* and *C. geochares*. A significantly higher growth rate was found for glucose only, but *C. sorbosivorans* exhibited rapid growth on L-sorbitol, in contrast with the other two species, which flocculated in the presence of that substrate. Although many species in the *Starmerella* clade have been linked to bees, a direct association may not be evident for *C. sorbosivorans*, although one cannot be ruled out.

Biotechnology: Unknown.

Agriculture and food: Trindade et al. (2002) reported on the occurrence of yeasts on ripe fruits and frozen pulps of various tropical plants of agricultural interest in Brazil. *C. sorbosivorans* was a major component of the community, but a wide diversity of species was observed, with an abundance of isolates capable of proteolysis and pectinolysis.

Clinical importance: Unknown.

90.266. *Candida sorboxylosa* Nakase (1971c)

Phylogenetic placement: unaffiliated clade (Fig. 90.3).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to long-ovoid, 3–6 × 4–8 μm, and occur singly and in pairs (Fig. 90.176).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of ovoid cells with clusters of blastoconidia. Aerobic growth is off-white, butyrous, smooth, soft and with an entire to an irregular margin.

Fermentation

Glucose	s	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	—	D-Mannitol	—
Maltose	—	D-Glucitol	—
Melezitose	—	myo-Inositol	—
Methyl-α-D-glucoside	—	DL-Lactate	+
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	+
Salicin	—	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	+	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

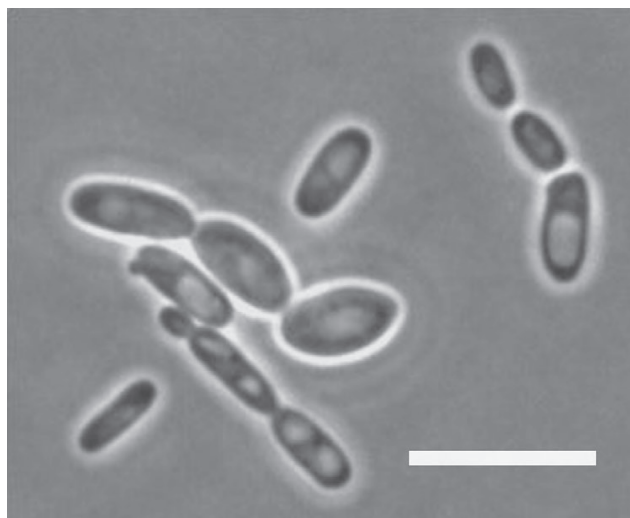


FIGURE 90.176 *Candida sorboxylosa* CBS 6378. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	—	DBB	—
D-Gluconate	—	Gelatin	—
Glucono-δ-lactone	—	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	v

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: 39.8, 39.9, 2 strains (T_m : Nakase 1971c); 40.7, CBS 2120, CBS 2121 (T_m : S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U62314.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 2120, isolated from fermenting cacao, Ghana; CBS 6378, from pineapple (*Ananas comosus*, Bromeliaceae); CBS 8042, from *Euphorbia* sp. (Euphorbiaceae), Indonesia; PYCC A58, from seawater, south of Portugal.

Other strain available: CBS 2121, from palm wine, Ghana.

Type strain: CBS 6378.

Systematics: Nakase (1971c) examined several strains previously identified as *C. krusei* and described *C. sorboxylosa* from five strains recovered from pineapple, banana and a feed used in the rearing of silkworm. He indicated that the utilization of both L-sorbose and D-xylose differentiated the species from many other species. *C. santamariae*, which shared those characteristics, could be distinguished by many other attributes. An analysis of D1/D2 LSU rRNA gene (Kurtzman and Robnett 1998a) placed *C. sorboxylosa* as a sister species to *C. silvatica* and suggested a relationship with *Dekkera* species. However, the sequence is highly divergent, the D2 variable region is practically non-existent and a credible phylogenetic placement on the basis of that sequence is not possible. Analysis of SSU rRNA gene sequences (Suzuki and Nakase 2002) positioned the species on a long branch near clades containing *Saturnispora* species and *Pichia membranifaciens*, leaving the placement essentially unresolved (Fig. 90.1). Strain PYCC A58, isolated from seawater south of Portugal, differed by four substitutions in the D1/D2 LSU rRNA gene (Gadanhho et al. 2003), and may or may not be conspecific.

The growth characteristics of the four strains received from the CBS exhibited some heterogeneity. Strain CBS 6394, collected in an insect tunnel in felled timber in South Africa, did not utilize xylitol or citric acid, grew on vitamin-free medium and exhibited a higher tolerance to ethanol (10% compared to 6%). The D1/D2 sequence was determined (AY551000) and found to resemble the sequence of *Pichia deserticola*. The strain therefore cannot be considered a member of *C. sorboxylosa*.

Strain CBS 2120 did not grow at 37°C, nor did it ferment glucose after 3 weeks. Strain CBS 8042 was the only one found to assimilate glycerol as reported in previous descriptions. None of the strains grew in the presence of 10% NaCl as previously reported. The species is oligophagic and resembles many species that share this characteristic. Most of those others species, however, do not assimilate L-sorbose. Differentiation from *Pichia membranifaciens* or the anamorph, *C. valida*, can be problematic.

Ecology: The diversity of sources for this rare species precludes generalization on the possible habitat. Braga et al. (1998) reported the isolation of a highly proteolytic strain of *C. sorboxylosa* from amapa fruit

(*Parahancornia amapa*, Apocynaceae) in the Brazilian Amazon rain forest. However, none of the strains examined in this study hydrolyzed gelatin or casein, thus suggesting a possible misidentification.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.267. *Candida spandovens* (Henninger & Windisch) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Wickerhamiella* clade (Fig. 79.1).

Synonym:

Torulopsis spandovens Henninger & Windisch (1976b)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to short-ovoid, 2.5–3.5 × 3–4.5 µm, and occur singly and in pairs (Fig. 90.177).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent or short chains of budding cells are present. Aerobic growth is white, butyrous, shiny, convex and with an entire margin.

Fermentation

Glucose	+	Lactose	–
Galactose	s	Raffinose	s/–
Sucrose	s	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	+
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	s
Soluble starch	–	Succinate	+
Cellulobiose	–	Citrate	s
Salicin	–	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	v	Hexadecane	–
L-Arabinose	+	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	v	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	v	Casein	–
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	v	Growth at 30°C	v
50% Glucose	+	Growth at 37°C	–

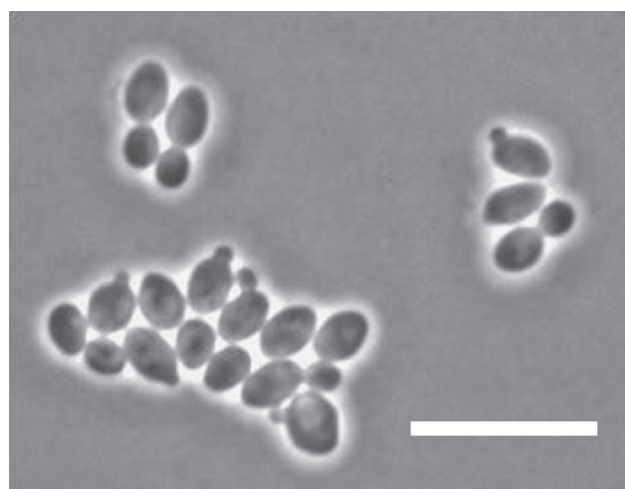


FIGURE 90.177 *Candida spandovens* CBS 6875. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 52.7, CBS 6875 (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U62309.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5511, CBS 6875, isolated from beer, Germany.

Type strain: CBS 6875.

Systematics: Henninger and Windisch (1976) investigated the occurrence of yeasts in German beers. Two weakly fermenting strains were recovered from Pilsener beer and described as *Torulopsis spandovens*. A similarity with *C. apis* was noted, but the two species differed by the assimilation of L-sorbose, D-ribitol and galactitol, which are positive in the species. *C. spandovens* is a distinct member of the *Wickerhamiella* clade and is related to *C. sorbophila* (Kurtzman and Robnett 1998a) and *C. galacta* (Suzuki et al. 1999). Trindade et al. (2004) described the sister species *C. sergiensis* to recognize several isolates recovered from fruit pulps in Brazil.

The two strains examined differed in the ability to grow at 30°C, which is negative in the type strain, and in resistance to 10% NaCl, which is positive in the type strain. Neither strain grew on D-xylose when examined by replica plating, the only trait to be at variance from previous descriptions. The assimilation of galactitol separates *C. spandovens* from other species.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: *Candida spandovens* was reported as a frequent isolate in tropical fruits in Brazil, along with *C. sergiensis* and *C. sorbosivorans* (Trindade et al. 2002, 2004).

Clinical importance: Unknown.

90.268. *Candida spencermartinsiae* Statzell-Tallman, Scorzetti & Fell (2010)

Phylogenetic placement: *Yamadazyma* clade; see Systematics (Fig. 90.2).

(The description is based on Statzell-Tallman et al. 2010.)

Growth on 5% malt extract agar: After 1 month at 25°C, the colonies are white, glistening and butyrous and the margin is fringed with hyphae.

Growth in 5% malt extract: After 3 days at 25°C, the cells are ovoid, spherical or elongate, $1.3\text{--}3.4 \times 2\text{--}10.7\text{ }\mu\text{m}$, and occur singly, in pairs or in short chains.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, branched pseudohyphae and some true hyphae are present.

Fermentation

Glucose	+	Lactose	–
Galactose	w	Raffinose	+
Sucrose	+	Trehalose	v
Maltose	w	Inulin	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	s
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	s	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	s/w	myo-Inositol	–
Methyl- α -D-glucoside	+	D,L-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	+	Citrate	+
Salicin	w/s	D-Gluconate	+
L-Sorbose	s	D-Glucosamine	+
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	–
D-Arabinose	s	Vitamin-free	–

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	–	10% NaCl/5% glucose	+
5-Keto-D-gluconate	–	Starch formation	–
D-Glucuronate	–	Urease	–
Saccharate	–	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = FJ008044, ITS and 5.8S rRNA = FJ008050.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 10894 (NRRL Y-48663), CBS 10895, NRRL-Y 27418 and 9611-26, all isolated from seawater at a water depth of 10 m adjacent to corals, Looe Key Reef, Florida, 16 December 1996; 9807-028, isolated from seawater adjacent to a coral reef near Rendezvous Cay, Belize; R/V Mary 092, whose identity was determined by GenBank sequence analysis, was isolated from Mid-Atlantic Ridge hydrothermal fields, near the Azores Archipelago by Gadanho and Sampaio, 2005 (Statzell-Tallman et al. 2010).

Type strain: CBS 10894.

Systematics: *Candida spencermartinsiae* belongs to the *Debaryomyces/Lodderomyces* clade (Fig. 90.2) in a cluster of species that includes *C. taylori*, *C. atlantica* and *C. atmosphaerica*, which have all been isolated from marine habitats (Gadanho and Sampaio 2005, Gadanho et al. 2003, Meyer et al. 1998, Statzell-Tallman et al. 2010).

Ecology: *Candida spencermartinsiae* was isolated at marine locations (Florida, Belize, Azores Archipelago) in coral reefs and hydrothermal field habitats. The species may represent a natural component of the marine ecosystem (Statzell-Tallman et al. 2010).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: No ascospores were produced after 6 weeks at 25°C on YM agar or on corn meal agar.

90.269. *Candida stellata* (Kroemer & Krumbholz) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Starmerella* clade (Figs 71.1, 90.3).

Synonyms:¹

Saccharomyces stellatus Kroemer & Krumbholz (Krumbholz 1931)
Torulopsis stellata (Kroemer & Krumbholz) Lodder (1932)
Cryptococcus stellatus (Kroemer & Krumbholz) Skinner (1947a)
Saccharomyces bacillaris Kroemer & Krumbholz (Krumbholz 1931)
Torulopsis bacillaris (Kroemer & Krumbholz) Lodder (1932)
Cryptococcus bacillaris (Kroemer & Krumbholz) Skinner (1947a)
Brettanomyces italicus Verona & Florenzano (1947)

¹ Synonymy based on phenotype.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, $4\text{--}5 \times 4\text{--}6\text{ }\mu\text{m}$, and occur singly and in pairs (Fig. 90.178).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent. Aerobic growth is white, butyrous, soft, glossy and with an entire margin.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	+/s
Sucrose	+	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	–
Raffinose	+	Glycerol	–
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	D,L-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	v	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

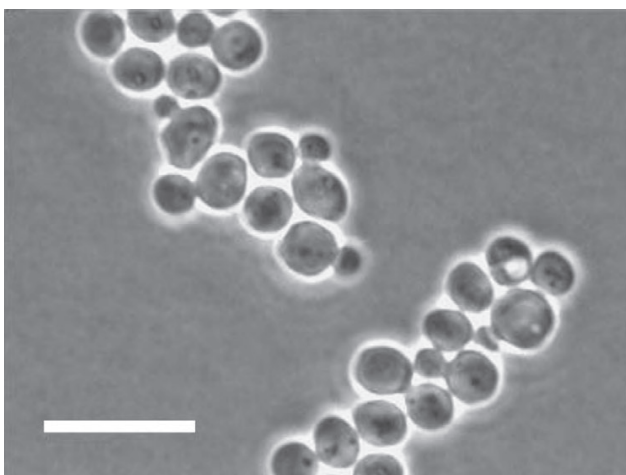


FIGURE 90.178 *Candida stellata* CBS 157. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	–	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	–	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	–	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	–

CoQ: 8 (Yamada and Kondo 1972a).

Mol% G + C: 42.0, 1 strain (T_m : Nakase and Komagata 1971d).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45730.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 157, isolated from wine grapes in Germany.

Other strains available: CBS 1713, from wine in Italy; CBS 1779, from tea-beer; CBS 6100, unknown.

Type strain: CBS 157.

Systematics: *Candida stellata* belongs to the *Starmerella sensu stricto* clade and is a sister species of *C. davenportii* (Rosa et al. 2003, Stratford et al. 2002). The species is extremely oligophagic. The only carbon sources utilized are sucrose and raffinose, and the two tests give variable responses among strains. Some strains grow only weakly at 30°C, and the type did not grow at all at that temperature. This property may be useful in separating *C. stellata* from *C. davenportii* and *C. zemplinina*, another related cryptic species (Sipiczki 2003), but a systematic study of maximum growth temperatures has not been performed. Several other species exhibit similar growth profiles, but most fail to utilize L-lysine, which is positive or weak in *C. stellata*.

Three strains isolated from grape must in the Niagara region (Holloway et al. 1992) were unusual by their ability to utilize 2-keto-D-gluconate, to grow weakly at 37°C and to form pseudohyphae. At the time of isolation, they were compared by electrophoretic

karyotyping to strain UWOPS 83-960.1, isolated from prickly pear fruit in the Bahamas, and found to be similar. Both strains have been reassigned to *C. zemplinina* on the basis of D1/D2 LSU rRNA gene sequencing data. CBS 4729 was reassigned to that species based on ITS sequences.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Beltran et al. (2002) followed the development of the yeast community associated with two varietal musts in a newly built winery over 6 years. *Hanseniaspora uvarum* and *C. stellata* were the dominant species in early fermentations, later to be supplanted by *S. cerevisiae*. Older reports of *C. stellata* in foods or fermented beverages should be viewed with caution in view of the recent discovery of *C. zemplinina* (Sipiczki 2003).

Clinical importance: Unknown.

Additional comments: Ciani et al. (2000) found that under anaerobic conditions, *C. stellata* diverted a substantial amount of carbon to glycerol production, thus explaining its low fermentation rates.

90.270. *Candida stellimalicola* M. Suzuki, Nakase & Komagata (1994)

Phylogenetic placement: *Starmera* sister clade (Figs 70.1, 90.1).

(Some of the morphological characteristics are based on Suzuki et al. 1994.)

Growth in YM broth: After 3 days at 25°C, the cells are spherical to ovoid, 2–4 μ m, occur singly or in pairs (Fig. 90.179) and a pellicle is not formed.

Growth on YM agar: After 1 month at 17°C, the streak culture is cream colored, smooth, glistening and with an entire margin.

Dalmau plate culture on corn meal agar: Pseudohyphae are not formed.

Fermentation

Glucose	s	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	D-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	w
D-Xylose	s	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	s	Vitamin-free	–

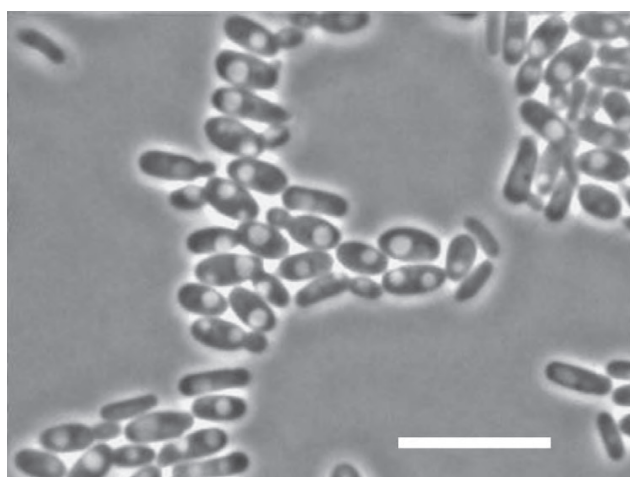


FIGURE 90.179 *Candida stellimalicola* CBS 7853. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	w
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: 40.7, JCM 3546 (HPLC: Suzuki et al. 1994).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U84234.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 7853 (JCM 3546), isolated from fruit of star apple (*Averrhoa carambola*, Oxalidaceae), Thailand.

Type strain: CBS 7853.

Systematics: Suzuki et al. (1994) described *C. stellimalicola* to accommodate a strain that resembled *C. diversa*, *C. silvae* and *C. karawaiewii* (syn. of *C. ernobii*), on the basis of low DNA reassociation and other properties. Analysis of D1/D2 LSU rRNA gene sequences (Kurtzman and Robnett 1998a) suggested an affinity for the genus *Starmera*. This suggestion was corroborated by an analysis of the SSU rRNA gene sequence determined by Yamada et al. (1999).

As noted in the original description, the growth characteristics of the species are similar to those of *C. silvae* and *C. diversa*. In addition, the growth profile resembles the profiles of a few other *Candida* species and the related species *Starmera caribaea*. Distinction from *C. silvae* would be problematic, as the two species differ only by the weak utilization of D-xylose by *C. stellimalicola*. Separation from *Starmera caribaea* can be based also on citric acid utilization (negative) and growth in the absence of amino acids, for which *Starmera caribaea* requires an organic source of sulfur (Phaff et al. 1992). In this study, the type strain was found to ferment glucose slowly, which was reported as negative in the description.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.271. *Candida stri* S.-O. Suh, N.H. Nguyen & M. Blackwell (2006a)

Phylogenetic placement: *Candida kruisii* clade (Fig. 90.5).

(The description is based on Suh et al. 2006a.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, butyrous and smooth.

Growth in YM broth: After 7 days at 25°C, cells are ellipsoidal to fusiform, 2–4 $\times$ 3–6 μ m, mostly ellipsoidal, occur singly, in pairs or in clusters and pseudohyphae and true hyphae are present.

Dalmeu plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae are present. Aerobic growth is off-white, smooth and with a filamentous margin.

Fermentation

Glucose	+	Lactose	–
Galactose	d	Raffinose	–
Sucrose	–	Trehalose	d
Maltose	–	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	d	myo-Inositol	–
Methyl- α -D-glucoside	+	D-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	–	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Ethylamine	+
2-Keto-D-gluconate	+	50% Glucose	–
D-Glucuronate	–	10% NaCl/5% glucose	–
L-Arabinitol	–	Starch formation	–
Arbutin	+	Urease	–
Propane 1,2 diol	–	DBB	–
Butane 2,3 diol	–	Cycloheximide 0.01%	+
Nitrite	–	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 30°C	+
Creatinine	–	Growth at 35°C	–
L-Lysine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = DQ647646, SSU rRNA = DQ647645, ITS and 5.8S rRNA = DQ647647.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-48063 (CBS 10378), isolated from the gut of a nitidulid beetle (*Pallodes* sp.) on the basidiocarp of a mushroom (*Gymnopus* sp., Tricholomataceae), Barro Colorado Island, Panama (Suh et al. 2006a).

Type strain: NRRL Y-48063.

Systematics: *Candida stri* belongs to a clade of species that all have been isolated from *Pallodes* nitidulid beetles, namely *C. barrocolora-densis*, *C. gatenensis* and *C. stri* (Suh et al. 2006a). Based on a phylogenetic analysis of combined D1/D2 LSU and SSU rRNA gene sequences, this cluster was found to belong to the *Candida kruisii* clade.

Ecology: *Candida stri* is known from the gut of a beetle in Panama (Suh et al. 2006a).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.272. *Candida subhashii* M. Groenewald, Sigler, Richardson & Sugiyama (Adam et al. 2009)

Phylogenetic placement: see Systematics.

(The description is based on Adam et al. 2009.)

Growth on YM agar: After 7 days at 25°C, colonies are 10–25 mm in diameter, convex, pale cream colored, smooth, shiny, soft and have an entire margin. Budding cells are globose to ovoid, 3–6 × 3–6 µm, and reproduce by unipolar or bipolar budding. Blastoconidia are produced sympodially on a rachis-like structure with numerous denticulate scars. Conidiophores are 1.8–3.5 µm in diameter and the distance between septa is 22–30 µm. Blastoconidia are more irregular in shape than budding yeast cells, and are globose to elongate. Pseudohyphae are not formed abundantly.

Dalmau plate culture on morphology agar: Unknown.

Fermentation: Absent.

Growth (in Liquid Media and on Microtiter Plates)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	n
Sucrose	+	Ethanol	n
Raffinose	–	Glycerol	–
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	w
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	+	D-Glucitol	–
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	w	DL-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	+	Citrate	–
Salicin	w	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	w	Hexadecane	n
L-Arabinose	w	Nitrate	–
D-Arabinose	–	Vitamin-free	+

Additional Growth Tests and Other Characteristics

Xylitol	–	Cadaverine	w
5-Keto-D-gluconate	–	Creatinine	–
D-Glucuronate	–	L-Lysine	+
L-Arabinitol	–	Ethylamine	w
Arbutin	w	Growth at 25°C	+
Propane 1,2 diol	–	Growth at 40°C	+
Butane 2,3 diol	–	Growth at 42°C	–
Nitrite	–		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = EU836708, ITS = EU836707.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 10753 (UAMH 10744), isolated from peritoneal dialysis fluid from a 69-year-old man with end-stage renal failure (Adam et al. 2009).

Type strain: CBS 10753.

Systematics: Phylogenetic analysis of the D1/D2 domains of the LSU rRNA gene sequence and the ITS 1 and 2 regions placed *C. subhashii* in a clade with some well-known human pathogens, namely, *C. parapsilosis*, *C. orthopsilosis*, *C. metapsilosis*, *C. tropicalis*, *C. albicans* and *C. dubliniensis*, *Debaryomyces hansenii* and *Meyerozyma guilliermondii* (Adam et al. 2009). Given the sparse phylogenetic sampling used by the authors, the phylogenetic position of the species remains unclear.

Ecology: *Candida subhashii* is known from peritoneal dialysis fluid from a 69-year-old man with end-stage renal failure (Adam et al. 2009).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: The only strain of this species was isolated from peritoneal dialysis fluid from a patient with end-stage renal failure (Adam et al. 2009).

90.273. *Candida succiphila* J.-D. Lee & Komagata (1980b)

Phylogenetic placement: *Ogataea* clade (Figs 53.1, 90.4).

Synonyms:

Candida methanolophaga Kumamoto & Yamamoto (Kumamoto et al. 1986)¹

Candida cellulolytica Nakase, M. Suzuki, Takashima & Yamamoto (Nakase et al. 1994c)²

¹ Synonymy based on identical chromosomal DNA banding patterns and 90% DNA relatedness (Lee et al. 1994b).

² D1/D2 LSU rRNA gene sequences (Kurtzman and Robnett 1998a).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are spherical to ovoid, 2–4.5 × 3–6 µm, and occur singly, in pairs and in short chains (Fig. 90.180).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent. Aerobic growth is white to slightly cream colored, smooth, butyrous, soft, glistening and with an entire margin.

Fermentation

Glucose	+	Lactose	–
Galactose	s	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–		

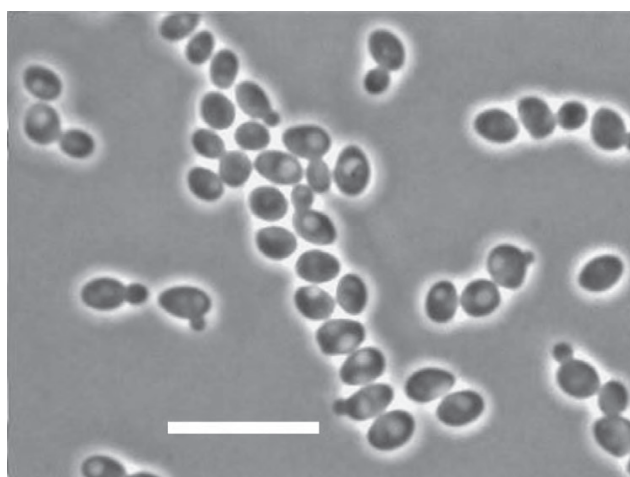


FIGURE 90.180 *Candida succiphila* CBS 8003. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	—/s	Methanol	+
Sucrose	—	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	+
Galactose	+/w	Ribitol	+
Lactose	—	Galactitol	v
Trehalose	+	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl-α-D-glucoside	—	D,L-Lactate	v
Soluble starch	—	Succinate	v
Cellobiose	+	Citrate	—
Salicin	+	D-Gluconate	v
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	—
L-Arabinose	+	Nitrate	—
D-Arabinose	+	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	v	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono-δ-lactone	+	Casein	—/w
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	—	Cycloheximide 0.1%	v
Cadaverine	—	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	+/w

CoQ: 7 (J.-D. Lee and Komagata 1980a, C.-F. Lee et al. 1994b).

Mol% G + C: 40.9, CBS 8003 (T_m : J.-D. Lee and Komagata 1980a); 41.2, CBS 7297 (T_m : Kumamoto et al. 1986); 40.0, CBS 8003; 39.5, CBS 7297 (HPLC: C.-F. Lee et al. 1994b).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70189.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 8003, isolated from sap of peach tree (*Amygdalus persica*, Rosaceae), Japan; CBS 7920, type strain of *C. cellulolytica*, from tree exudate, Japan; UWOPS 79-230, from black knot (*Dibotryon morbosum*, Venturaceae) on chokecherry (*Prunus virginiana*, Rosaceae), Ontario, Canada.

Other strain available: CBS 7297, type strain of *C. methanolphaga*, isolated from soil of oilfield, Japan.

Type strain: CBS 8003.

Systematics: J.-D. Lee and Komagata (1980a) described *C. succiphila* from six methylotrophic strains recovered from soil, peach tree sap and peaches. They noted a similarity with *C. cariosilignicola* (teleomorph *Ogataea methylivora*) and indirectly with *C. apicola* and *C. bombicola*, as well as some differences in growth characteristics and DNA base composition. Kumamoto et al. (1986) described *C. methanolphaga* in the context of a large survey of methylotrophic yeasts for potential use in single-cell protein production. From 205 isolates, eight strains could not be identified, of which three were assigned to that taxon. The authors noted a similarity with *C. succiphila*, but the two species reportedly differed in the assimilation of lactose, cellobiose and galactitol. Lee et al. (1994b) found identical chromosomal DNA banding patterns and 90% DNA relatedness between the type strains of *C. methanolphaga* and *C. succiphila*, thus demonstrating their conspecificity. This conclusion was corroborated by the finding of identical sequences in the D1/D2 LSU rRNA genes of the type strains (Kurtzman and Robnett 1998a). *C. cellulolytica* was described by Nakase et al. (1994c) after screening for yeasts able to degrade carboxymethyl-cellulose. The single strain, recovered from a sap flux, was reported to resemble *C. caco* (teleomorph *Millerozyma farinosa*) and *C. conglobata*, but differed in CoQ values and several growth characteristics. The D1/D2 LSU rRNA gene sequence of *C. cellulolytica* is identical to that of *C. succiphila* (Kurtzman and Robnett 1998a) and the SSU rRNA gene sequence differs by only one gap from that of *C. methanolphaga*. The three species are therefore considered synonyms. Sequence analysis also confirms membership of *C. succiphila* in the methylotroph *Ogataea* clade (Fig. 90.4).

The growth characteristics of *C. succiphila* and its synonyms are more homogeneous than anticipated on the basis of the published descriptions. The type strain of *C. cellulolytica* assimilates ethanol, which was reported as negative by Nakase et al. (1994c), as did all other strains examined. The only remaining difference is in the assimilation of galactitol, which is negative in the type strain of *C. methanolphaga*, compared to weak or slow in other strains. An isolate from black knot (UWOPS 79-230), identified by D1/D2 LSU rRNA gene sequencing, differed from the rest on the assimilation of 2-keto-D-gluconate and resistance to 0.1% cycloheximide, which were both found to be negative. The species also resembles *Ogataea pini*, which differs by the lack of growth on *N*-acetyl-D-glucosamine, but appears variable for a number of other potentially diagnostic traits.

Ecology: Unknown.

Biotechnology: Dien et al. (1996) screened 116 yeasts for the ability to ferment L-arabinose and found *C. succiphila* capable of producing a small amount of ethanol from that sugar as well as D-xylose.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.274. *Candida suecica* Rodrigues de Miranda & Norkrans (1968)

Phylogenetic placement: *Kodamaea* clade (Fig. 36.1).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, long ovoid, ellipsoidal or cylindrical,

2–4 × 6–14 μm, and occur singly, in pairs and short chains (Fig. 90.181 left). Pseudohyphae are present.

Growth in yeast nitrogen base + 0.5% glucose: After 3 days at 25°C, a delicately wrinkled pellicle is present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, abundant pseudohyphae are present and consist of branched chains of cylindrical cells (Fig. 90.181 right), many with verticils of ovoid blastoconidia. Aerobic growth is white, smooth and wrinkled, soft, dry and with a lobed margin.

Fermentation

Glucose	–/s	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	v	Citrate	v
Salicin	v	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	v
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	–	Cycloheximide 0.01%	–
L-Lysine	–	Cycloheximide 0.1%	–
Cadaverine	–	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	–
50% Glucose	–	Growth at 37°C	–

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 42.7, 42.4, CBS 5724 (T_m : Meyer et al. 1984; BD: Kurtzman 1987a, respectively).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45732.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 5724, isolated from seawater, Sweden.

Type strain: CBS 5724.

Systematics: *Candida suecica* was described by Rodrigues de Miranda and Norkrans (1968) from an isolate recovered from seawater along with a few other species in a Swedish estuary. Noting a similarity with *C. mesenterica*, the authors found differences in pseudohyphal formation, glucose fermentation and growth on a few carbon compounds. Analysis of D1/D2 LSU rRNA gene sequences (Fig. 36.1) places the species in a basal position with respect to most species in the *Kodamaea* clade. A connection to the newly described species *C. arcana* and *C. derodonti* (Suh and Blackwell 2005) is possible. *C. mesenterica*, which occupies the most basal position in the clade (Fig. 36.1), was identified as a sister species due to the fewer SSU rRNA gene sequences available at the time (Nakase et al. 1999).

The type strain did not grow well when studied by replica plating, although some concordance was found with published

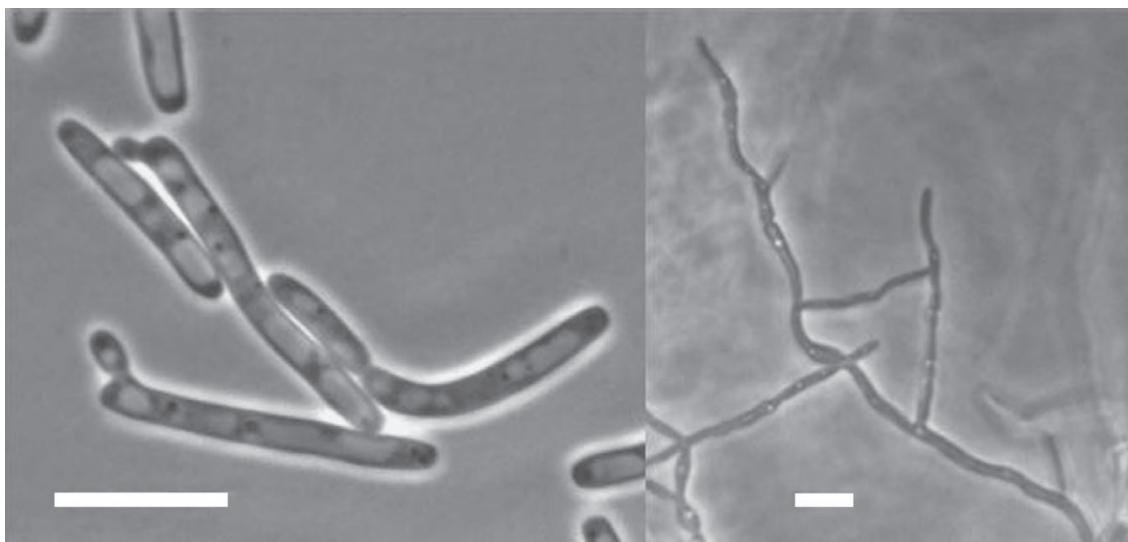


FIGURE 90.181 *Candida suecica* CBS 5724. Budding cells after 3 days, 25°C, YM agar (left) and pseudohyphae after 14 days, 18°C, YCBAS agar (right). Bars = 10 μm.

descriptions. No growth was observed on cellobiose and salicin, and glucose was not fermented. These responses were reported as positive in the original description and variable in the 4th Edition of this monograph, which serves as the primary source of growth responses here (Meyer et al. 1998). Assimilation of 2-keto-D-glucuronate was found to be negative when tested by replica plating, but a weak growth was observed on galactose, D-glucosamine and N-acetyl-D-glucosamine (carbon sources), and ethylamine and cadaverine (nitrogen). The discrepancies in nitrogen utilization may be explained in part by the slow growth observed on YNB without amino acids, as these compounds are only present at low concentrations in YCB medium. No particular physiological similarity was found with other members of the clade. Identification based on the physiological profile may be difficult.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.275. *Candida suzukii* Péter, Tornai-Lehoczki, Fülöp & Dlačuchy (2003)

Phylogenetic placement: *Ogataea* clade (Figs 53.1, 90.4). (The description is based on Péter et al. 2003.)

Growth on malt agar: After 3 days at 25°C, the streak culture is butyrous, cream colored, smooth, glistening, slightly raised and has an entire margin.

Growth in malt extract broth: After 3 days at 25°C, the cells are subspherical to ovoid, 1.5–3 × 2–6 µm, occur singly, in pairs or in small clusters and reproduce by multilateral budding (Fig. 90.182). A pellicle is absent and sediment is present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, neither pseudohyphae nor septate hyphae are formed.

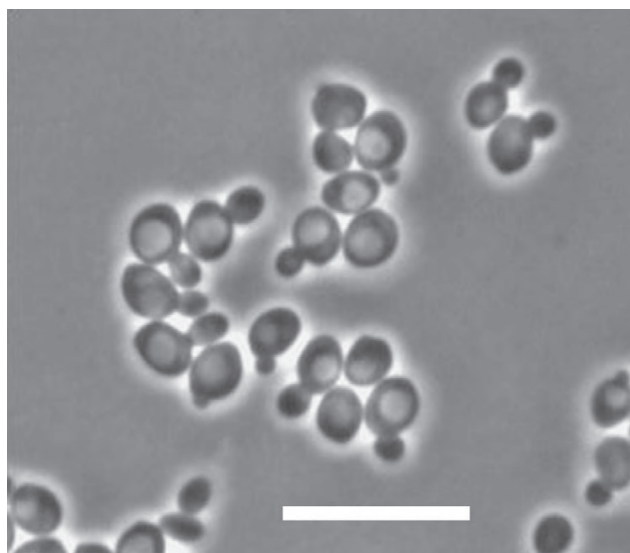


FIGURE 90.182 *Candida suzukii* CBS 9253. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

Fermentation: Absent.

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	+
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D,L-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	+
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Ethylamine	+
2-Keto-D-glucuronate	–	50% Glucose	–
D-Glucuronate	–	10% NaCl/5% glucose	–
L-Arabinitol	+	Formation of starch-like compounds	–
Propane 1,2 diol	s		
Butane 2,3 diol	–	Urease	–
Nitrite	+	DBB	–
Cadaverine	+	Cycloheximide 0.1%	+
Creatinine	–	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY028434.

Cell carbohydrates: Not determined.

Origin of the strain studied: NCAIM Y.01500 (CBS 9253), isolated from bark of an unidentified tree, Taiwan (Péter et al. 2003).

Type strain: NCAIM Y.01500.

Systematics: Sequence analysis of the D1/D2 domains of the LSU rRNA gene places *C. suzukii* in a clade with *Ogataea ramenticola*, *C. nitratophila* and *C. nanaspora* (Péter et al. 2003).

Ecology: *Candida suzukii* is known from a single strain from tree bark in Taiwan (Péter et al. 2003).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.276. *Candida takamatsuzukensis* Nagatsuka, Kiyuna, Kigawa & Sugiyama (Nagatsuka et al. 2009)

Phylogenetic placement: *Yamadazyma* clade; see Systematics (Fig. 90.2).

(The description is based on Nagatsuka et al. 2009.)

Growth on YM agar: After 3 weeks at 25°C, the colony is white to cream, dry, wrinkled, pulvinate and with a lobate margin.

Growth in YM broth: After 3 days at 25°C, cells are spherical to ovoid, 1.9–4 × 2–6 µm, reproduce by multipolar budding and occur singly or in pairs.

Growth on the surface of fermentation media: Sediment and a thin ring are formed.

Dalmau plate culture on YM agar: After 6 days at 25°C, pseudohyphae and septate hyphae are present.

Fermentation

Glucose	w	Lactose	–
Galactose	w	Raffinose	–
Sucrose	–	Trehalose	w
Maltose	–		

Growth (Media not Specified)

Glucose	+	D-Ribose	+/w
Inulin	n	Methanol	–
Sucrose	w	Ethanol	w
Raffinose	–	Glycerol	w
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+/w	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+/w	D-Gluconate	+
L-Sorbose	w	D-Glucosamine	w
L-Rhamnose	w	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	+/w	Nitrate	–
D-Arabinose	w	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	w	L-Lysine	+
2-Keto-D-gluconate	+	Ethylamine	+
5-Keto-D-gluconate	–	50% Glucose	–
D-Glucuronate	–	10% NaCl/5% glucose	w
L-Arabinitol	+	Starch formation	–
Arbutin	+	Urease	–
Propane 1,2 diol	–	DBB	–
Butane 2,3 diol	–	Cycloheximide 0.01%	+
Isopropyl alcohol	–	Cycloheximide 0.1%	+
Nitrite	–	Growth at 25°C	+
Cadaverine	+	Growth at 30°C	+
Creatinine	–	Growth at 35°C	–

CoQ: 9 (Nagatsuka et al. 2009).

Mol% G + C: 36.7 (HPLC: Nagatsuka et al. 2009).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AB365470.

Cell carbohydrates: Not determined.

Origin of the strains studied: JCM 15410 (CBS 10916, NBRC 104391, T4922-1-1), isolated from air in a stone chamber of the Takamatsu-zuka tumulus, September 22, 2004; JCM 15411–JCM 15414, all

isolated from various places and substrates in the stone chamber of the Takamatsu-zuka tumulus, such as biofilms (i.e., viscous gel), and part of a mural that turned black, all from Asuka, Nara Prefecture, Japan (Nagatsuka et al. 2009).

Type strain: JCM 15410.

Systematics: Phylogenetic analysis of the D1/D2 LSU rRNA gene sequence placed *C. takamatsuzukensis* in the weakly supported *Candida membranifaciens* clade, together with *C. atmosphaerica* and *C. atlantica* (Nagatsuka et al. 2009).

Ecology: *Candida takamatsuzukensis* was isolated from the stone chamber of the Takamatsu-zuka tumulus, Asuka, Nara Prefecture, Japan (Nagatsuka et al. 2009). This tumulus was excavated in 1972, and is thought to have been built in the 7th or 8th century. Since protective work performed in 1976, a high humidity (approximately 100% relative humidity) is maintained within a temperature range of 14–20°C. Restoration and construction work probably resulted in growth of fungal colonies on the murals. In addition, multi-species biofilms, which also contained mites, were seen on the wall plaster since 2004. Because both ethanol and isopropyl alcohol have been used to reduce growth of microbes inside the chamber, it has been speculated that the presence of these compounds combined with a high relative humidity may have caused the growth of the yeasts. As ethanol is weakly assimilated, and isopropyl alcohol is not utilized by *C. takamatsuzukensis*, it may be that the capability to utilize ethanol has contributed to growth of the yeast.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.277. *Candida taliae* S.-O. Suh & M. Blackwell (Suh et al. 2004b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5).

(The description is based on Suh et al. 2004b.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, butyrous, mostly smooth with raised areas in the center.

Growth in YM broth: After 7 days at 25°C, cells are globose to ovoid, 2.5–5 × 3.8–6.5 µm, mostly ellipsoidal, occur singly, in pairs or in short chains and pseudohyphae and septate hyphae are present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae are present but septate hyphae are absent, although they are formed in YM broth, above. Aerobic growth is white, shiny, smooth and with a filamentous margin.

Fermentation

Glucose	+	Lactose	–
Galactose	d	Raffinose	–
Sucrose	–	Trehalose	d
Maltose	–	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–

Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	D-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	n	D-Glucosamine	+
L-Rhamnose	n	N-Acetyl-D-glucosamine	n
D-Xylose	d	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	+	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	d	50% Glucose	+
2-Keto-D-gluconate	+	10% NaCl/5% glucose	+
D-Glucuronate	—	Starch formation	—
Arbutin	+	Urease	—
Propane 1,2 diol	—	DBB	—
Butane 2,3 diol	—	Cycloheximide 0.01%	—
Nitrite	—	Cycloheximide 0.1%	—
Cadaverine	+	Growth at 25°C	+
Creatinine	—	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	w
Ethylamine	+	Growth at 40°C	—

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY242254, SSU rRNA = AY242145.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27589 (CBS 9838), isolated from the guts of an unidentified tenebrionid beetle (Tenebrionidae) on a polypore, Barro Colorado Island, Panama (Suh et al. 2004b).

Type strain: NRRL Y-27589.

Systematics: Phylogenetic analysis of the SSU and D1/D2 LSU rRNA genes placed *C. taliae* in the *Candida tanzawaensis* clade, in which it clusters with *C. maxi*, *C. anneliseae* and *C. bibrorum* as a sister species (Suh et al. 2004b).

Ecology: *Candida taliae* is known only from a tenebrionid beetle in Panama (Suh et al. 2004b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.278. *Candida tammaniensis* Kurtzman & Robnett (1998b)

Phylogenetic placement: *Yamadazyma* clade (Fig. 90.2).

(Some of the morphological characteristics are based on Kurtzman and Robnett 1998b.)

Growth on 5% malt agar: After 3 days at 25°C, the cells are spherical, 2–6 μ m, to ellipsoidal 1.3–4 $\times$ 2–6 μ m, and occur singly or in pairs (Fig. 90.138A,D). Budding is multilateral. Growth is tannish-white, semi-glistening and butyrous. In addition to the preceding, cells with an aculeate shape are present (Fig. 90.138A–C). These aculeate cell clusters may be single or joined basally in groups of two and three cells.

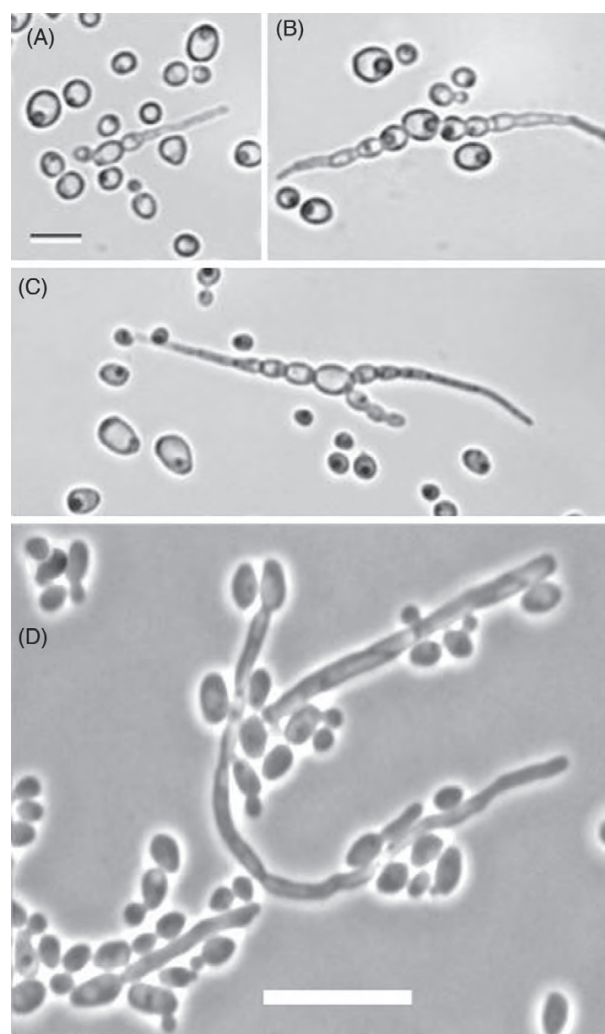


FIGURE 90.183 *Candida tammaniensis* NRRL Y-8257. Budding cells and needle-shaped cell aggregates after 3 days, 25°C, 5% malt extract agar (A–C); bar = 5 μ m; budding cells and pseudohyphae after 3 days, 25°C, YM agar (D); bar = 10 μ m.

Growth on the surface of liquid media: Pellicles may be formed.

Dalmeu plate culture on morphology agar: After 7 days at 25°C, moderately branched pseudohyphae with abundant blastoconidia are formed under the coverglass, but true hyphae are not present. Aerobic growth is glistening, tannish-white, butyrous and raised but with a slightly depressed center. The margin is entire or rarely lobed. The odor is faintly acidic.

Fermentation

Glucose	+	Lactose	—
Galactose	+	Raffinose	—
Sucrose	—	Trehalose	+
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	+
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	s	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	w	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF017243.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 8504 (NRRL Y-8257), isolated from frass of a wood-boring insect on oak (*Quercus* sp.), Louisiana, USA.

Type strain: CBS 8504.

Systematics: Kurtzman and Robnett (1998b) described *C. tammaniensis* to accommodate a strain recovered from insect frass. The species occupies a basal position relative to the *C. membranifaciens* clade. The authors noted that *C. tammaniensis* is easily recognized by the formation of cell clusters where the terminal cells are elongated in a needle-like fashion. A similar morphology had been noted for *Mastigomyces philippovii* by Bab'eva and Levin (1979). The latter is considered a synonym of *C. tenuis*, a moderately related species. A physiological similarity with *Yamadazyma (Pichia) nakazawae* or *Scheffersomyces (Picha) stipitis* was noted (Kurtzman and Robnett 1998b).

The species is moderately polyphagic, making separation from many other species difficult. Starch utilization (negative) is useful in some cases. Distinction from *C. tenuis* is hampered by the presence of several variable responses in that species.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.279. *Candida tanzawaensis* Nakase & M. Itoh (Nakase et al. 1988b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, $1\text{--}2 \times 1.5\text{--}4\ \mu\text{m}$, and occur singly or in pairs. Short, branched chains of cells are also present. Other cells are long-ovoid or elongate ($10\ \mu\text{m}$ and longer), slender and some are branched (Fig. 90.184 top). There is abundant pseudohyphal development. A pellicle appears to have dropped from the surface and the liquid is flocculent.

Growth in yeast nitrogen base + 0.5% glucose: After 3 days at 25°C, a wrinkled pellicle is present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of long, branched chains of cells (Fig. 90.184 bottom) with globose to ovoid blastoconidia occurring singly or in small verticils. Septate hyphae may be present. Aerobic growth is white, dull and irregular. The margin is fringed.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	w/s
Maltose	–		

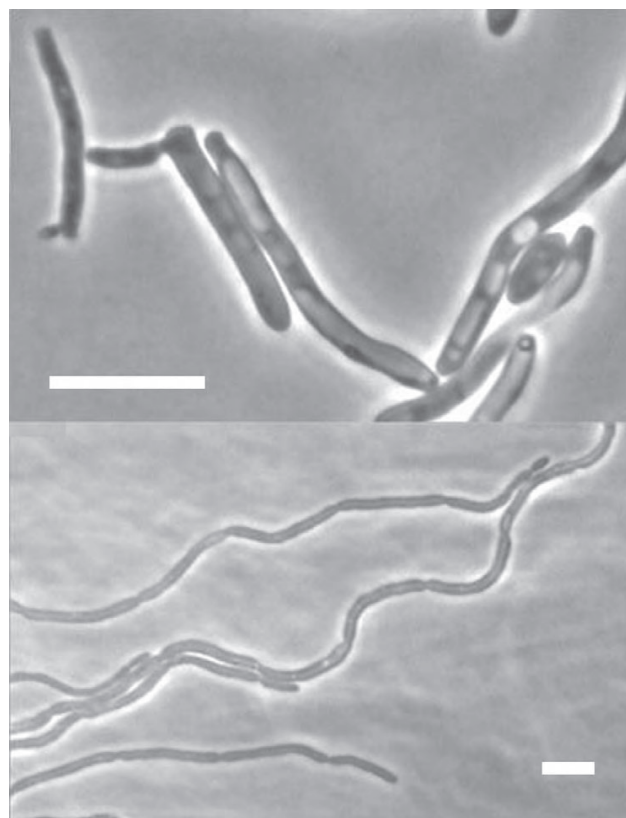


FIGURE 90.184 *Candida tanzawaensis* CBS 7422. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μm .

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	s
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	D-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	w
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	—	Hexadecane	—
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	w	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	w
Ethylamine	+	Cycloheximide 0.01%	w
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	—

CoQ: 9 (Nakase et al. 1988b).

Mol% G + C: 45.1, 44.1, CBS 7422 (T_m and HPLC, respectively: Nakase et al. 1988b).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U44811.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 7422, isolated from common haircap moss (*Polytrichum commune*), Mount Tanzawa, Japan.

Type strain: CBS 7422.

Systematics: Nakase et al. (1988b) described *C. tanzawaensis* from a strain isolated from common haircap moss. A similarity with *C. oleophila* and *C. kruisii* was noted, but DNA reassociation with those species was low. Based on the analysis of D1/D2 LSU rRNA gene sequences of Kurtzman and Robnett (1998b), *C. tanzawaensis* occupies a basal position with respect to the *Debaryomyces/Lodderomyces* clade (Kurtzman and Robnett 1998b). The SSU rRNA gene analysis of Sugita and Nakase (1999) suggested a relationship with *C. sake* and *C. kruisii* with an affinity to *Lodderomyces*. Upon adding six new species (i.e., *C. ambrosiae*, *C. canberraensis*, *C. prunicola*, *C. pyralidae*, *C. xylopsoci* and *C. caryicola*) to the formerly monotypic clade, Kurtzman (2001b) predicted that our current sampling of existing yeasts represents but a small fraction of existing species. The prediction turned to prophecy with the publication by Suh et al. (2004b) of no fewer than 16 new species affiliated to the clade. They are *C. anneliseae*, *C. atakaporum*, *C. bokatorum*, *C. bolitothieri*, *C. bribrorum*, *C. chickasaworum*, *C. choctaworum*, *C. emberorum*, *C. guaymorum*, *C. kunorum*, *C. maxii*, *C. panamericana*, *C. taliae*, *C. terraborum*, *C. wounanorum* and *C. yuchorum*.

The original description (Nakase et al. 1988b) reported positive or latent growth on D-arabinose, variable results for D-ribose, weak or negative reactions on starch, L-rhamnose and galactitol, weak growth in the presence of 50% glucose and a maximum growth temperature of 35–36°C. Different results for these tests were reported by Meyer et al. (1998). In the present study, weak responses on D-arabinose and 50% glucose were confirmed. Other results were largely in agreement, except for the observation of weak growth on D-gluconic acid and in the presence of 0.01% cycloheximide. The report of strong acid production on chalk agar given in the original description was not confirmed, but a weak reaction was observed. Species with similar growth profiles include *C. fungicola* and others, but *C. tanzawaensis* can be separated based on fermentative activity, utilization of galactose, the lack of growth on starch and a few other characteristics. The impracticality of identification from growth tests is probably exacerbated by the recent discovery of many additional species.

Ecology: The related species described by Kurtzman (2001b) and by Suh et al. (2004b) originated almost entirely from beetles or their habitats. In the latter case, a strong yeast–host specificity has been noted and the specificity appears to be correlated with the growth characteristics. The most important sources of isolation include *Neomida bicornis* (Coleoptera: Tenebrionidae) from the tree canker polypore *Fomitella supinus*, in southern Louisiana, and the tenebrionid beetle *Bolitotherus cornutus*, also associated with tree fungi, but across the south-eastern and central USA. Other insects harboring these yeasts included the coleopteran families Erotylidae, Ciidae, Endomychidae, Scaphidiidae, Scarabaeidae, Staphylinidae and Nitidulidae, as well as some Lepidoptera (geometrid caterpillars).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.280. *Candida tartarivorans* Fonseca, Fell, Kurtzman & Spencer-Martins (2000c)

Phylogenetic placement: unaffiliated clade (Fig. 90.3).

(Some of the morphological characteristics are based on Fonseca et al. 2000c.)

Growth in YM broth: After 3 days at 25°C, the cells are ellipsoidal to short cylindrical, 2–3 $\times$ 3–7 μ m, and occur singly, in pairs or in short chains. Some irregular shapes and a few elongated (up to 10 μ m), slightly curved cells occur (Fig. 90.185). Symptodial holoblastic conidiogenesis gives rise to ovoid to obclavate conidia, 2–3 μ m, that arise on more or less pronounced protuberances.

Growth on YM agar: After 7 days at 25°C, the colonies are white to cream colored and butyrous. Two colony types may appear after repeated subculturing, one with a rough and dull surface and another with a smooth and slightly glistening surface. The margin is fringed with hyphae developing into the agar in both colony types.

Dalmau plate culture on corn meal agar: After 1 week at 25°C, well-developed pseudohyphae are formed aerobically and anaerobically, with obclavate blastoconidia. True hyphae are formed after 1 month.

Fermentation

Glucose	+	Lactose	—
Galactose	+	Raffinose	s
Sucrose	s	Trehalose	s
Maltose	s		

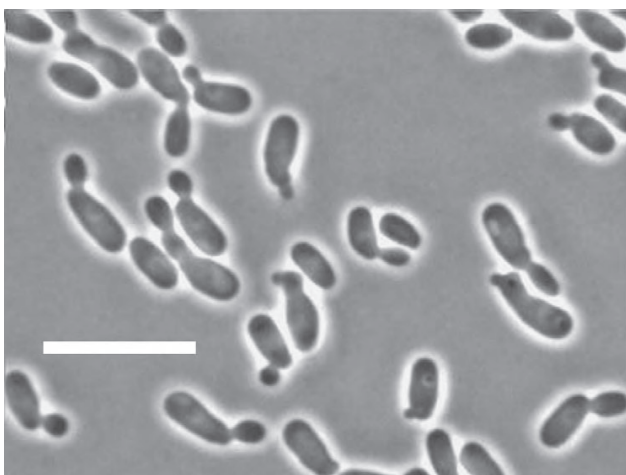


FIGURE 90.185 *Candida tartarivorans* CBS 7955. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	—	Methanol	—
Sucrose	+	Ethanol	w
Raffinose	+	Glycerol	+
Melibiose	+	Erythritol	+
Galactose	+	Ribitol	+
Lactose	+	Galactitol	+
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	s	myo-Inositol	+
Methyl-α-D-glucoside	s	DL-Lactate	—
Soluble starch	+	Succinate	s
Cellobiose	s	Citrate	w
Salicin	s	D-Gluconate	w
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	w
L-Arabinose	+	Nitrate	—
D-Arabinose	s	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	+	Gelatin	—
Glucono-δ-lactone	s	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	s	Cycloheximide 0.1%	+
Cadaverine	s	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: 40.1, type strain (T_m : Fonseca et al. 2000c).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF105335.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 7955 (IGC 4854), isolated from dried wine lees, Portugal.

Type strain: CBS 7955.

Systematics: Fonseca et al. (2000c) described *C. tartarivorans* after screening a variety of substrates for the ability to metabolize L-tartaric acid. A strain recovered from wine lees was found not to match any known species, although it exhibited some physiological similarity with *Blastobotrys proliferans*. The presence of sympodial budding was also noted. Analysis of the D1/D2 LSU rRNA gene sequence indicated that the species is related to *C. aurangiensis* and *C. salmanticensis*, which formed a clade with no defined affinities with respect to other ascomycetous yeasts, although a possible link with the *Stephanosascus* clade (*sensu* Kurtzman and Robnett 1998a) was suspected. Analysis of SSU rRNA gene sequences (Suzuki et al. 1999) supported such a link. The multi-gene analysis of Kurtzman and Robnett (2007) instead favored a placement near the neighboring *Wickerhamiella* clade, but without strong support.

Candida tartarivorans is highly polyphagic, utilizing the majority of standard carbon compounds. Replica plating detected weak growth on inulin and L-rhamnose, both of which were reported as negative in the description, but scavenging of trace nutrients of the agar is suspected. Utilization of L-tartaric acid is not commonly determined, but in view of the results obtained by Fonseca et al. (2000c), the addition of that carbon source to the list of standard compounds may be advisable. Related species do not utilize the compound, but a few species related to *Sugiyamaella* (*Stephanosascus*) *smithiae* do utilize L-tartaric acid. Separation of *C. tartarivorans* from *Blastobotrys proliferans* does not appear possible based on nutritional characteristics. The utilization of myo-inositol distinguishes the species from the polyphagic and highly variable *Debaryomyces hansenii*. Other similar species can be identified based on some growth responses.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.281. *Candida taylori* Statzell-Tallman, Scorzetti & Fell (2010)

Phylogenetic placement: *Yamadazyma* clade; see Systematics (Fig. 90.2).

(The description is based on Statzell-Tallman et al. 2010.)

Growth on 5% malt extract agar: After 1 month at 25°C, the colonies are flat, rough, white and with fringed margins.

Growth in 5% malt extract: After 3 days at 25°C, the cells are elongated to oblong, ovoid or lemon-shaped, 1.3–3 × 3–5 µm, occur singly or in pairs and reproduce by multilateral budding. After a month sediment is present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, branched pseudohyphae and some true hyphae are present.

Fermentation

Glucose	+	Lactose	+
Galactose	+	Raffinose	—
Sucrose	+	Trehalose	s
Maltose	w	Inulin	—

Growth (in Liquid Media)

Glucose	+	D-Ribose	s
Inulin	—	Methanol	—
Sucrose	+	Ethanol	s
Raffinose	—	Glycerol	+

Melibiose	—	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	s	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	s	myo-Inositol	—
Methyl- α -D-glucoside	+	D,L-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	s	D-Gluconate	s
L-Sorbose	s	D-Glucosamine	s
L-Rhamnose	s	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	—
L-Arabinose	+	Nitrate	—
D-Arabinose	s	Vitamin-free	—

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	s	Starch formation	—
5-Keto-D-gluconate	—	Urease	—
Saccharate	—	Growth at 25°C	+
10% NaCl/5% glucose	+	Growth at 37°C	—

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = FJ008045, ITS and 5.8S rRNA = FJ008051.

Cell carbohydrates: Not determined.

Origin of the strains studied: Several strains were isolated from seawater samples collected at coral reefs at Looe Key Reef, Florida, USA (CBS 8508, NRRL-Y 27213), Rendezvous Cay and South Long Cay, Belize and Highbourne Cay, Exumas, Bahamas. Additional strains (NRRL Y-27419, NRRL Y-27420 and NRRL Y-27421) were collected from waters in mangrove swamps at the Monkey River and Pelican Cays, Belize and Bimini, Bahamas (Statzell-Tallman et al. 2010).

Type strain: CBS 8508.

Systematics: *Candida taylori* belongs to the *Yamadzzyma* clade in a cluster of species that includes *Candida spencermartinsiae*, *C. atlantica* and *C. atmosphaerica*, which have all been isolated from marine habitats (Gadanhó and Sampaio 2005, Gadanhó et al. 2003, Meyer et al. 1998, Statzell-Tallman et al. 2010).

Ecology: *Candida taylori* was isolated from marine waters in coral reef and mangrove habitats and may represent a natural component of the marine ecosystem (Statzell-Tallman et al. 2010).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Additional comments: No ascospores were produced after 6 weeks at 25°C on YM agar or corn meal agar.

90.282. *Candida temnochilae* S.-O. Suh, N.H. Nguyen & M. Blackwell (2005b)

Phylogenetic placement: *Yamadzzyma* clade (Fig. 90.2). (The description is based on Suh et al. 2005b.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, smooth and butyrous.

Growth in YM broth: After 7 days at 25°C, cells are globose to ellipsoidal, 2.5–6.3 $\times$ 2.5–6.3 μ m, mostly subglobose, occur singly, in pairs, in short chains or in clusters and pseudohyphae may be present.

Dalmeu plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae are present. Aerobic growth is white, shiny and smooth.

Fermentation

Glucose	+	Lactose	—
Galactose	+	Raffinose	—
Sucrose	—	Trehalose	+/-
Maltose	—	D-Xylose	—

Growth (in Liquid Media)

Glucose	+	D-Ribose	s/w
Inulin	—	Methanol	—
Sucrose	+	Ethanol	w
Raffinose	—	Glycerol	+/-
Melibiose	—	Erythritol	+/-
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	D,L-Lactate	v
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	+/-
L-Rhamnose	+/-	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	—
D-Arabinose	+/-	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+/-	50% Glucose	+
2-Keto-D-gluconate	+	10% NaCl/5% glucose	+
D-Glucuronate	—	Starch formation	—
Arbutin	+	Urease	—
Propane 1,2 diol	v	DBB	—
Butane 2,3 diol	—	Cycloheximide 0.01%	+
Cadaverine	+/-	Cycloheximide 0.1%	+
Creatinine	—	Growth at 30°C	+
L-Lysine	+/-	Growth at 35°C	—
Ethylamine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY964678, SSU rRNA = AY242232, ITS and 5.8S rRNA = AY242344.

Cell carbohydrates: Not determined.

Origin of the strains studied: NRRL Y-27763 (CBS 9938), isolated from the gut of a beetle (*Temnochila* sp., Trogossitidae); NRRL Y-27764 (CBS 9939), from the gut of a beetle (*Veturius platyrhinus*, Passalidae, Coleoptera), both from Barro Colorado Island, Panama (Suh et al. 2005b).

Type strain: NRRL Y-27763.

Systematics: Phylogenetic analysis of the LSU and SSU rRNA gene sequences placed *C. temnochilae* in the *C. membranifaciens* clade.

Ecology: *Candida temnochilae* is only known from the gut of beetles in Panama (Suh et al. 2005b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.283. *Candida tenuis* Diddens & Lodder (1942)

Phylogenetic placement: *Yamadazyma* clade (Fig. 90.2).

Synonym:

Mastigomyces philippovii Imshenetskii & Kriss (1933)¹

¹ Synonymy determined from D1/D2 LSU rRNA gene sequence analysis (Kurtzman and Robnett 1998a).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to cylindroidal or elongate, 1.5–3.5 × 2–7 µm, and occur singly, in pairs, chains and clusters (Fig. 90.186 top). Pseudohyphae may be present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of cylindrical cells (Fig. 90.186 bottom), sometimes with verticils of ovoid blastoconidia. Septate hyphae may be present. Aerobic growth is off-white, creamy, lacy to wrinkled, with a fringed border.

Fermentation

Glucose	v	Lactose	—
Galactose	v	Raffinose	—
Sucrose	—/s	Trehalose	v
Maltose	—/s		

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	v
Galactose	+	Ribitol	+
Lactose	v	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	v
Melezitose	v	myo-Inositol	—
Methyl-α-D-glucoside	+	DL-Lactate	v
Soluble starch	v	Succinate	+
Cellulobiose	+	Citrate	+
Salicin	+	D-Gluconate	v
L-Sorbose	v	D-Glucosamine	v
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	—
L-Arabinose	v	Nitrate	v
D-Arabinose	+	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	v
Glucono-δ-lactone	v	Casein	—
Amino acid-free	+	Lipase	v
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	v
L-Lysine	+	Cycloheximide 0.1%	v
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	v
50% Glucose	—	Growth at 37°C	—

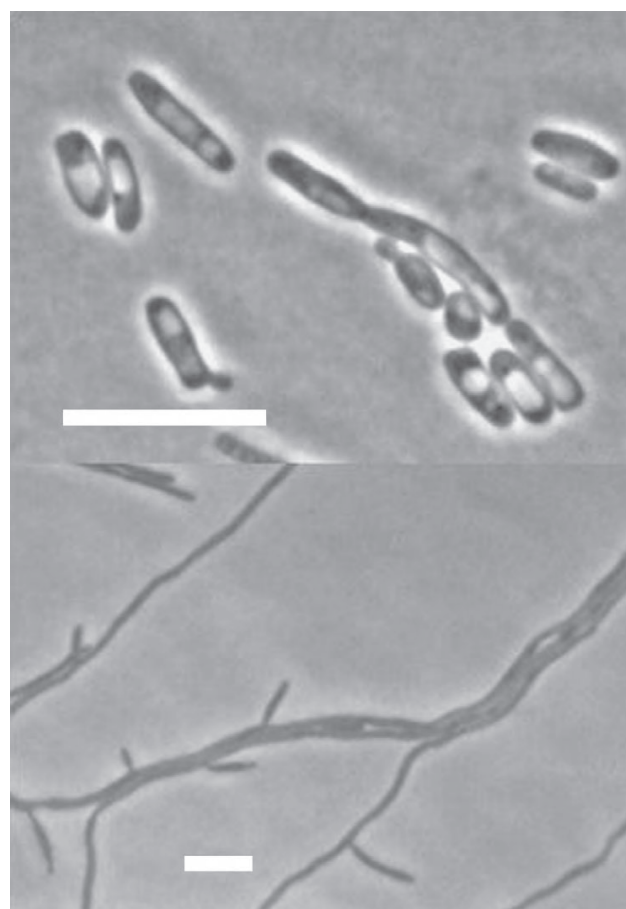


FIGURE 90.186 *Candida tenuis* CBS 615. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 µm.

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 44.0, CBS 615 (T_m : Stenderup and Bak 1968); 43.8, one strain (Miranda et al. 1982); 43.2, AJ 4667 (T_m : Nakase and Komagata 1971f); 44.4, CBS 7047 (T_m : S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45774.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 615, isolated from bark beetles, USA; CBS 7047, neotype strain of *Mastigomyces philippovii*, isolated from litter of coniferous forest in Russia.

Other strains available: CBS 2308, CBS 2309, from bark beetles, USA; CBS 2885, from bark beetle, South Africa; CBS 4113, larva of cerambicid beetle (*Harpium mordax*, Coleoptera: Cerambycidae), in bark of birch (*Betula* sp., Betulaceae); CBS 4285, from cerambicid beetle (*Rhagium sycophanta*, Coleoptera: Cerambycidae); CBS 4435, from *Rhagium bifasciatum*.

Type strain: CBS 615.

Systematics: *Candida tenuis* has affinities within the *Yamadazyma* clade (Fig. 90.2). Analyses of the D1/D2 LSU rRNA gene sequence (Kurtzman and Robnett 1998a, 1998b and this study) suggest either a sisterhood to *C. insectorum* or a basal position with respect to *Yamadazyma nakazawae* and relatives. The latter position is supported by SSU rRNA gene sequences (Sugita and Nakase 1999). The genus *Mastigomyces* was validly described by Imshenetskii and Kriss (1933), but the type strain of

the single species was subsequently lost. Bab'eva and Levin (1979) reinstated *Mastigomyces philippovii* from a new isolate designated as neotype, but Kurtzman and Robnett (1997) found that the strain differs from the type of *C. tenuis* by only one substitution in the D1/D2 sequence, suggesting that the two are conspecific. The basis for the description of a separate genus was the formation of clusters in which the terminal cells extended in a whip-like fashion. Similar structures have since been reported in *C. tammaniensis* (Kurtzman and Robnett 1998b). As this trait appears to vary among related species, the justification for a separate genus appears tenuous. In addition, one cannot be certain that the neotype is a true representative of the species originally described as *Mastigomyces philippovii*.

The growth characteristics of the strains as determined by replica plating agreed with the description of the type strain given by Meyer et al. (1998). However, the type of *Mastigomyces philippovii* did not utilize L-sorbose as previously reported. Strain CBS 7880, which is assigned to *C. tenuis*, differed from other strains by the absence of growth on sucrose and methyl- α -D-glucoside and the ability to grow in the presence of 5% NaCl. The overall growth profile for that strain resembled that of *C. sequanensis*. The D1/D2 sequence was determined (AY559041) and found to match the sequence of *C. takamatsuzukensis*.

Ecology: The independent isolation of *C. tenuis* and related species (Kurtzman and Robnett 1998a) from tree-invading beetles or other insects suggests a possible association with that habitat.

Biotechnology: Enzymes involved in the metabolism of D-xylose of *C. tenuis* have received considerable attention. Relevant references can be found in Kavanagh et al. (2003).

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.284. *Candida tepae* Grinbergs (1967)

Phylogenetic placement: *Sugiyamaella* clade (Fig. 90.3).

Synonyms:

Candida antillancae C. Ramírez & A. González (1984a)¹

Candida bondarzewiae C. Ramírez & A. González (1984a)¹

¹ Synonymy based on rRNA gene sequence analysis (Kurtzman and Robnett 1997, M.A. Lachance, this work).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, 3–4 $\times$ 4–10 μ m, and occur singly, in pairs or in small groups (Fig. 90.187 top).

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of densely branched chains of ovoid cells (Fig. 90.187 bottom). Aerobic growth is off-white, butyrous, smooth, soft and mostly with an entire margin. A few tufts of pseudohyphal development may be present.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+/s	Ethanol	v
Raffinose	–	Glycerol	v
Melibiose	–	Erythritol	–
Galactose	v	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	v	D-Mannitol	s/–
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	–

Methyl- α -D-glucoside	–	D-Lactate	+
Soluble starch	–	Succinate	v
Cellobiose	v	Citrate	v
Salicin	v	D-Gluconate	–
L-Sorbose	s	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	–	Casein	–
Amino acid-free	s	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	s	Cycloheximide 0.01%	+
L-Lysine	s	Cycloheximide 0.1%	+
Cadaverine	v	1% Acetic acid	–
10% NaCl	v	Growth at 30°C	–
50% Glucose	–	Growth at 37°C	–

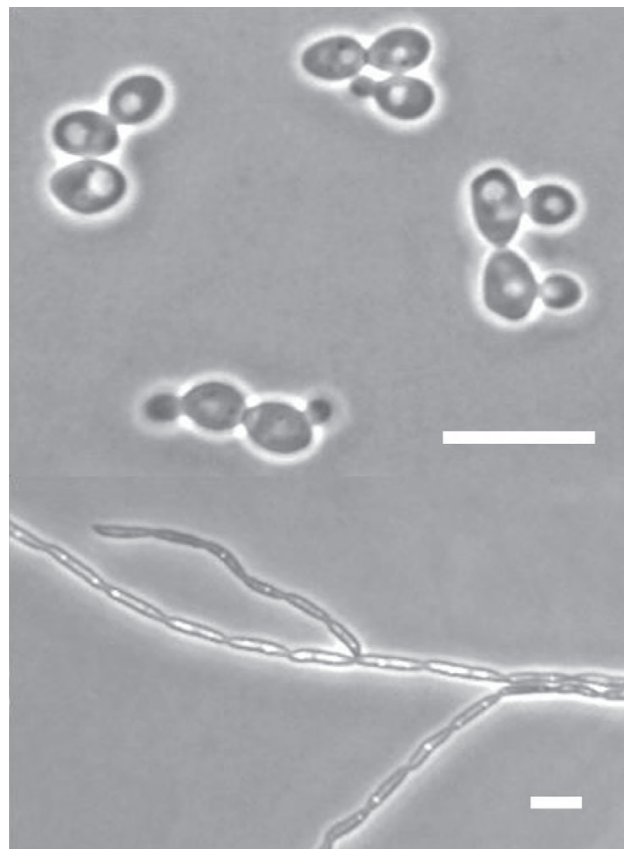


FIGURE 90.187 *Candida tepae* CBS 5115. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μ m.

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 39.0, CBS 8171, 41.0, CBS 5115 (T_m : Meyer et al. 1984 and S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45816.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5115, isolated from rotten wood of tepa (*Laurelia philippiana*, Atherospermataceae), Chile; CBS 8170, type strain of *C. antillancae*, and one other, from rotten wood of Chilean laurel (*Laurelia sempervirens*, Atherospermataceae); CBS 8171, type strain of *C. bondarzewiae*, from fallen trunk of ulmo (*Eucryphia cordifolia*, Eucryphiaceae), all from the Valdivian evergreen rainforest, Chile.

Type strain: CBS 5115.

Systematics: Grinbergs (1967) described *C. tepae* from an isolate recovered in a decaying tepa tree in Chile. A similarity with *C. mesenterica* was noted. *C. antillancae* was described by Ramírez and Gonzáles (1984a) on the basis of two isolates that were part of a large collection from rotting wood (palo podrido) in the Valdivian rainforest. In the same publication, a single strain of similar origin was described as *C. bondarzewiae* on the basis of differences in the assimilation of galactose, glycerol, D-mannitol and lactic acid, plus the splitting of arbutin, which was found positive in *C. antillancae* in spite of the absence of growth on cellobiose or salicin. Assessment of the physiological profiles of the type strains of *C. antillancae* and *C. bondarzewiae* by replica plating showed them to be indistinguishable and somewhat at variance with published results. Moreover, Kurtzman and Robnett (1997) found *C. antillancae*, *C. bondarzewiae* and *C. tepae* to have identical sequences in the D1/D2 LSU rRNA gene, indicating that the three taxa might be conspecific. However, the type of *C. antillancae* was reported to differ by 15–17 substitutions and 2 indels from the other two in the SSU rRNA gene (Suzuki et al. 1999), suggesting otherwise. This is complicated by the fact that the types of *C. antillancae* and *C. bondarzewiae* have identical physiological profiles, but differ slightly from *C. tepae* in that respect. For these reasons, the sequences of the ITS regions and the 5.8S rRNA gene were determined for the three strains and found to be identical (*C. tepae* = AY569004). These results support treatment of the three taxa as synonyms. *C. tepae* is part of the *Sugiyamaella* clade (Fig. 90.3).

Some of the strains grow poorly at 25°C and it is preferable to conduct assimilation tests at lower temperatures. Growth in amino acid-free medium was noticeably slower, which would explain the conflicting reports for the assimilation of some nitrogen compounds.

Ecology: All isolates of the merged species originate from rotten wood in Chile, which suggests a possible habitat specificity.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.285. *Candida terraborum* S.-O. Suh & M. Blackwell (Suh et al. 2004b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5). (The description is based on Suh et al. 2004b.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, butyrous and smooth.

Growth in YM broth: After 7 days at 25°C, cells are globose to ellipsoidal, 4–6 × 5–7 µm, mostly subglobose, and occur singly, in pairs or in short chains, but large, elongated cells are also observed.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae are present, but true hyphae are absent. Aerobic growth is white with a fuzzy margin.

Fermentation

Glucose	d	Lactose	–
Galactose	w	Raffinose	–
Sucrose	d	Trehalose	d
Maltose	d	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	d
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	w
L-Sorbose	n	D-Glucosamine	w
L-Rhamnose	n	N-Acetyl-D-glucosamine	n
D-Xylose	w	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	50% Glucose	+
2-Keto-D-gluconate	+	10% NaCl/5% glucose	w
D-Glucuronate	–	Starch formation	–
Arbutin	+	Urease	–
Propane 1,2 diol	w	DBB	–
Butane 2,3 diol	–	Cycloheximide 0.01%	–
Cadaverine	+	Cycloheximide 0.1%	–
Creatinine	–	Growth at 25°C	+
L-Lysine	+	Growth at 30°C	+
Ethylamine	+	Growth at 35°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY309810, SSU rRNA = AY426956.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27573 (CBS 9826), isolated from the gut of an erotyloid beetle (*Iphiclus sedecimmaculatus*, Erotylidae) on a corticioid fungus, Barro Colorado island, Panama (Suh et al. 2005b).

Type strain: NRRL Y-27573.

Systematics: Sequence analysis of the SSU and D1/D2 LSU rRNA genes placed *C. terraborum* in the *Candida tanzawaensis* clade, in which it clusters together with *C. yuchorum*, *C. wounanorum*, *C. emberorum* and *C. chickasaworum*, and with *C. kunorum*, *C. bokatorum* and *C. guaymorum* forming a sister clade (Suh et al. 2005b).

Ecology: *Candida terraborum* is known only from the gut of an erotyloid beetle in Panama (Suh et al. 2005b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.286. *Candida tetrigidarum* S.-O. Suh, N.H. Nguyen & M. Blackwell (2008)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Fig. 90.5).

(The description is based on Suh et al. 2008.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, butyrous and dull.

Growth in YM broth: After 7 days at 25°C, cells are globose to ellipsoidal, 4–7 × 4–7 μm, mostly globose, occur singly, in pairs, in short chains or in clusters and pseudohyphae are present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae are present. Aerobic growth is off-white and fringed with a filamentous margin.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	+	Trehalose	+
Maltose	+	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	+
Soluble starch	–	Succinate	–
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	10% NaCl/5% glucose	+
2-Keto-D-glucuronate	+	Starch formation	–
D-Glucuronate	–	Urease	–
L-Arabinitol	–	DBB	–
Arbutin	–	Cycloheximide 0.01%	+
Propane 1,2 diol	–	Cycloheximide 0.1%	+
Butane 2,3 diol	–	Growth at 25°C	+
Cadaverine	+	Growth at 30°C	+
Creatinine	–	Growth at 35°C	+
L-Lysine	+	Growth at 37°C	+
Ethylamine	+	Growth at 40°C	–
50% Glucose	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = EF120599, SSU rRNA = EF120586.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRLY-48142 (CBS 10457), isolated from the gut of an unidentified tetrigid beetle (Orthoptera, Tetrigidae), Baton Rouge, Louisiana, USA (Suh et al. 2008).

Type strain: NRRLY-48142.

Systematics: Phylogenetic analysis of the combined SSU and D1/D2 LSU rRNA gene sequences placed *C. tetrigidarum* in the *Candida albicans*/*Lodderomyces elongisporus* clade (Suh et al. 2008).

Ecology: The species is known only from the gut of a beetle in Louisiana, USA (Suh et al. 2008).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.287. *Candida thaimueangensis* Limtong, Yongmanitchai, Kawasaki & Seki (2007a)

Phylogenetic placement: *Pichia* clade (Figs 57.1, 90.1).

(The description is based on Limtong et al. 2007a.)

Growth on YM agar: After 3 days at 28°C, the cells are spherical, ellipsoidal, to elongate, 2–5 × 3–7 μm, and occur singly, in pairs or in short chains. The colonies are butyrous, cream colored, semiglistening and raised, with a smooth surface and an entire margin. Budding is multilateral.

Dalmau plate culture on corn meal agar: After 7 days at 28°C, pseudohyphae consist of chains of slightly elongated cells with verticils of ovoid buds.

Fermentation

Glucose	–	Lactose	–
Galactose	n	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	n
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	n
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	n	DL-Lactate	+
Soluble starch	n	Succinate	+
Cellobiose	–	Citrate	–
Salicin	n	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	n
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	s	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Nitrite	–	Urease	–
Cadaverine	+	DBB	–
L-Lysine	+	Growth at 37°C	+
Ethylamine	+	Growth at 40°C	–
Starch formation	–		

CoQ: 7 (Limtong et al. 2007a).

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AB264009.

Cell carbohydrates: Not determined.

Origin of the strains studied: TM1-01 (CBS 10360, NBRC 101967, BCC 21229), TM1-07, TM3-47 and TM3-49, isolated from water in a mangrove forest in Thailand; NRRL Y-27416, from water, Little Shark River, Florida, USA, J.W. Fell.

Type strain: TM1-01.

Systematics: Limtong et al. (2007a) described *C. thaimueangensis* from several isolates obtained by filtration of water samples collected in a mangrove forest in Thailand. The strains differed from *Pichia deserticola* by 27 substitutions in the D1/D2 domains of the LSU rRNA gene. The species belongs to the *Pichia membranifaciens* clade.

Ecology: *Candida thaimueangensis* is known primarily from mangrove water in Thailand, and one isolate from Florida, USA. Several D1/D2 sequences have been deposited in GenBank by various laboratories, but information on their respective origins is not available.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.288. *Candida tibetensis* Bai & Wu (Wu and Bai 2006)

Phylogenetic placement: unaffiliated clade (Fig. 90.5).

(The description is based on Wu and Bai 2006.)

Growth on YM agar: After 1 month at 25°C, the streak culture is butyrous, membranous, cream colored, raised, dull, smooth and creased with ridges, and with an undulating margin.

Growth in YM broth: After 3 days at 25°C, the cells are cylindrical to bacilliform, 2.5–2.7 × 5–21.4 µm, reproduce by multilateral budding and occur singly, in pairs, in chains or in branches. After 1 month at 25°C, sediment and a climbing ring are present.

Dalmau plate culture on corn meal agar: Pseudohyphae are formed.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	n
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	s/w
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	s
Cellobiose	s	Citrate	w
Salicin	w	D-Gluconate	n
L-Sorbose	–	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	+
L-Arabinose	+	Nitrate	–
D-Arabinose	s	Vitamin-free	+

Additional Growth Tests and Other Characteristics

Nitrite	–	Urease	–
Cadaverine	+	DBB	–
L-Lysine	+	Growth at 19°C	+
Ethylamine	+	Growth at 25°C	+
Starch formation	–	Growth at 28°C	–

CoQ: 9 (Wu and Bai 2006).

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = DQ269920.

Cell carbohydrates: Not determined.

Origin of the strain studied: XZ 41-6 (AS 2.3072, CBS 10298), isolated in July 2004 from a flower of an unidentified plant collected in Linzhi District, Tibet.

Type strain: XZ 41-6.

Systematics: Sequence analysis of the D1/D2 domains of the LSU rRNA gene placed *C. tibetensis* in a clade with *C. caryicola* (Wu and Bai 2006).

Ecology: *Candida tibetensis* is known only from a flower of an unidentified plant in Tibet.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.289. *Candida tilneyi* Lachance (Lachance et al. 2001a)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

Growth on YM agar: After 2 weeks at 17°C, colonies are low-convex, glabrous, smooth, white and butyrous.

Growth in glucose–yeast extract broth: After 3 days at 25°C, cells are spherical to ovoid, 1–3 × 2–4 µm, and occur singly or in parent–bud pairs. A thin pellicle is formed.

Dalmau plate culture on corn meal agar: After 2 weeks at 18°C, pseudohyphae or true hyphae are not formed.

Fermentation

Glucose	s	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	–
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	w
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	s
Cellobiose	–	Citrate	s
Salicin	–	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	w
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	—
2-Keto-D-gluconate	s	DBB	—
D-Glucuronate	—	Gelatin	w
Glucono-δ-lactone	+	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	s	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	s	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	—

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF251553.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 8794 (UWOPS 99-325.1), isolated from a nitidulid beetle (*Conotelus* sp., Coleoptera: Nitidulidae) from flower of morning glory (*Ipomoea carnea*, Convolvulaceae); UWOPS 99-331.2, from a wasp (Hymenoptera), and UWOPS 00-118.2, from a halictid bee in flower of *Ipomoea carnea*; all from Costa Rica.

Type strain: CBS 8794.

Systematics: Lachance et al. (2001a) described *C. tilneyi* from three strains recovered from *Ipomoea carnea* flowers and associated insects in Costa Rica. According to D1/D2 LSU rRNA gene sequence analysis, the species belongs to the *Starmerella sensu lato* clade (Fig. 71.1), but is well separated from neighboring species.

The original description stated that the species resembles *C. geochares*, but could be distinguished by the lack of growth on sucrose, cellobiose, salicin and D-ribose. However, a direct comparison of the results obtained in this study by replica plating suggests that the two species are not as different as previously postulated. The utilization of salicin appears to remain the only clear difference between the two.

Ecology: The low frequency of isolation of *C. tilneyi* only allows the tentative identification of hymenopteran insects as habitat.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.290. *Candida tolerans* Lachance, Bowles, Starmer & Barker (1999)

Phylogenetic placement: *Metschnikowia* clade (Fig. 90.1).

Growth on YM agar: After 2 weeks at 17°C, the colonies are white, convex to low-convex, slightly umbonate, small, smooth and slightly dull.

Growth in glucose–yeast extract broth: After 3 days at 25°C, the cells occur singly or in pairs. The cells are ovoid to cylindrical, 2–3 × 3–6 μm, and budding is multilateral but occurs preferentially near the cell apices. An extensive pellicle is formed.

Dalmat plate culture on corn meal agar: After 2 weeks at 18°C, linear pseudohyphae with occasional lateral buds are formed.

Fermentation

Glucose	+	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (on Agar)

Glucose	+	D-Ribose	w
Inulin	—	Methanol	—
Sucrose	+	Ethanol	s
Raffinose	v	Glycerol	s
Melibiose	—	Erythritol	—
Galactose	w	Ribitol	w
Lactose	—	Galactitol	w
Trehalose	s	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl-α-D-glucoside	—	D-Lactate	w
Soluble starch	—	Succinate	w
Cellobiose	—	Citrate	s
Salicin	—	D-Gluconate	w
L-Sorbose	w	D-Glucosamine	s
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	w	Hexadecane	s
L-Arabinose	w	Nitrate	—
D-Arabinose	—	Vitamin-free	+

Additional Growth Tests and Other Characteristics

Xylitol	w	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono-δ-lactone	—	Casein	+/w
Amino acid-free	+	Lipase	—
Nitrite	—	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	w
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	s

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF092281.

Cell carbohydrates: Not determined.

Origin of the strains studied: UWOPS 95-794.2, isolated from a fruit fly (*Drosophila* sp.) from flower of *Hibiscus heterophyllus* (Malvaceae); UWOPS 95-824.2, from flower of *Hibiscus tiliaceus*, both from Queensland, Australia; UWOPS 98-117.5 (CBS 8613), and several others, from flowers of *Hibiscus* spp., Northern Territory, Australia; UWOPS 99-697.3 and two others, from a nitidulid beetle (*Aethina concolor*, Coleoptera: Nitidulidae) on flowers of various plants, Rarontonga, Cook Islands.

Type strain: CBS 8613.

Systematics: *Candida tolerans* was described by Lachance et al. (1999) on the basis of several strains collected in flowers of *Hibiscus* species or associated insects in several Australian localities. A similarity was noted with *Zygosaccharomyces rouxii*, due mostly to weak growth on many carbon compounds combined with halotolerance (15% NaCl) and osmotolerance (50% glucose). Analysis of D1/D2 LSU rRNA gene sequences suggested a connection with *C. mogii* in the *Metschnikowiaceae* clade (Fig. 90.1).

The growth profile of *C. tolerans* is sufficiently distinct to allow separation for any other species, although misidentification as *C. sake* might result from the variable nature of the latter. Separation from *Zygosaccharomyces rouxii* can be based on the assimilation of several carbon compounds, but *N*-acetyl-D-glucosamine gives the clearest result.

Ecology: All isolates were recovered in flowers (or associated insects) that are frequently visited by *Aethina concolor*, a nitidulid beetle that is widespread in Australia and South Pacific islands. However, the community associated with the beetle is dominated by *Kodamaea* species, and *C. tolerans* appears to be a minority component. A single strain (UWOPS 99-704.2) of a distinct, but related species, was isolated in an unidentified nitidulid in Rarotonga (Lachance et al. 2001e).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

**90.291. *Candida torresii* (van Uden & Zobell)
S.A. Meyer & Yarrow (Yarrow and Meyer
1978)**

Phylogenetic placement: *Metschnikowia* clade (Figs 46.1, 90.1).

Synonym:

Torulopsis torresii van Uden & Zobell (1962)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to long-ovoid, 1.5–2.5 × 3.5–7 µm, and occur singly and in pairs (Fig. 90.188).

Dalman plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent. Aerobic growth is off-white, smooth, butyrous and with an entire margin.

Fermentation

Glucose	+/-	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	+/-
Maltose	–		

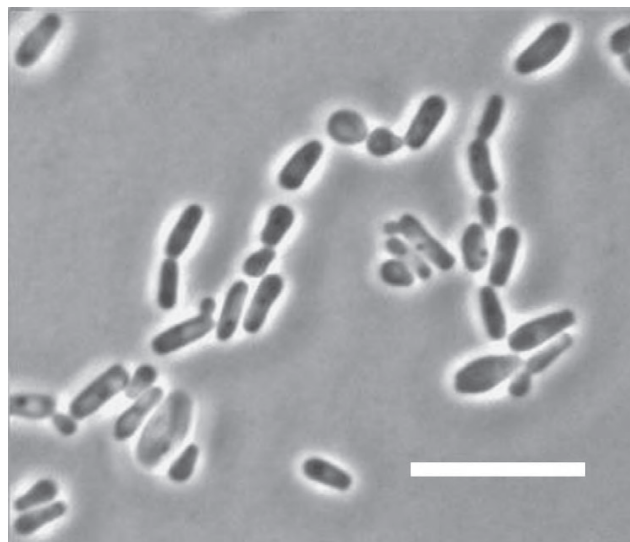


FIGURE 90.188 *Candida torresii* CBS 5152. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

Growth (on Agar)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	s	Ribitol	v
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	s
L-Sorbose	v	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	w	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	v	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	–

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 52.0, AJ 4937 (T_m : Nakase and Komagata 1971f; 51.7, 51.7, CBS 5152 (BD: Meyer et al. 1984; T_m : Ribeiro 1995, respectively).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45731.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 5152, isolated from seawater, Torres Strait, Australia.

Type strain: CBS 5152.

Systematics: Van Uden and Zobell (1962) examined many isolates recovered in 65 samples of seawater collected near corals in Torres Strait between Australia and Papua New Guinea. Of the 12 possible species examined, three strains could not be identified and were assigned to new species, one of which was *C. torresii*. The authors did not suggest possible affinities, but van der Walt et al. (1971b) noted similarities with *C. insectalens* and *C. nemodendra*, and reported the occurrence of *C. torresii* in three families of tree-boring beetles. However, one of the vouchers deposited in the context of that work, strain CBS 6035, was found in the present study to exhibit many growth test differences, casting doubt upon its identification. The D1/D2 sequence of that strain was determined and found to match perfectly that of the type of *Yarrowia lipolytica*. Analysis of D1/D2 LSU rRNA gene sequences (Kurtzman and Robnett 1998a) placed the species close to the genus *Metschnikowia*, which received further support from the discovery of the sister species, *Metschnikowia drosophilae* (Lachance et al. 2001b). Analysis of SSU rRNA gene sequences (Sugita and Nakase 1999) confirmed the affinity, but placed the species near

C. haemulonii. A neighbor-joining analysis of SSU rRNA gene data performed in this study (not shown) suggested a closer link to *C. oregonensis*.

The growth characteristics of *C. torresii* determined by replica plating showed minor disagreements with previous descriptions. Weak growth was observed on L-arabinose, which had been reported as positive in the original description and negative by Meyer et al. (1998). D-Ribose and citric acid were utilized. Both tests were reported as negative in the original description and variable by Meyer et al. (1998). The growth profile is similar to that of *M. drosophilae*, although the latter species fails to utilize 2-keto-D-gluconic acid.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.292. *Candida transvaalensis* Kurtzman (2007b)

Phylogenetic placement: *Sugiyamaella* clade (Fig. 90.3).

(The description is based on Kurtzman 2007b.)

Growth on 5% malt extract agar: After 3 days at 25°C, cells are spherical, 2.5–4.3 µm, ellipsoidal to elongate, 2–4 × 2–9 µm, occasionally triangular or curved, reproduce by multilateral budding and occur singly, in pairs and in small clusters (Fig. 90.189A). Some cells may form short denticles that produce blastoconidia on short denticles (Fig. 90.189B). Colony growth is light tannish-white in color, butyrous and with a smooth semiglistening surface.

Dalmau plate culture on morphology agar: After 7 days at 25°C, growth under the coverglass shows only sparingly developed pseudohyphae, but the individual cells may form blastoconidia on short denticles (Fig. 90.189B). Aerobic growth is butyrous, low, convex with a depressed center, light tannish-white with a smooth, glistening surface and with a finely lobed margin.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	+	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	+
Trehalose	–	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	+
Methyl-α-D-glucoside	+	D,L-Lactate	+
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	–
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

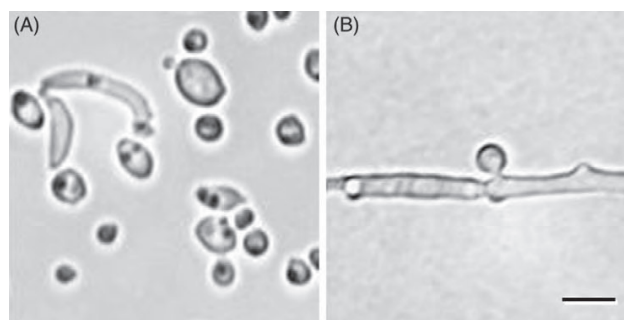


FIGURE 90.189 *Candida transvaalensis* NRRL Y-27140. Budding cells after 3 days, 25°C, 5% malt extract agar (A) and denticulate pseudohypha after 7 days, 25°C, yeast morphology agar (B). Bar = 5 µm.

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	+	Starch formation	–
5-Keto-D-gluconate	+	Gelatin liquefaction	–
Saccharate	–	Cycloheximide 0.1%	+
Cadaverine	+	Growth at 37°C	–
10% NaCl/5% glucose	–		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA = DQ442702, COXII = DQ443109.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27140 (CBS 6663), isolated from forest litter, J.P. van der Walt, Transvaal, South Africa (Kurtzman 2007b).

Type strain: NRRL Y-27140.

Systematics: Phylogenetic analysis of the LSU rRNA gene, the mitochondrial SSU rRNA gene and the COXII gene placed *C. transvaalensis* in a clade with *C. santjacobensis* (Kurtzman 2007b).

Ecology: *Candida transvaalensis* is only known from forest litter in South Africa (Kurtzman 2007b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.293. *Candida tritomae* S.-O. Suh, N.H. Nguyen & M. Blackwell (2006a)

Phylogenetic placement: *Candida kruisii* clade (Fig. 90.5).

(The description is based on Suh et al. 2006a.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, shiny, smooth or slightly wrinkled on the surface of old colonies.

Growth in YM broth: After 7 days at 25°C, cells are globose to ellipsoidal, 1.25–6 × 2–7 µm, occur singly, in pairs, in short chains or in clusters and pseudohyphae and septate hyphae may be present.

Dalmau plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae are present. Aerobic growth is white, shiny and smooth.

Fermentation

Glucose	+	Lactose	–
Galactose	d/w	Raffinose	–
Sucrose	–	Trehalose	+/d
Maltose	d	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	+/s
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+/s	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	v
Soluble starch	v	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+/s
L-Sorbose	—	D-Glucosamine	s
L-Rhamnose	—	N-Acetyl-D-glucosamine	n
D-Xylose	s/w	Hexadecane	n
L-Arabinose	—	Nitrate	—
D-Arabinose	—	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+/s	Ethylamine	+
2-Keto-D-gluconate	+	50% Glucose	v
D-Glucuronate	—	10% NaCl/5% glucose	+/w
L-Arabinitol	—	Starch formation	—
Arbutin	+	Urease	—
Propane 1,2 diol	v	DBB	—
Butane 2,3 diol	—	Cycloheximide 0.01%	—
Nitrite	—	Cycloheximide 0.1%	—
Cadaverine	+	Growth at 30°C	+
Creatinine	—	Growth at 35°C	+/s
L-Lysine	+	Growth at 40°C	—

CoQ: Not determined.**Mol% G + C:** Not determined.**Gene sequence accession numbers, type strain:** D1/D2 LSU rRNA = AY242255, SSU rRNA = AY242146, ITS and 5.8S rRNA = AY640189.**Cell carbohydrates:** Not determined.**Origin of the strains studied:** NRRL Y-27650 (CBS 9843), isolated from the guts of a fungus beetle (*Tritoma biguttata*, Coleoptera, Erotylidae) on a basidiocarp of *Amanita* sp., Baton Rouge, Louisiana; NRRL Y-48090, from gut of *T. angulata* on an agaric, Lake Placid, Florida; NRRL Y-27912, from the gut of an unidentified scarabid beetle (Coleoptera, Scarabidae), Lake Placid, Florida, all from USA (Suh et al. 2006a).**Type strain:** NRRL Y-27650.**Systematics:** Phylogenetic analysis of SSU and D1/D2 LSU rRNA gene sequences placed *C. tritomae* in the *Candida kruisii* clade, in which it clusters with *C. pallodes*, *C. panamensis* and *C. lycoperdinae*. Note that all these species originated from the guts of beetles (Suh et al. 2006a).**Ecology:** *Candida tritomae* is only known from the guts of beetles in the south-east USA (Suh et al. 2006a).**Biotechnology:** Unknown.**Agriculture and food:** Unknown.**Clinical importance:** Unknown.**90.294. *Candida tropicalis* (Castellani) Berkhout (1923)****Phylogenetic placement:** *Lodderomyces*–*Spathaspora* clade (Fig. 90.5).**Synonyms:**¹*Oidium tropicale* Castellani (1910)*Monilia tropicalis* (Castellani) Castellani & Chalmers (1913)*Endomyces tropicalis* Castellani (1911) [non *Endomyces tropicalis* Acton 1919]*Atelosaccharomyces tropicalis* (Castellani) Froilano de Mello (Froilano de Mello and Gonzaga Fernandes 1918)*Myceloblastanone tropicale* (Castellani) Ota (1928)*Castellania tropicalis* (Castellani) Dodge (1935)*Procandida tropicalis* (Castellani) Novák & Zsolt (1961)*Monilia candida* Bonorden (1851)*Monilia candida* Hansen (1888a)*Saccharomyces linguae-pilosae* Lucet (1901)*Cryptococcus linguae-pilosae* (Lucet) Gedoelst (1902)*Myceloblastanone linguae-pilosae* (Lucet) Ota (1928)*Torulopsis linguae-pilosae* (Lucet) de Almeida (1933)*Castellania linguae-pilosae* (Lucet) Dodge (1935)*Monilia bonordenii* Vuillemin (1911)*Candida bonordenii* (Vuillemin) Basgal (1931)*Endomyces paratropicalis* Castellani (1911)*Monilia paratropicalis* (Castellani) Castellani & Chalmers (1913)*Atelosaccharomyces paratropicalis* (Castellani) Froilano de Mello (Froilano de Mello and Gonzaga Fernandes 1918)*Myceloblastanone paratropicale* (Castellani) Ota (1928)*Candida paratropicalis* (Castellani) Basgal (1931)*Mycocandida paratropicalis* (Castellani) Guerra (1935)*Castellania paratropicalis* (Castellani) Dodge (1935)*Candida paratropicalis* J.G. Baker, Salkin, Pincus & D'Amato (1981) [non *Candida paratropicalis* (Castellani) Basgal (1931)]*Endomyces bronchialis* Castellani (1912b)*Monilia bronchialis* Castellani (Castellani and Chalmers 1913)*Myceloblastanone bronchiale* (Castellani) Ota (1928)*Candida bronchialis* (Castellani) Basgal (1931)*Castellania bronchialis* (Castellani) Dodge (1935)*Endomyces entericus* Castellani (1912b)*Monilia enterica* (Castellani) Castellani & Chalmers (1913)*Myceloblastanone entericum* (Castellani) Ota (1928)*Candida enterica* (Castellani) de Almeida (1933)*Castellania enterica* (Castellani) Dodge (1935)*Monilia faecalis* (Castellani) Castellani & Chalmers (1913)*Myceloblastanone faecalis* (Castellani) Ota (1928)*Castellania faecalis* (Castellani) Dodge (1935)*Endomyces insolitus* Castellani (1912a)*Monilia insolita* (Castellani) Castellani & Chalmers (1913)*Myceloblastanone insolitum* (Castellani) Ota (1928)*Candida insolita* Redaelli (Graziano 1930)*Castellania insolita* (Castellani) Dodge (1935)*Endomyces niveus* Castellani (1912a)*Monilia nivea* (Castellani) Castellani & Chalmers (1913)*Myceloblastanone niveum* (Castellani) Ota (1928)*Candida nivea* (Castellani) Basgal (1931)*Castellania nivea* (Castellani) Dodge (1935)*Endomyces burgessi* Castellani (1913)*Monilia burgessi* Castellani (Castellani and Chalmers 1913)*Castellania burgessi* (Castellani) Dodge (1935)*Endomyces perryi* Castellani (1913)*Parendomyces perryi* (Castellani) Dodge (1935)*Parasaccharomyces candidus* Anderson (1917)*Myceloblastanone candidum* Ota (1928)*Endomyces cruzi* Froilano de Mello & Paes (1918)*Zymonema cruzi* (Froilano de Mello & Paes) Dodge (1935)*Monilia metatropicalis* Castellani (Castellani and Chalmers 1919)*Castellania metatropicalis* (Castellani & Chalmers) Dodge (1935)*Monilia pseudobronchialis* Castellani (Castellani and Chalmers 1919)*Monilia accraensis* Macfie (1921)*Candida vulgaris* Berkhout (1923)*Geotrichoides vulgaris* (Berkhout) Langeron & Talice (1932)

Blastodendron irritans Mattlet (1926)
Parasaccharomyces irritans (Mattlet) Dodge (1935)
Blastodendron kayongosi Mattlet (1926)
Cryptococcus kayongosi (Mattlet) Nannizzi (1934)
Torulopsis tonsillae Carnevale-Ricci (1926)
Monilia issavi Mattlet (1926)
Syringospora issavi (Mattlet) Dodge (1935)
Mycotorula interdigitalis Redaelli *apud* Flarer (1931)
Mycotorula dimorpha Redaelli & Ciferri (Ciferri and Redaelli 1935)
Syringospora dimorpha (Redaelli & Ciferri) Dodge & Moore (1936)
Mycotorula trimorpha Redaelli & Ciferri (Ciferri and Redaelli 1935)
Mycotoruloides trimorpha (Redaelli & Ciferri) Dodge & Moore (1936)
Monilia aegyptiaca Khouri (1932)
Castellania aegyptiaca (Khouri) Dodge (1935)
Monilia argentina Vivoli, Avellaneda & de Bardessi (1932)
Mycotoruloides argentina (Vivoli, Avellaneda & de Bardessi) Dodge (1935)
Cryptococcus mattleti Nannizzi (1934)
Castellania accraensis (Macfie & Ingram) Dodge (1935)
Monilia murmanica Plevako and Cheban (1935)
Parasaccharomyces talicei Dodge (1935)
Pseudomonilia miso Mogi (1942)
Mycotorula japonica Yamaguchi (1943)
Candida benhamii Novak & Vitez (1964)
Candida citrica Furukawa, Matsuyoshi, Minoda & K. Yamada (1977)
Candida bimundalis Wickerham & Santa María var. *chlamydospora* Nowakowska-Waszczyk & Pietka (1983)
Torulopsis candida (Saito) Lodder var. *nitratophila* Nowakowska-Waszczyk & Pietka (1983)

¹ Synonymy primarily based on phenotype. See also Systematics section.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C the cells are subglobose to ovoid, 3.5–7 × 5.5–10 μm, and occur singly and in pairs.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of cylindrical cells with blastoconidia formed singly or in verticils, and septate hyphae are usually present. Aerobic growth is white, smooth, butyrous, soft and with a fringed border.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	v	Trehalose	+/s
Maltose	+		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	v	Ethanol	+
Raffinose	–	Glycerol	v
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	v
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	v	myo-Inositol	–
Methyl-α-D-glucoside	v	D-Lactate	v
Soluble starch	+	Succinate	+
Cellobiose	v	Citrate	v
Salicin	v	D-Gluconate	v
L-Sorbose	v	D-Glucosamine	v

L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	v

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Gluconate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	+

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 34.9, 1 strain (T_m : Stenderup and Bak 1968); 34.9, UCD-FST 60-31 (T_m : Meyer and Phaff 1969); 35.0, one strain (T_m : Nakase and Komagata 1968a); 34.4–35.4, three strains (T_m : Nakase and Komagata 1971f) 36.1, CBS 94; 35.1, CBS 6320; 35.9, CBS 5701 (T_m : Meyer et al. 1975); 34.1, IFO 0006; 34.4, ATCC 750 (T_m : Kaneko et al. 1977); 33.2, GSU 59; 34.6, GSU 372 and 446 (T_m : Ahearn et al. 1977); 35.6, two strains (T_m : Su and Meyer 1991).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45749.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: UWOPS 83-936.2 and three others, isolated from fruit of *Stenocereus hystris* (Cactaceae), Jamaica; UWOPS 83-984.2, from flower of Royen's tree cactus (*Cephalocereus royenii*, Cactaceae), Jamaica; UFMG F-173R, as contaminant of a clinical specimen of *C. albicans*, Brazil.

Other strains available: CBS 94, from bronchitic patient; CBS 433, type strain of *Saccharomyces pleomorphus*, from rotten pineapples, from R. Ciferri; CBS 642, origin unknown; CBS 643, from kefir, The Netherlands; CBS 2310, type strain of *C. vulgaris*, origin unknown; CBS 2311, origin unknown, from O. Winge; CBS 2313, type strain of *Mycotorula dimorpha*, from interdigital infection, Egypt; CBS 2314, as *Mycotorula trimorpha*, from child's feces, Italy; CBS 2317, from fodder yeast, Russia; CBS 2318, from sprue in Puerto Rico (Ashford 1917); CBS 2320, origin unknown, from Dessy; CBS 4913, origin unknown, from T. Sawai as *Mycotorula japonica*; CBS 5701, type strain of *C. benhamiae*, from infected hand, Hungary; CBS 6320, from citric acid production; CBS 6361, CBS 6362, both from human blood (Ahearn et al. 1977); CBS 6400, from soil, Japan; CBS 6628, CBS 6632, both origin unknown; CBS 6719, from water, Chesapeake Bay, near Maryland and Virginia, USA; CBS 7097, from clinical specimen, Japan; CBS 8072, type strain of *C. paratropicalis*, from human blood, New York (Baker et al. 1981); CBS 8250, type strain of *C. bimundalis* var. *chlamydospora*; CBS 8252, type strain of *Torulopsis candida* var. *nitratophila*, from citric acid fermentation vats, Poland.

Type strain: CBS 94.

Systematics: Meyer et al. (1975) and Kaneko et al. (1977) confirmed by DNA reassociation experiments that *C. tropicalis*, *C. maltosa* and *C. sake* were distinct species. The phylogenetic position and relationships of *C. tropicalis* have been clarified by analysis of D1/D2 LSU (Kurtzman and Robnett 1998a) and SSU (Sugita and Nakase 1999) rRNA gene sequences. The species belongs to the

Lodderomyces clade and is closely related to *C. sojae*. Sukroongreung and Rodrigues de Miranda (1973) suggested that *C. tropicalis* can undergo self-diploidization followed by meiosis. The photographs presented by the authors were most persuasive for strain CBS 6418, which unfortunately has been reassigned to *Torulaspora delbrueckii* on the basis of rRNA gene sequences (V. Robert, CBS database). In the type strain of *C. tropicalis*, a diploid nucleus was seen to divide unequally, but complete meiosis was less clearly documented.

The correct identification of *C. tropicalis* by growth characteristics is problematic due to the high degree of similarity with related species, many of which exhibit variability among strains. Although a phenetic comparison of the entire growth profile is generally successful in assigning strains to the species correctly, monothetic keys are inadequate, and a dependable identification should rely on DNA-based approaches. Because of the clinical relevance of the species, many rapid identification methods have been published. For example, Mannarelli and Kurtzman (1998) formulated a set of rRNA gene-based species-specific oligonucleotides that can be used for rapid identification of clinically important *Candida* species by PCR amplification.

Ecology: Unknown.

Biotechnology: Although extensive literature exists on *C. tropicalis* due to its clinical importance, the species is also known for the ability to degrade hydrocarbons and perform lipid biotransformations. Among the more recently reported applications are the fermentation of cocoa beans (Ardhana and Fleet 2003) and the degradation of polyphenols in waste water (Ettayebi et al. 2003).

Agriculture and food: Unknown.

Clinical importance: *Candida tropicalis* is one of the more frequently encountered clinical yeast species after *C. albicans* (Moran et al. 2002). It occurs frequently in septicemic patients suffering from leukemia or other debilitating conditions and in most cases seems to originate from the patients' own endogenous yeast community.

90.295. *Candida trypodendroni* Kurtzman and Robnett (1998b)

Phylogenetic placement: *Yamadazyma* clade (Fig. 90.2).

(Some of the morphological characteristics are based on Kurtzman and Robnett 1998b.)

Growth on 5% malt extract agar: After 3 days at 25°C, the cells are spherical, 2–6 µm, ellipsoid or elongate, 1.5–4 × 1.8–10 µm, sometimes tapered, occur singly or in pairs and budding is multilateral. Pseudohyphal cells are present (Fig. 90.190), as are individual cells with germ tube-like extensions. Growth is tannish-white, dull and butyrous.

Growth on the surface of assimilation media: Pellicles are formed on some media.

Dalmau plate culture on morphology agar: After 7 days at 25°C, pseudohyphae with infrequent blastoconidia are formed under the coverglass. True hyphae are absent after 7 days on morphology agar, but they are occasionally present on 5% malt extract and YM agars after 10 days at 25°C. Aerobic growth is semiglistening, tannish-white, butyrous and raised but with a slightly depressed center. The margin is finely lobed. A faintly acidic odor is present.

Fermentation

Glucose	+	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

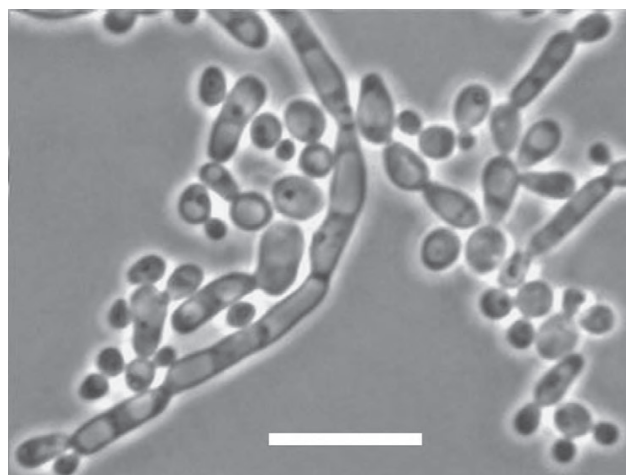


FIGURE 90.190 *Candida trypodendroni* CBS 8505. Budding cells and pseudohyphae after 3 days, 25°C, YM agar. Bar = 10 µm.

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	–	Casein	–
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	v	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF017240.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 8505 (NRRL Y-6488), isolated from an ambrosia beetle (*Trypodendron lineatum*, Coleoptera: Scolytidae) in Victoria, British Columbia, Canada.

Type strain: CBS 8505.

Systematics: *Candida trypodendroni* was described by Kurtzman and Robnett (1998b) to accommodate an isolate from an ambrosia beetle. Two colony variants were examined. The presence of unusual, thin protuberances emerging from cells grown on 5% malt agar was noted. The species keyed physiologically to *C. atlantica* but some differences existed. Analysis of the D1/D2 LSU rRNA gene sequences placed the species close to *Yamadazyma* (*Pichia*) *nakazawae* and other related species now assigned to the genus *Yamadazyma*.

Growth on replica plates was poor; although the results were correlated with the original description, most responses were weak or slow, whereas they were stronger in liquid media. At variance from the description, glucose fermentation was weak rather than strong.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.296. *Candida tsuchiyae* Nakase & M. Suzuki (1985d)

Phylogenetic placement: *Metschnikowia* clade (Fig. 90.1).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, 3.5–5 × 4.5–6 μm, and occur singly and in pairs (Fig. 90.191).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent. Aerobic growth is white, smooth, butyrous and with an entire margin.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	s
Sucrose	+	Trehalose	+
Maltose	+		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D,L-Lactate	–
Soluble starch	+	Succinate	+
Cellobiose	–	Citrate	+
Salicin	–	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

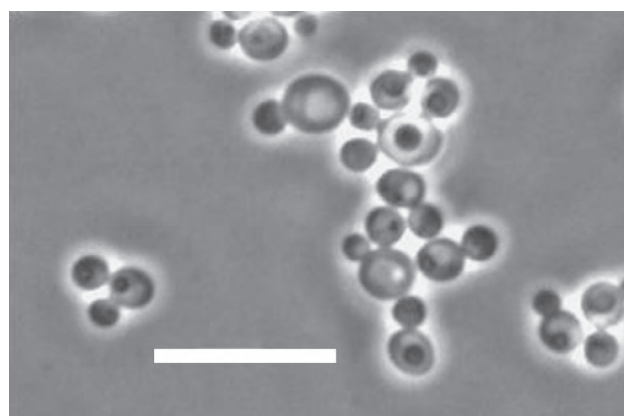


FIGURE 90.191 *Candida tsuchiyae* CBS 7195. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μm.

Additional Growth Tests and Other Characteristics

Xylitol	s	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	–
50% Glucose	+	Growth at 37°C	–

CoQ: 9 (Nakase and Suzuki 1985d).

Mol% G + C: 47.4, 47.6, 2 strains (T_m : Nakase and Suzuki 1985d).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U49064.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 7195, isolated from moss, Japan.

Type strain: CBS 7195.

Systematics: Nakase and Suzuki (1985d) described *C. tsuchiyae* from two isolates from moss. Similarities in physiology and serology were noted with *C. musae* and *C. haemulonii*, but DNA reassociation showed them to be distinct. Sequence analyses (Kurtzman and Robnett 1998a, Sugita and Nakase 1999) position the species in the *Metschnikowiaceae* clade, but the closest relatives vary as a function of the sequence analyzed, which is somewhat typical for several species in the clade.

The growth characteristics determined by replica plating agreed with previous descriptions, except for the strong utilization of *N*-acetyl-D-glucosamine. Growth at 30°C was not observed as reported in the original description.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.297. *Candida tumulicola* Nagatsuka, Kiyuna, Kigawa & Sugiyama (Nagatsuka et al. 2009)

Phylogenetic placement: *Yamadazyma* clade; see Systematics (Fig. 90.2). (The description is based on Nagatsuka et al. 2009.)

Growth on YM agar: After 3 weeks at 25°C, the colony is white to cream, butyrous, smooth, with a pulvinate elevation having radial striations, and a filamentous margin.

Growth in YM broth: After 3 days at 25°C, cells are ellipsoidal, 2.5–3.5 × 4–6.5 µm, reproduce by multilateral budding, and occur singly or in pairs.

Growth on the surface of fermentation media: Sediment and a thin ring are formed.

Dalmau plate culture on YM agar: After 5–6 days at 25°C, pseudohyphae composed of branched chains of cylindrical cells and septate hyphae are present.

Fermentation

Glucose	w	Lactose	–
Galactose	w	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (Media not Indicated)

Glucose	+	D-Ribose	w/d
Inulin	n	Methanol	–
Sucrose	+w	Ethanol	w
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	+	Galactitol	–
Trehalose	w/d	D-Mannitol	+
Maltose	d	D-Glucitol	+
Melezitose	v	myo-Inositol	–
Methyl-α-D-glucoside	w	DL-Lactate	v
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+w
Salicin	+	D-Gluconate	w/d
L-Sorbose	w	D-Glucosamine	d
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	+	Nitrate	–
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	+w	L-Lysine	+
2-Keto-D-gluconate	w	Ethylamine	+
5-Keto-D-gluconate	–	50% Glucose	–
D-Glucuronate	–	10% NaCl/5% glucose	–
L-Arabinitol	+	Starch formation	–
Arbutin	+	Urease	–
Propane 1,2 diol	w	DBB	–
Butane 2,3 diol	–	Cycloheximide 0.01%	+
Isopropyl alcohol	–	Cycloheximide 0.1%	+
Nitrite	–	Growth at 25°C	+
Cadaverine	+	Growth at 37°C	+
Creatinine	–		

CoQ: 9 (Nagatsuka et al. 2009).

Mol% G + C: 43.1 (HPLC: Nagatsuka et al. 2009).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AB365463.

Cell carbohydrates: Not determined.

Origin of the strains studied: JCM 15403 (CBS 10917, NBRC 104392, T6517-9-5), isolated May 17, 2006 from a sample of viscous gel collected near the feet of the rightmost of the four woman depicted on the east plaster wall in the stone chamber of the Takamatsu-zuka tumulus; and 13 other isolates (JCM 15396–JCM 15402, JCM 15404–JCM 15409) from various places and substrates in the stone chamber

of the Takamatsu-zuka tumulus, such as different types of biofilm (e.g., viscous gel, brownish gel), a mural that turned black, a mural that turned white, an area covered with black molds and also a springtail (Colembola). All of the strains were collected in Asuka, Nara Prefecture, Japan (Nagatsuka et al. 2009).

Type strain: JCM 15403.

Systematics: Phylogenetic analysis of D1/D2 LSU rRNA gene sequences placed *C. tumulicola* in the weakly supported *Candida membranifaciens* clade, with *C. buinensis*, *C. blattariae*, *C. membranifaciens*, *C. friedrichii*, *C. diospyri* and with *C. amphixiae* as a basal lineage (Nagatsuka et al. 2009).

Ecology: *Candida tumulicola* was isolated from the stone chamber of the Takamatsu-zuka tumulus, Asuka, Nara Prefecture, Japan (Nagatsuka et al. 2009). This tumulus was excavated in 1972, and is thought to have been built in the 7th or 8th century. Since protective work performed in 1976, a high humidity (approximately 100% relative humidity) is maintained within a temperature range of 14–20°C. Restoration and construction work probably resulted in growth of fungal colonies that appeared on the murals. Since 2004, biofilms composed of different microorganisms and mites were seen on the wall plaster. Because both ethanol and isopropyl alcohol have been used to reduce growth of microbes inside the chamber, it has been speculated that the presence of these compounds combined with a high relative humidity may have caused the growth of the yeasts. As ethanol is weakly assimilated, and isopropyl alcohol is not utilized by *C. tumulicola*, it may be that the capability to utilize ethanol has contributed to the growth of the yeast.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.298. *Candida ubatubensis* Ruivo, Pagnocca, Lachance & Rosa (Ruivo et al. 2005)

Phylogenetic placement: *Metschnikowia* clade (Figs 46.1, 90.1).

(The description is based on Ruivo et al. 2005.)

Growth on YM agar: After 4 days at 25°C, the colonies are white to cream, smooth and butyrous.

Growth in 0.5% yeast extract–2% glucose broth: After 3 days at 25°C, the cells are spherical to ovoid, 3–4.5 × 4–6 µm, reproduce by multilateral budding, and occur singly or in budded pairs.

Dalmau plate culture on corn meal agar: After 2 weeks at 25°C, pseudohyphae and true hyphae are not formed.

Fermentation

Glucose	+	Lactose	n
Galactose	n	Raffinose	n
Sucrose	n	Trehalose	n
Maltose	n		

Growth (Media not Indicated)

Glucose	+	D-Ribose	+
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	+
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–

Soluble starch	–	Succinate	–
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	w	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	+	10% NaCl/5% glucose	+
2-Keto-D-gluconate	–	Urease	–
5-Keto-D-gluconate	–	DBB	–
L-Arabinitol	+	Cycloheximide 0.01%	–
Cadaverine	+	Cycloheximide 0.1%	–
L-Lysine	+	Growth at 35°C	+
Ethylamine	+	Growth at 37°C	–
50% Glucose	–		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY695395, SSU rRNA = AY695397.

Cell carbohydrates: Not determined.

Origin of the strains studied: UNESP 01-247R (CBS 10003, NRRL Y-27812), and two other strains, all isolated from water tanks of a bromeliad (*Canistropis seidelii*) in an Atlantic rainforest, Picinguaba site, Serra do Mar State Park, São Paulo State, Brazil (Ruivo et al. 2005).

Type strain: UNESP 01-247R.

Systematics: Phylogenetic analysis of the SSU rRNA and D1/D2 domains of the LSU rRNA genes showed that *C. ubatubensis* belongs to the *Metschnikowia* clade, where it occupies an isolated position as a basal lineage (Ruivo et al. 2005).

Ecology: *Candida ubatubensis* is known from the water tank of a bromeliad in south-east Brazil (Ruivo et al. 2005).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.299. *Candida ulmi* Kurtzman (2000a)

Phylogenetic placement: *Wickerhamomyces* clade (Figs 90.4, 80.1. (Some of the morphological characteristics are based on Kurtzman 2000a.)

Growth on 5% malt agar: After 3 days at 25°C, the cells are spherical, 1.8–7 µm, ellipsoidal or elongate, 1.3–6 × 2–8 µm, occur singly or in pairs and reproduce by multilateral budding (Fig. 90.192A). Growth is butyrous, tannish-white and semi-glistening.

Growth in liquid media: Thin pellicles are formed.

Dalmat plate culture on morphology agar: After 7 days at 25°C, the type of growth under the coverglass is strain dependent and may show rudimentary pseudohyphae or well-branched pseudohyphae with abundant blastoconidia (Fig. 90.192B). True hyphae were not detected. Aerobic growth is tannish-white, butyrous, glistening and low convex. Colony margins are smooth to finely serrate. A faint, fragrant ester-like odor may be produced.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

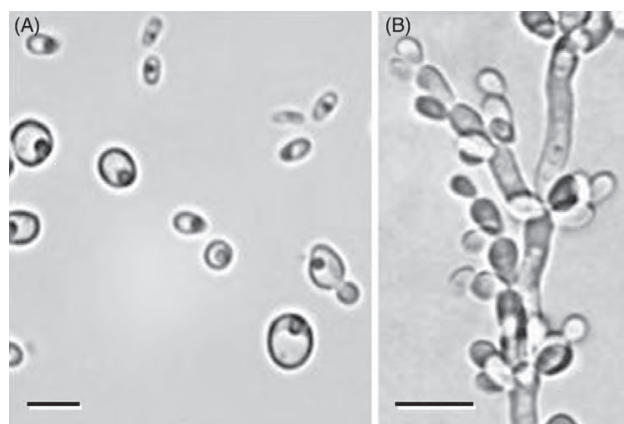


FIGURE 90.192 *Candida ulmi* NRRL YB-2694. Budding cells after 3 days, 25°C, 5% malt extract agar (A) and pseudohyphae after 7 days, 25°C, yeast morphology agar (B). Bars = 5 µm.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	w
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	+	N-Acetyl-D-glucosamine	–
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	+
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	–	DBB	–
D-Gluconate	–	Gelatin	–
Glucono-δ-lactone	+	Casein	+/w
Amino acid-free	+	Lipase	–
Nitrite	+	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF017249.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 8670 (NRRL YB-2694), isolated from insect frass on elm (*Ulmus* sp., Ulmaceae); UWOPS 82-333, from *Drosophila* sp., Ontario, Canada.

Type strain: CBS 8670.

Systematics: Kurtzman (2000a) described *C. ulmi* from three isolates, one from soil and two from insect frass collected in an elm tree. The species was defined primarily on the basis of divergence in the D1/D2 LSU rRNA gene sequence, which demonstrated an affinity with *Wickerhamomyces (Pichia) alni*, *C. quercuum* and others.

The two strains studied are similar physiologically, although the isolate from a *Drosophila* sp. collected in an oak–pine forest hydrolyzed casein strongly. Replica plating did not confirm the assimilation of lactic and citric acids reported in the original description. The profile is typical of many related species, but the following characters are discriminatory when considered jointly: positive responses on L-rhamnose and nitrate utilization, growth at 37°C and fermentation; negative responses on raffinose, D-arabinose, D-ribose and xylitol.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	–
Raffinose	+	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	v	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+
L-Sorbose	+	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	w
L-Arabinose	–	Nitrate	+
D-Arabinose	–	Vitamin-free	–

90.300. *Candida vaccinii* Tokuoka, Ishitani, S. Goto & Komagata (1987)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to ovoid, 2–5 μ m (Fig. 90.193). Short chains are more frequent than single cells.

Dalmat plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent. Aerobic growth is off-white to beige, smooth and with an entire margin.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–/s
Sucrose	+	Trehalose	–
Maltose	–		

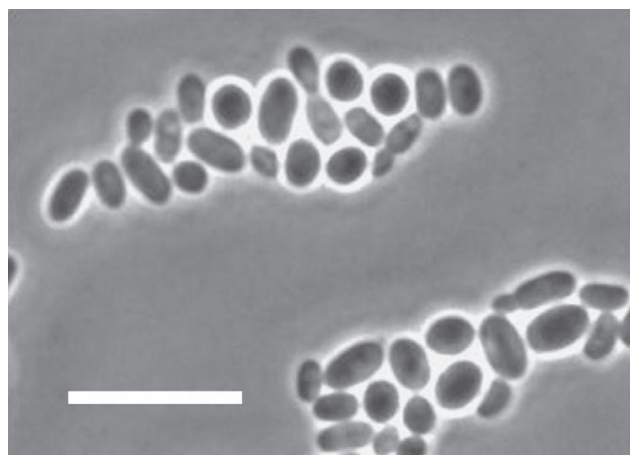


FIGURE 90.193 *Candida vaccinii* CBS 7318. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

Additional Growth Tests and Other Characteristics

Xylitol	s	Starch production	–
2-Keto-D-gluconate	s	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	+	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	s
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	v

CoQ: 9 (Tokuoka et al. 1987).

Mol% G + C: 52.0, CBS 7318 (T_m : Tokuoka et al. 1987).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45708.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 7318, isolated from flower of blueberry (*Vaccinium* sp., Ericaceae), Japan.

Type strain: CBS 7318.

Systematics: *Candida vaccinii* was described by Tokuoka et al. (1987) to accommodate an osmophilic isolate from a blueberry flower. The authors remarked on the similarity of the species with *C. etchellsii* and *C. versatilis*, but listed a number of diagnostic traits. Analysis of rRNA gene sequences (Kurtzman and Robnett 1998a, Suzuki et al. 1999) showed that the species belongs to the *Starmerella sensu lato* clade (Fig. 71.1).

As pointed out by Meyer et al. (1998), the growth characteristics of *C. vaccinii* are similar to those of *C. magnoliae*. Although the re-identification of strains previously assigned to the latter species resulted in the elimination of several ambiguous test results, discrimination on the basis of physiological responses remains problematic. Separation from related species can be based on nitrate utilization, cycloheximide resistance (slow on 0.01%) and absence of growth on galactose (although many similar species give a weak reaction). The convergent similarity to *C. versatilis* is superficial, and separation can make use of several growth responses, including growth at 37°C.

Ecology: As with many related species in the *Starmerella* clade, the species may be associated with flower-visiting insects (Rosa et al. 2003).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.301. *Candida vadensis* Middelhoven & Kurtzman (2007)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5). (Description based on Middelhoven and Kurtzman 2007.)

Growth on 5% malt extract agar: After 3 days at 25°C, the slant culture is white, powdery, butyrous and fringed with a narrow band of growth consisting of pseudohyphae. Cells are short ellipsoidal to elongate, 2–3 × 2.5–21 μm, reproduce by multilateral budding and occur singly, in pairs and in small clusters (Fig. 90.194A). Some cells have one or more short denticles that bear blastoconidia. Occasionally, cells produce extensions that resemble conjugation tubes, although conjugation between cells was not observed.

Growth on the surface of GPYM media: After 3 days at 25°C, the cells are globose and ovoid, occur singly or in pairs and short chains and some pseudohyphae may be present. A pellicle and sediment are formed.

Dalmau plate culture on morphology agar: After 7 days at 25°C, extensive well-branched pseudohyphae with blastoconidia occur (Fig. 90.194B), but true hyphae are not present. Aerobic growth has a dull grayish-white, powdery surface with a flat, shallow central crater and the colony is surrounded by a narrow zone of pseudohyphae.

Fermentation: Absent.



FIGURE 90.194 *Candida vadensis* NRRL Y-27778. Budding cells after 3 days, 25°C, 5% malt extract agar (A) and pseudohyphae after 7 days, 25°C, yeast morphology agar (B). Bar = 5 μm.

Growth (in Liquid Media)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	+/s
L-Sorbose	–	D-Glucosamine	+/s
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+/s
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	–	10% NaCl/5% glucose	+
2-Keto-D-gluconate	+	Extracellular starch-like compounds	–
5-Keto-D-gluconate	–	Urease	–
D-Glucuronate	–	DBB	–
Propane 1,2 diol	–	Cycloheximide 0.01%	s
Butane 2,3 diol	–	Cycloheximide 0.1%	–
Cadaverine	+	Growth at 30°C	+
Creatinine	–	Growth at 32°C	–
L-Lysine	+		
Ethylamine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = DQ839396 and AY498863, ITS = AY498864.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27778 (CBS 9454), isolated in September 2000 from a rotten lion's mane mushroom (*Hericium erinaceus*) growing on a beech tree (*Fagus sylvatica*, Fagaceae), Wageningen, The Netherlands (Middelhoven and Kurtzman 2007).

Type strain: CBS 9454.

Systematics: Phylogenetic analysis of the D1/D2 domains of the LSU rRNA gene placed *C. vadensis* in the *Candida tanzawaensis* clade, in which it clusters with *C. xylopsoci*, *C. pyralidae* and *C. prunicola* (Middelhoven and Kurtzman 2007).

Ecology: *Candida vadensis* is known only from a single strain isolated from a mushroom growing on a beech tree in The Netherlands (Middelhoven and Kurtzman 2007).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.302. *Candida valdiviana* Grinbergs & Yarrow (1970a)

Phylogenetic placement: *Sugiyamaella* clade (Figs 72.1, 90.3).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 2–4 × 4–7 μm, and occur singly and in pairs (Fig. 90.195 top).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae consist of branched chains of elongate cells with verticils of ovoid blastoconidia (Fig. 90.195 bottom). Aerobic growth is white, creamy, smooth, glistening and with an entire margin.

Fermentation

Glucose	s	Lactose	—
Galactose	—	Raffinose	—
Sucrose	—	Trehalose	—
Maltose	—		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	s
Raffinose	+	Glycerol	s
Melibiose	+	Erythritol	—
Galactose	+	Ribitol	s
Lactose	w/—	Galactitol	s/—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	+
Methyl- α -D-glucoside	+	DL-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	w
L-Sorbose	+	D-Glucosamine	s
L-Rhamnose	—	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	w	Nitrate	+
D-Arabinose	v	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	—	Starch production	—
2-Keto-D-gluconate	+	DBB	—
D-Gluconate	+	Gelatin	—
Glucono- δ -lactone	v	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	+	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	—	Growth at 37°C	v

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 55.3, CBS 5721 (BD: Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45835.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5721, isolated from rotting wood of southern beech (*Nothofagus* sp., Fagaceae), Chile; CBS 6247, from insect frass, Spain.

Type strain: CBS 5721.

Systematics: In the description of *C. valdiviana*, Grinbergs and Yarrow (1970a) noted a similarity with *C. curvata* and *C. humicola*, both of which have since been transferred to the genus *Cryptococcus* based on their basidiomycetous affinities. The authors commented on the unusual ability of the species to utilize *myo*-inositol, from

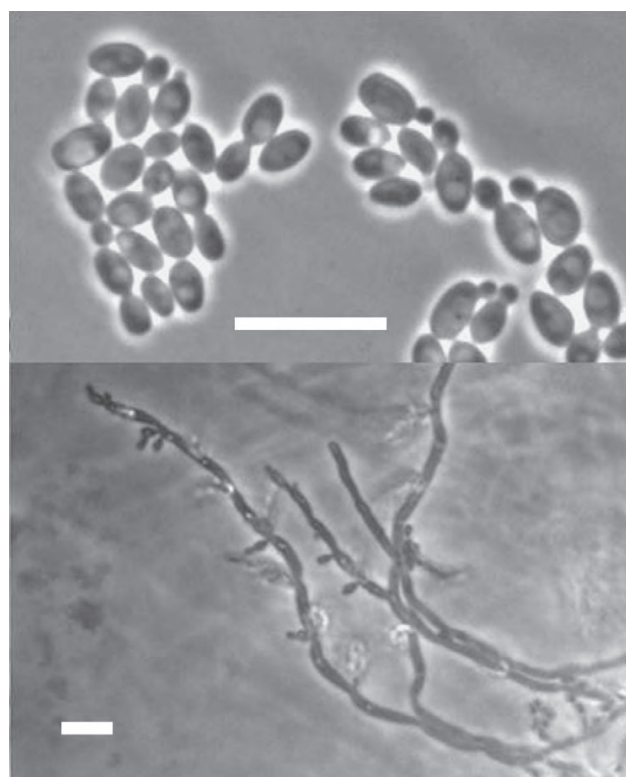


FIGURE 90.195 *Candida valdiviana* CBS 5721. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 µm.

which they inferred possible affinities with *C. incommis*, *C. curiosa* and *C. edax*. Analyses of rRNA gene sequences place *C. valdiviana* near *C. castrensis* and *C. paludigena* in the *Trichomonascus/Sugiyamaella* clade (Kurtzman and Robnett 1998a, 2007, Suzuki et al. 1999).

The species is polyphagic. As pointed out in the original description, the growth responses are similar to those of *C. incommis*, although the latter utilizes erythritol and not raffinose or melibiose. *C. saitoana* is also similar, but does not utilize galactitol, *myo*-inositol or nitrate.

Ecology: Meyer et al. (1998) and the CBS database indicated that the type strain was isolated from sputum. It would seem from the original description that the strain came from decaying wood in the province of Valdivia in Chile, which has been shown to harbor a vast array of yeast species. However, the rarity of the species precludes further generalization of an ecological nature.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.303. *Candida vanderwaltii* (Vidal-Leiria) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Wickerhamiella* clade (Fig. 79.1).

Synonym:

Torulopsis vanderwaltii Vidal-Leiria (1966b)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid, 2–3 × 4–6 µm, and occur singly and in pairs (Fig. 90.196).

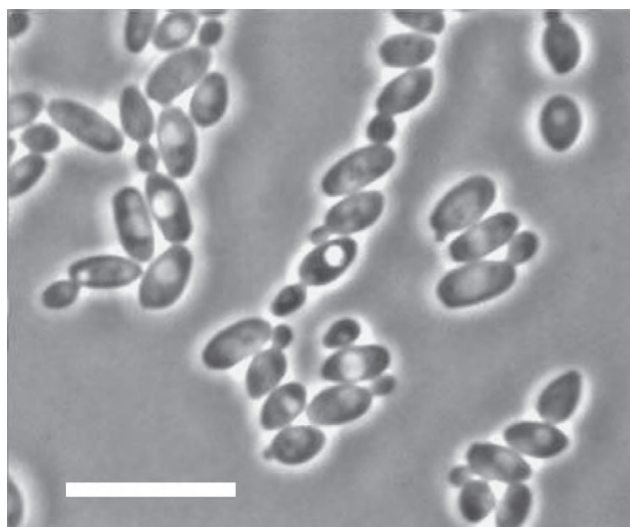


FIGURE 90.196 *Candida vanderwaltii* CBS 5524. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are usually absent, but sometimes short, dense chains of ovoid cells are present. Aerobic growth is off-white to cream colored, shiny, soft, smooth and with an entire margin.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	s
Inulin	—	Methanol	—
Sucrose	v	Ethanol	—
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	+	Ribitol	+
Lactose	—	Galactitol	s
Trehalose	+	D-Mannitol	+
Maltose	—	D-Glucitol	+
Melezitose	—	myo-Inositol	—
Methyl-α-D-glucoside	—	D,L-Lactate	—
Soluble starch	—	Succinate	+
Cellobiose	—	Citrate	+
Salicin	—	D-Gluconate	—
L-Sorbose	+	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	+	Hexadecane	—
L-Arabinose	+	Nitrate	+
D-Arabinose	s	Vitamin-free	—

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	v	DBB	—
D-Glucuronate	—	Gelatin	s
Glucono-δ-lactone	v	Casein	—
Amino acid-free	+	Lipase	s
Nitrite	+	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+
50% Glucose	+	Growth at 37°C	—

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 49.7, CBS 5524 (T_m : Stenderup et al. 1972).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U62313.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 5524, isolated from winery, South Africa; CBS 8271, from dessert grapes, Italy.

Type strain: CBS 5524.

Systematics: Vidal-Leiria (1966b) described *Torulopsis vanderwaltii* from two unidentified strains recovered from winery equipment by van der Walt. She noted similarities with *Torulopsis (Candida) nitrato-phila*, but the two species could be separated based on some growth characteristics. *C. vanderwaltii* belongs to the *Wickerhamiella* clade, as evidenced by rRNA gene sequence studies (Kurtzman and Robnett 1998a, Suzuki et al. 1999), and is closest to recently discovered *Wickerhamiella* and related *Candida* species (Fig. 79.1, Lachance et al. 1998c).

The growth characteristics of the two strains examined by replica plating agreed with previous descriptions with the exception that ethanol was utilized slowly. The physiological profile is unique and can be used for identification. Growth on trehalose, L-arabinose, citric acid and nitrate will separate *C. vanderwaltii* from all species that show some similarity, which includes other members of the clade as well as unrelated species.

Ecology: The two known strains were isolated independently from substrates linked to grapes, suggesting an association with fruit flies. The latter receives further support from the association of related species with *Drosophila* species in other substrates (see discussion of the genus *Wickerhamiella*).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.304. *Candida vartiovaarae* (Capriotti) van Uden & H.R. Buckley ex S.A. Meyer & Ahearn (1983)

Phylogenetic placement: *Wickerhamomyces* clade (Fig. 90.4).

Synonyms:

Torulopsis vartiovaarae (as *T. vartiovaarae*) Capriotti (1961e)

Candida vartiovaarae (Capriotti) van Uden & H.R. Buckley (1970) nom. inval.

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 3–5 × 5.5–8 µm, and occur singly and in pairs (Fig. 90.197 top). Van Uden and Buckley (1970) reported that a pellicle may be formed, but this was not confirmed in this study.

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are sometimes formed, and consist of branched chains of elongate to cylindrical cells (Fig. 90.197 bottom), sometimes with dense verticils of subglobose to ovoid blastoconidia. Aerobic growth is off-white to cream colored, somewhat dull, soft, smooth and with an entire margin.

Fermentation

Glucose	+	Lactose	—
Galactose	—	Raffinose	—
Sucrose	+	Trehalose	—
Maltose	v		

Growth (on Agar)

Glucose	+	D-Ribose	—
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	—	Glycerol	+
Melibiose	—	Erythritol	—
Galactose	—	Ribitol	—
Lactose	—	Galactitol	—
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	—
Methyl- α -D-glucoside	+	DL-Lactate	+
Soluble starch	—	Succinate	+
Cellobiose	+	Citrate	v
Salicin	+	D-Gluconate	+
L-Sorbose	—	D-Glucosamine	—
L-Rhamnose	—	N-Acetyl-D-glucosamine	—
D-Xylose	+	Hexadecane	—
L-Arabinose	—	Nitrate	+
D-Arabinose	—	Vitamin-free	+

Additional Growth Tests and Other Characteristics

Xylitol	+	Starch production	—
2-Keto-D-gluconate	s/w	DBB	—
D-Glucuronate	—	Gelatin	—
Glucono- δ -lactone	+	Casein	—
Amino acid-free	+	Lipase	—
Nitrite	+	Acid production	—
Ethylamine	+	Cycloheximide 0.01%	—
L-Lysine	+	Cycloheximide 0.1%	—
Cadaverine	+	1% Acetic acid	—
10% NaCl	—	Growth at 30°C	+/w
50% Glucose	—	Growth at 37°C	—

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: 48.8, CBS 4289 (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U69875.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 4289, isolated from soil, Finland; CBS 2895, from cider, UK.

Other strains available: CBS 4290, from soil, Finland; CBS 6720, from water in Chesapeake Bay, USA.

Type strain: CBS 4289.

Systematics: Capriotti (1961e) examined 258 yeast strains isolated from 32 soil samples in Finland. Of these, four strains could not be identified and were described as *Torulopsis vartiovaarae*. He noted a similarity with *Torulopsis colliculosa*, *T. globosa* and *T. osloensis* (*osloensis*?), now considered synonyms of *Torulasporea delbrueckii*, *Citeromyces matritensis* and *Zygosaccharomyces rouxii*, respectively, although the standard set of assimilation tests was not completely determined. *C. vartiovaarae* is a sister species to *Lindnera* (*Williopsis*) *saturnus* (Kurtzman and Robnett 1998a, Suzuki and Nakase 2002).

The growth characteristics of the species assessed by replica plating matched the descriptions given by Meyer et al. (1998) except for the utilization of 2-keto-D-gluconic acid, found positive (albeit not strong) in both strains. The utilization of trehalose, combined with the lack of growth on raffinose, starch and L-rhamnose, or at 37°C, can be used to separate *C. vartiovaarae* from similar species.

Ecology: Unknown.

Biotechnology: Unknown.

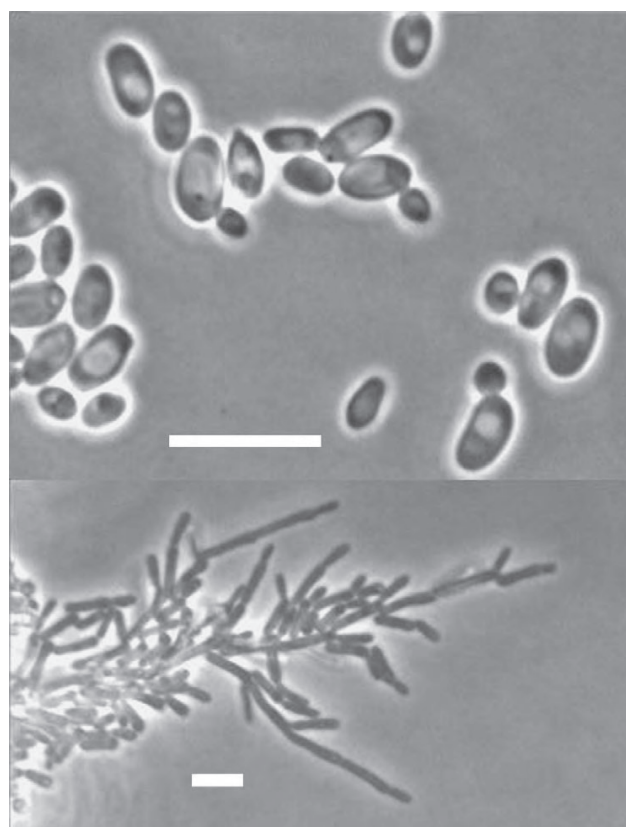


FIGURE 90.197 *Candida vartiovaarae* CBS 4289. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 µm.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.305. *Candida versatilis* (Etchells & T.A. Bell) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Wickerhamiella* clade (Figs 79.1, 90.3)

Synonyms:

- Brettanomyces versatilis* Etchells & T.A. Bell (1950b)
- Torulopsis versatilis* (Etchells & T.A. Bell) Lodder & Kreger-van Rij (1952)
- Torulopsis anomala* Lodder & Kreger-van Rij (1952)
- Torulopsis mannitofaciens* Onishi & T. Suzuki (1969a)
- Candida mannitofaciens* (Onishi & T. Suzuki) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)
- Torulopsis halophilus* Onishi (1957) nom. inval.
- Candida halophila* Yarrow & S.A. Meyer (1978)
- Candida rhodohalophila* Mori (Suzuki et al. 1992) nom. nud.
- Debaryomyces tamarii* Y. Ohara & Nonomura (1954a)
- Pichia tamarii* (Y. Ohara & Nonomura) Campbell (1973)
- Torulasporea tamarii* (Y. Ohara & Nonomura ex van der Walt & E. Johannsen) van der Walt & E. Johannsen (1975a)
- Debaryozyma tamarii* (Y. Ohara & Nonomura ex van der Walt & E. Johannsen) van der Walt & E. Johannsen (1978)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to subglobose, 3–6 µm, and occur singly and in pairs (Fig. 90.198).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent. Aerobic growth is off-white to beige, glistening soft, smooth and with an entire margin.

Fermentation

Glucose	s	Lactose	–/s
Galactose	s	Raffinose	–/s
Sucrose	v	Trehalose	v
Maltose	v		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+/s
Raffinose	v	Glycerol	+/w
Melibiose	v	Erythritol	–
Galactose	+/w	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	+/w	D-Mannitol	w
Maltose	v	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	D,L-Lactate	–
Soluble starch	–	Succinate	w
Cellobiose	+/w	Citrate	–
Salicin	v	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	+
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	s/w	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	v	Casein	–
Amino acid-free	s	Lipase	–
Nitrite	+	Acid production	–
Ethylamine	v	Cycloheximide 0.01%	v
L-Lysine	v	Cycloheximide 0.1%	v
Cadaverine	+/w	1% Acetic acid	–
10% NaCl	+/w	Growth at 30°C	+/w
50% Glucose	+	Growth at 37°C	–

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 45.4–46.6, three strains (T_m : Nakase and Komagata 1971d); 53.7, CBS 1752 (T_m : Meyer et al. 1984); 47.5, type strain of *C. mannifaciens* (BD: Meyer et al. 1984); 46.4, one strain of *Debaryomyces tamarii* (BD: Price et al. 1978); 45.0, type strain; 46.2, type strain of *C. mannifaciens*; 44.1, type strain of *C. halophila*; 45.4, JCM 5957 and JCM 5974; 46.0, JCM 5958 (T_m : Suzuki et al. 1992).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45834.

Cell carbohydrates: Glucose, mannose and galactose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 1731, type strain of *Torulopsis anomala*, CBS 1752, CBS 4019, type strain of *C. halophila* and CBS 4333, type strain of *Debaryomyces tamarii*, all isolated from fermenting

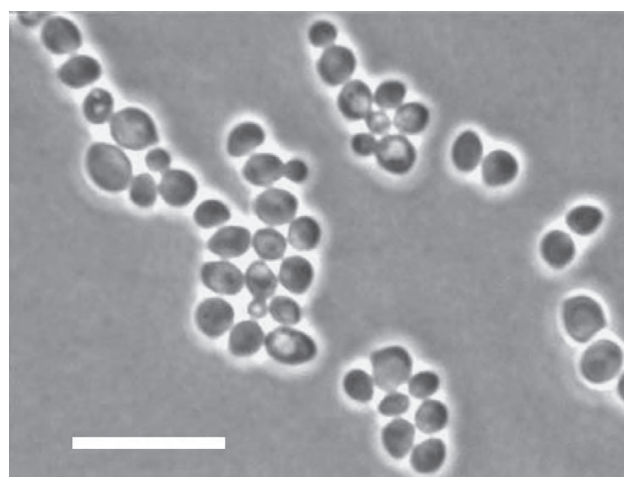


FIGURE 90.198 *Candida versatilis* CBS 1752. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

cucumber brines, USA; CBS 5007, from sugar, Mauritius; CBS 5981, type strain of *C. mannifaciens*, and others, from mash of soybeans (*Soja hispida*); UWOPS 01-171.3, from sugar-bag bee (*Trigona* sp., Hymenoptera: Apidae) from cassia (*Cassia* sp., Fabaceae), Costa Rica.

Type strain: CBS 1752.

Systematics: The conspecificity of *C. versatilis*, *C. mannifaciens*, *C. halophila*, *Debaryomyces tamarii* and two strains designated “*C. rhodohalophila*” was demonstrated by DNA reassociation (F.-L. Lee et al. 1992, Suzuki et al. 1992). *D. tamarii* did not fit in *Debaryomyces*, having been shown to possess a higher DNA base composition than typical *Debaryomyces* species (Nakase and Komagata 1971a, Price et al. 1978) and highly divergent rRNA sequences (Kurtzman and Robnett 1991, Yamada et al. 1991a). The original claim of spherical warty-walled ascospores in *D. tamarii* was never confirmed. Independent analyses of rRNA gene sequences (Kurtzman and Robnett 1998a, Suzuki et al. 1999) placed *C. versatilis* as a sister species to *Wickerhamiella domercqiae*, although the degree of divergence between the two is high and taxon sampling in these studies was sparse. Fig. 79.1 suggests instead that the species is probably basal to the *Wickerhamiella* clade. Strain CBS 5981, the type strain of *C. mannifaciens*, differs from others by two substitutions in the D1/D2 LSU rRNA gene.

Although one might have expected the fusion of several taxa into a single species to result in a substantial increase in variation in growth characteristics, the opposite was observed. Growth on raffinose, melibiose, maltose, ethanol and glucono- δ -lactone as carbon sources, ethylamine and L-lysine as nitrogen source, and resistance to various concentrations of NaCl or cycloheximide still vary, but the number of results previously reported as variable was reduced considerably. As assessed by replica plating, none of the strains was found to assimilate lactose, methyl- α -D-glucoside, D-xylose, L-arabinose, D-ribose, lactic acid or citric acid. All strains except for the Costa Rican isolate grew in the presence of 15% NaCl regardless of previous assignments.

Ecology: Unknown.

Biotechnology: Van der Sluis et al. (2001) successfully used immobilized cells of *C. versatilis* in the production of 4-ethylguaiacol as a flavor component in soy sauce. Yang et al. (2003) isolated a strain of *C. haplophila* (presumed to be *C. versatilis*) that grew well in mixed culture with *Rhodotorula glutinis* in the presence of 25% (NH₄)₂SO₄ and could be used for reduction of the chemical oxygen demand in monosodium glutamate wastewater.

Agriculture and food: Salt tolerance is considered a significant factor affecting the distribution and biochemical activities of *C. versatilis*. Seiler and Busse (1990) found the species to be an important member of the community associated with cheese brines. In a multi-laboratory comparison of media used to detect xerophilic yeasts in foods, Braendlin (1996) found that *C. versatilis* could only be recovered with confidence on media containing dichloran and 18% glycerol as selective agents. Other media tested used various concentrations of glucose as an osmoticum.

Clinical importance: Unknown.

Additional comments: Silva-Graça et al. (2003) found that the type strain of the former *C. halophila* was able to grow in the presence of NaCl at concentrations approaching 5 M (ca. 29%). The authors considered the yeast to be exceptional in being able to maintain low intracellular sodium concentrations while keeping potassium levels well above the minimum requirement. In view of the ability of the yeast to grow in normal media, the authors concluded that the term halotolerant is more appropriate than the term halophilic.

90.306. *Candida viswanathii* Viswanathan & H.S. Randhawa ex R.S. Sandhu & H.S. Randhawa (1962)

Phylogenetic placement: *Lodderomyces*–*Spathaspora* clade (Fig. 90.5).

Synonyms:

Candida viswanathii Viswanathan & Randhawa (1959) nom. inval.
Trichosporon lodderae (as *T. lodderi*) Phaff, Mrak & Williams (1952)
Fermentotrichon lodderae (Phaff, Mrak & Williams) Novák & Zsolt (1961)
Candida lodderae (Phaff, Mrak & Williams) S.A. Meyer & Ahearn (1983) [non *Candida lodderae* Kumbhojkar (1981)]¹
Candida aquatextoris Vallini, Frassinetti & Scorzetti (1997)²

Synonymy based on: ¹ D1/D2 LSU rRNA gene sequence analysis (Kurtzman and Robnett 1997) and nuclear DNA reassociation (F.-L. Lee et al. 1998), ² D1/D2 LSU rRNA gene sequence analysis (C.P. Kurtzman, M.-A. Lachance, unpublished data).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are subglobose to ovoid, 3.5–7 × 5–9 μm, and occur singly and in pairs (Fig. 90.199 top). Some cylindrical cells and pseudohyphae may be present.

Dalmau plate culture on corn meal agar: After 7 days at 25°C, pseudohyphae consist of branched chains of long, cylindrical cells with small verticils of ovoid blastoconidia (Fig. 90.199 bottom) and septate hyphae may be present. Aerobic growth is off-white to chalky-white, dull, dry to powdery, smooth, butyrous, lacy to wrinkled and with a hyphal edge.

Fermentation

Glucose	+	Lactose	–
Galactose	s	Raffinose	–
Sucrose	v	Trehalose	+/s
Maltose	+		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+

Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	D-Lactate	s
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	w	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	w
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	–/w	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	v	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	–/w
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	+
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	+

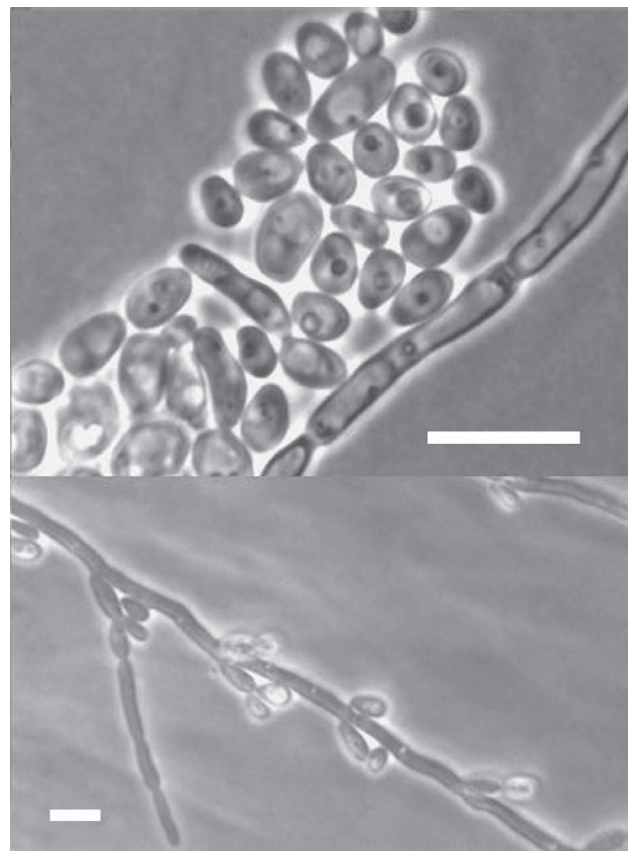


FIGURE 90.199 *Candida viswanathii* CBS 4024. Budding cells and pseudohypha after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μm.

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 46.3, CBS 4024 (T_m : Meyer and Phaff 1972); 45.6, one strain (T_m : Nakase and Komagata 1971g); 45.9, CBS 4024; 45.6, CBS 1924 (T_m : Duncan and S.A. Meyer, unpublished data).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45752.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 4024, isolated from cerebrospinal fluid, India; CBS 1924, type strain of *C. lodderae*, from shrimp (*Penaeus setiferus*), from Gulf of Mexico; CBS 7923 (DBVPG 6732), type strain of *C. aquatextoris*, from sludge of textile industry wastewater treatment plant, Italy.

Other strain available: CBS 5362, isolated from Sputum in India, R.S. Sandha.

Type strain: CBS 4024.

Systematics: Sandhu and Randhawa (1962) validated the description of *C. viswanathii* upon isolating a second strain from sputum. The original strain had been recovered from a fatal case of meningitis. The authors noted a similarity with *C. albicans*, but differentiated the two species on the basis of hairy projections in the streak culture, the lack of formation of chlamydospores or clusters of spherical blastoconidia in the pseudohyphae, and the assimilation of β -glucosides. Kurtzman and Robnett (1997) found two nucleotide differences in the D1/D2 LSU rRNA gene sequences of the type strains of *C. viswanathii* and *C. lodderae*. Conspecificity was confirmed by F.-L. Lee et al. (1998), who reported DNA reassociation values of 91–100% in these taxa. Low values were obtained with three strains of *C. tropicalis*, including the type, as well as two strains previously labeled *C. tropicalis* (CBS 434) and *C. viswanathii* (CBS 2780). These strains were reidentified as *C. neerlandica* and *C. lyxosophila*, respectively. *C. aquatextoris* was described by Vallini et al. (1997) from a single isolate from the secondary settling tank of an industrial wastewater treatment plant (Corti et al. 1995). The strain had been first identified as *C. maltosa*, but differed by a few reactions and had the ability to assimilate some unusual phenolic compounds not utilized by *C. maltosa*. In particular, the toxic compound 4-(1-nonyl)phenol was broken down into 4-acetylphenol. DNA reassociation experiments later showed that the isolate was genetically distinct from the types of *C. maltosa*, *C. tropicalis* and *C. haemulonii*, for which reason it was described as a new species (Vallini et al. 1997). The close physiological similarity with *C. maltosa* was confirmed. As the sequence of the D1/D2 LSU rRNA gene was not available, it was determined in this study and found to match exactly that of *C. viswanathii*. A re-examination of the growth characteristics also revealed a strong similarity between the types of *C. aquatextoris* and *C. viswanathii*. Accordingly, they are treated as synonyms. Sequence analyses (Kurtzman and Robnett 1998a, Sugita and Nakase 1999) place *C. viswanathii* in the *Lodderomyces–Spathaspora* clade (Fig. 90.5).

The type strains of *C. viswanathii*, *C. lodderae* and *C. aquatextoris* were nearly identical in growth characteristics. Differences included growth on L-arabinose, xylitol and D-glucosamine and in the presence of 50% glucose. At variance with previous descriptions, lactic acid was utilized (slowly) by all strains, but L-sorbose was not. The species resembles its relatives in the clade, making differentiation on the basis of physiology difficult. Growth on cellobiose and starch, and the absence of growth on L-sorbose are the most useful tests. Separation from *C. tropicalis* is particularly problematic, although F.-L. Lee et al. (1998) reported differences in maximum growth temperature that should be further explored.

Ecology: The natural habitat of *C. viswanathii* is not known, but an opportunistic association with animals is likely in view of the origin of some isolates as well as the ability to growth at 37°C and to excrete lipase.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: An opportunistic association with animals is likely in view of the origin of some isolates as well as the ability to grow at 37°C and to excrete lipase.

90.307. *Candida wickerhamii* (Capriotti) S.A. Meyer & Yarrow (Yarrow and Meyer 1978)

Phylogenetic placement: *Nakazawaea* clade (Figs 51.1, 90.4).

Synonym:

Torulopsis wickerhamii Capriotti (1958g)

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are globose to subglobose, 3–4.5 $\times$ 3–4.5 μ m, and occur singly and in pairs (Fig. 90.200).

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae are absent. Aerobic growth is off-white to cream colored, smooth, soft and has an entire margin.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	v
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	–	Ethanol	s
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	v	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl- α -D-glucoside	–	D-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	v
L-Sorbose	–	D-Glucosamine	v
L-Rhamnose	w	N-Acetyl-D-glucosamine	+
D-Xylose	s	Hexadecane	–
L-Arabinose	w	Nitrate	+
D-Arabinose	v	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	v	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono- δ -lactone	+	Casein	w/–
Amino acid-free	+	Lipase	–
Nitrite	+	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: 7 (Suzuki and Nakase 1998).

Mol% G + C: 38.1, CBS 2928 (T_m : Meyer et al. 1984).

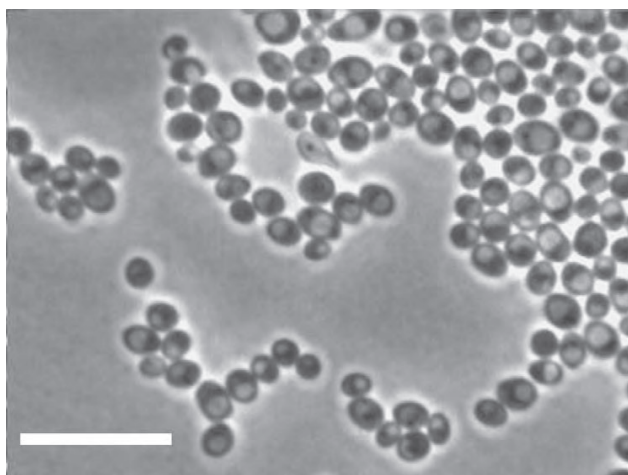


FIGURE 90.200 *Candida wickerhamii* CBS 2928. Budding cells after 3 days, 25°C, YM agar. Bar = 10 μ m.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U70243.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 2928, isolated from silage, Italy; CBS 5379, from alpechin, Spain.

Other strain available: CBS 6395, from insect tunnels in timber, South Africa.

Type strain: CBS 2928.

Systematics: Capriotti (1958g) described *Torulopsis wickerhamii* based on 22 isolates recovered from silage made of olive husks, molasses and whey. The species differed from similar members of the genus by a few growth characteristics, in particular the assimilation of nitrate. Analysis of rRNA and other gene sequences placed *C. wickerhamii* in a small clade with *Nakazawaea (Pichia) holstii* and some *Candida* species such as *C. populi* (Kurtzman and Robnett 1998a, 2010, Suzuki and Nakase 2002).

The two strains examined did not grow vigorously when studied by replica plating, giving weak or negative reactions on L-rhamnose, D-arabinose, D-ribose and citric acid, which were previously reported as positive. The growth profile is similar to the profiles of *C. wyomingtonensis*, *C. norvegica* and *C. zeylanoides*, although the utilization of galactose, D-xylose and glucono- δ -lactone, and the lack of growth on trehalose and nitrate can be used for separation.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: *Candida wickerhamii* is of particular interest due to its ability to ferment cellodextrins through a cell-bound β -glucosidase. Skory and Freer (1995) cloned a gene thought to code for this enzyme and found the sequence to be unique among known iso-functional enzymes. Ciafardini and Zullo (2002) found that the disappearance of the bitter compound oleuropein in fresh olive oil is probably due to the β -glucosidase activity of contaminant yeasts. Cell numbers were 10^4 cfu/ml in fresh oil and over 10^5 per gram of sediment, and consisted of *Saccharomyces cerevisiae* and *C. wickerhamii* in a 2:1 ratio. The count declined progressively over 150 days. The absence of lipolytic activity in both species was interpreted as an indication that the yeasts are not agents of spoilage. Both species were reported to exhibit β -glucosidase activity, but in view of the lack of growth of *S. cerevisiae* on β -glucosides, one can only assume that *C. wickerhamii* plays a more important function in the process.

Clinical importance: Unknown.

90.308. *Candida wounanorum* S.-O. Suh & M. Blackwell (Suh et al. 2004b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5). (The description is based on Suh et al. 2004b.)

Growth on YM agar: After 7 days at 25°C, colonies are off-white, butyrous, smooth, but with fuzzy white spots.

Growth in YM broth: After 7 days at 25°C, cells are globose to ovoid, 2–4 $\times$ 3–6 μ m, mostly subglobose and occur singly, in pairs or in short chains.

Dalmay plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae are absent.

Fermentation

Glucose	s	Lactose	–
Galactose	w	Raffinose	–
Sucrose	–	Trehalose	s
Maltose	–	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	w	myo-Inositol	–
Methyl- α -D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	s
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	–
L-Sorbose	n	D-Glucosamine	s
L-Rhamnose	n	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	50% Glucose	w
2-Keto-D-gluconate	+	10% NaCl/5% glucose	+
D-Glucuronate	–	Starch formation	–
Arbutin	+	Urease	–
Propane 1,2 diol	–	DBB	–
Butane 2,3 diol	–	Cycloheximide 0.01%	–
DBB	–	Cycloheximide 0.1%	–
Cadaverine	+	Growth at 25°C	+
Creatinine	–	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	–
Ethylamine	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY309813, SSU rRNA = AY426957.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27574 (CBS 9828), isolated from the gut of a erotyloid beetle (*Mycotretus dorsonotatus*, Erotyliidae) on a corticioid fungus, Barro Colorado Island, Panama (Suh et al. 2004b).

Type strain: NRRL Y-27574.

Systematics: Phylogenetic analysis of the D1/D2 LSU and SSU rRNA genes placed *C. wouanorum* in the *Candida tanzawaensis* clade, in which it clusters together with *C. emberorum*, *C. chickasaworum*, *C. yuchorum* and with *C. terraborum* as a basal lineage (Suh et al. 2004b).

Ecology: *Candida wouanorum* is known only from the gut of a beetle in Panama (Suh et al. 2004b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.309. *Candida wyomingensis* Kurtzman (2000b)

Phylogenetic placement: *Nakazawaea* clade (Fig. 90.4).

(Some of the morphological characteristics are based on Kurtzman 2000b.)

Growth on 5% malt extract agar: After 3 days at 25°C, the cells are spherical, 2–6 µm, to ellipsoidal, 1.5–5 × 2–7 µm, occur singly and in pairs and reproduce by multilateral budding (Fig. 90.201). Growth is tannish-white, glistening and mucoid.

Growth on the surface of assimilation media: Pellicles are not formed.

Dalmau plate culture on morphology agar: After 7 days at 25°C, neither pseudohyphae nor true hyphae are formed under the cover-glass. Aerobic growth is tannish-white, glistening, mucoid and with an entire margin.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	v
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	v
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D,L-Lactate	v
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	+
L-Rhamnose	+	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	–
L-Arabinose	–	Nitrate	+
D-Arabinose	+	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	v	DBB	–
D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	–	Casein	–

Amino acid-free	+	Lipase	–
Nitrite	s	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+
Cadaverine	+	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	–	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AF153673.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 8703 (NRRL YB-2152), sap of trembling aspen (*Populus tremuloides*, Salicaceae), Wyoming, USA; UWOPS 91-127 and UWOPS 92-9.4, from sap fluxes of red oak (*Quercus rubra*, Fagaceae), Ontario, Canada.

Other strains available: NRRL YB-2199 and two others, from freshwater; NRRL YB-3068 and one other, from bark of trembling aspen; all from Wyoming, USA.

Type strain: CBS 8703.

Systematics: Kurtzman (2000b) described *C. wyomingensis* from six strains recovered by L.J. Wickerham from various sources in Wyoming. The strains diverged by nine substitutions from that of *C. wickerhamii* in the D1/D2 LSU rRNA gene sequence. These strains and other species have an affinity to *Nakazawaea* (*Pichia*) *holstii*.

Assessment of the type culture by replica plating gave results that were nearly identical to those in the original description, with a few exceptions. The results presented here are based on the three authentic strains examined, including the type. The utilization of 2-keto-D-gluconate varied between strains, which is unusual. The assimilation of ribitol also varied. *C. wyomingensis* is easily recognized from similar species by its ability to utilize L-rhamnose but not galactose.

Ecology: The species is probably associated with insects that breed or feed in sap fluxes of trees.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

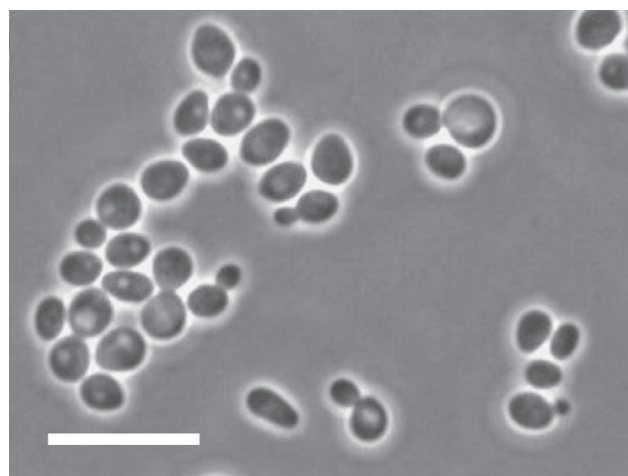


FIGURE 90.201 *Candida wyomingensis* CBS 8703. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

90.310. *Candida xylopsoci* Kurtzman (2001b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5). (Some of the morphological characteristics are based on Kurtzman 2001b.)

Growth on 5% malt extract agar: After 3 days at 25°C, yeast cells are spherical, 2.5–7 µm, to elongate, 1.5–7 × 2–21 µm, occur singly or in pairs and reproduce by multilateral budding with 1–2 buds per cell, usually formed near the poles of the cell (Fig. 90.202 top). Cells occasionally form small denticles that bear blastoconidia. Cells with inflated spherical tip cells are common. Colonies are tannish-white, dull, butyrous, but with pseudohyphal margins.

Dalmau plate culture on yeast morphology agar: After 7 days at 25°C, growth under the coverglass shows abundant branched pseudohyphae, but few blastoconidia (Fig. 90.202 bottom). True hyphae were not observed, but many of the pseudohyphal filaments have robust, sparingly constricted septa. Aerobic growth is dull, tannish-white and with a texture that ranges from butyrous to hyphal. Colonies are low convex with finely convoluted margins.

Fermentation

Glucose	w	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	w
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	v	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	–	D-Gluconate	+
L-Sorbose	–	D-Glucosamine	+
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	+	Hexadecane	+
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	+

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Glucuronate	–	Gelatin	w
Glucono-δ-lactone	+	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	–
L-Lysine	+	Cycloheximide 0.1%	–
Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

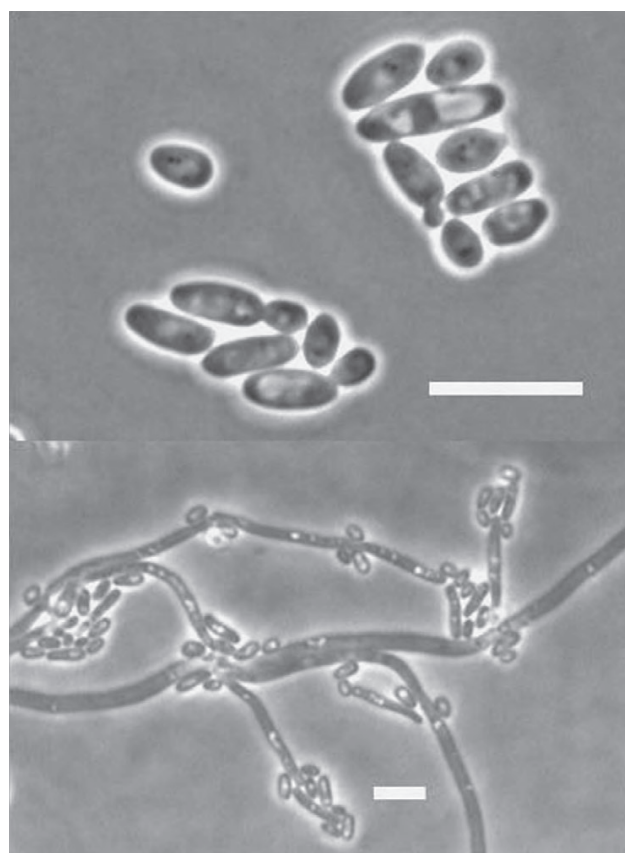


FIGURE 90.202 *Candida xylopsoci* CBS 6037. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 µm.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY013719.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 6037 (NRRL Y-27066), isolated from tunnels of a false powder-post beetle (*Xylopsocus capucinus*, Coleoptera: Bostrichidae) in white stinkwood (*Celtis africana*, Ulmaceae), South Africa.

Type strain: CBS 6037.

Systematics: Kurtzman (2001b) described *C. xylopsoci* from a strain recovered from tunnels of a false powder-post beetle. The species is part of a small clade of yeasts related to *C. tanzawaensis* (Fig. 90.5).

The physiological profile determined by replica plating differed from the original description by the assimilation of trehalose, ribitol and lactic acid, and the lack of growth on salicin and hexadecane. A weak reaction was obtained for gelatin hydrolysis, and fermentation was complete in 1 week. The growth characteristics resemble those of many other species. A combination of growth on D-xylose, 2-keto-D-gluconic acid and N-acetyl-D-glucosamine, growth at 37°C and in the absence of vitamins, and the absence of growth on erythritol or in the presence of 0.01% cycloheximide can be used for separation.

Ecology: Like other members of the *C. tanzawaensis* clade, *C. xylopsoci* appears to be involved in a symbiotic association with beetles involved in fungal decay of trees (Kurtzman 2001b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.311. *Candida yuanshanicus* Lee & Liu (Liu et al. 2008)

Phylogenetic placement: *Wickerhamomyces* clade; see Systematics. (The description is based on Liu et al. 2008.)

Growth on YM agar: After 7 days at 25°C, the streak culture is creamy, butyrous, smooth, glistening and has an entire margin.

Growth in YM broth: After 3 days at 25°C, the cells are globose to ovoid, 2–5 × 2–6 μm, reproduce by multilateral budding and occur singly or in pairs. Sediment is present.

Dalmat plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and hyphae are absent.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	–
Sucrose	–	Trehalose	–
Maltose	–		

Growth (Media not Indicated)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	–
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	s	D-Mannitol	w
Maltose	+	D-Glucitol	–
Melezitose	+	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	+	Citrate	s
Salicin	+	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	w
L-Rhamnose	–	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	–
D-Arabinose	–	Vitamin-free	n

Additional Growth Tests and Other Characteristics

Xylitol	w	50% Glucose	–
2-Keto-D-gluconate	–	10% NaCl/5% glucose	–
5-Keto-D-gluconate	–	Starch formation	–
D-Glucuronate	–	Urease	–
Propane 1,2 diol	+	DBB	–
Butane 2,3 diol	+	Cycloheximide 0.01%	–
Nirite	–	Growth at 30°C	+
Cadaverine	–	Growth at 35°C	+
Creatinine	–	Growth at 37°C	+
L-Lysine	+	Growth at 40°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = EF460670.

Cell carbohydrates: Not determined.

Origin of the strain studied: SY3S02 (BCRC 23100, CBS 10589, NBRC 102648), isolated in 2006 from forest soil in Yuanshan, Ilan, Taiwan (Liu et al. 2008).

Type strain: SY3S02.

Systematics: Phylogenetic analysis of the D1/D2 domains of the LSU rRNA gene placed *C. yuanshanicus* in a clade with *Wickerhamomyces onychis* and *C. dajiaenensis* (Liu et al. 2008).

Ecology: *Candida yuanshanicus* is only known from forest soil in Taiwan (Liu et al. 2008).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.312. *Candida yuchorum* S.-O. Suh & M. Blackwell (Suh et al. 2004b)

Phylogenetic placement: *Candida tanzawaensis* clade (Fig. 90.5). (The description is based on Suh et al. 2004b.)

Growth on YM agar: After 7 days at 25°C, colonies are cream colored, smooth, shiny and with a filamentous margin.

Growth in YM broth: After 7 days at 25°C, cells are globose to ellipsoidal, 2.5–7 × 2.5–7 μm, mostly globose or subglobose, occur singly, in pairs or in short chains and pseudohyphae and septate hyphae may be present.

Dalmat plate culture on corn meal agar: After 10 days at 25°C, pseudohyphae and septate hyphae may be present. Aerobic growth is white and dull.

Fermentation

Glucose	+	Lactose	–
Galactose	s	Raffinose	–
Sucrose	–	Trehalose	+
Maltose	–	D-Xylose	–

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	–
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	+	Ribitol	+
Lactose	–	Galactitol	–
Trehalose	+	D-Mannitol	+
Maltose	+	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	+	DL-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	+	Citrate	+
Salicin	+	D-Gluconate	s
L-Sorbose	n	D-Glucosamine	–
L-Rhamnose	n	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	50% Glucose	+
2-Keto-D-gluconate	+	10% NaCl/5% glucose	+
D-Glucuronate	–	Starch formation	–
Arbutin	+	Urease	–
Propane 1,2 diol	–	DBB	–
Butane 2,3 diol	–	Cycloheximide 0.01%	–
Nitrite	–	Cycloheximide 0.1%	–
Cadaverine	+	Growth at 25°C	+
Creatinine	–	Growth at 30°C	+
L-Lysine	+	Growth at 35°C	+
Ethylamine	+	Growth at 40°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY242278, SSU rRNA = AY242169.

Cell carbohydrates: Not determined.

Origin of the strain studied: NRRL Y-27569 (CBS 9829), isolated from the guts of a fungus beetle (*Tritoma atriventris*, Erotylidae) on a mushroom (*Lepiota* sp.), Athens, Georgia, USA (Suh et al. 2004b)

Type strain: NRRL Y-27569.

Systematics: Phylogenetic analysis of the SSU and D1/D2 LSU rRNA gene sequences placed *C. yuchorum* in the *Candida tanzawaensis* clade, in which it clusters with *C. wouwanorum*, *C. emberorum*, *C. chickasaworum* and with *C. terraborum* as a basal lineage (Suh et al. 2004b).

Ecology: *Candida yuchorum* is known only from the guts of a fungus beetle in Georgia, USA (Suh et al. 2004b).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

90.313. *Candida zemplinina* Sipiczki (2003)

Phylogenetic placement: *Starmerella* clade (Fig. 71.1).

(Some of the morphological characteristics are based on Sipiczki 2003.)

Growth on morphology agar: After 3 days at 25°C, cells are ellipsoid to elongated, 2–3 × 3–5 µm, occur singly and in pairs and budding is multilateral (Fig. 90.203). After 7 days at 25°C, colonies are low, butyrous and the margins smooth to finely lobed.

Dalmay plate culture on corn meal agar: After 2 weeks at 18°C, pseudohyphae and true hyphae are not formed.

Fermentation

Glucose	+	Lactose	–
Galactose	–	Raffinose	+
Sucrose	+	Trehalose	n
Maltose	–		

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	v	Ethanol	–
Raffinose	v	Glycerol	–
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	–
Lactose	–	Galactitol	–
Trehalose	–	D-Mannitol	–
Maltose	–	D-Glucitol	–
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	DL-Lactate	–
Soluble starch	–	Succinate	–
Cellobiose	–	Citrate	–
Salicin	–	D-Gluconate	–
L-Sorbose	–	D-Glucosamine	–
L-Rhamnose	–	N-Acetyl-D-glucosamine	–
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	v	DBB	–

D-Glucuronate	–	Gelatin	–
Glucono-δ-lactone	–	Casein	–/w
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	–	Cycloheximide 0.01%	–
L-Lysine	w/s	Cycloheximide 0.1%	–
Cadaverine	–	1% Acetic acid	–
10% NaCl	–	Growth at 30°C	+
50% Glucose	s	Growth at 37°C	–/w

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession number, type strain: D1/D2 LSU rRNA = AY160761.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 9494, isolated from white wine, Hungary; CBS 4729, from fruit fly (*Drosophila pinicola*), H.J. Phaff; UWOPS 83-775.2, from fruit of prickly pear (*Opuntia stricta*, Cactaceae), Bahamas; UWOPS 88-15 and two others, from grape must, Ontario, Canada; UWOPS 91-743.1, from fruit fly (*Drosophila* sp.) on soapberry (*Sapindus saponaria*, Sapindaceae), Hawai'i, USA; UWOPS 07-402.2, on decaying osage orange (*Maclura pomifera*, Moraceae), Ontario, Canada.

Type strain: CBS 9494.

Systematics: Sipiczki (2003) described *C. zemplinina* to accommodate four isolates that were representative of highly osmotolerant strains found in botrytized Tokaj wine fermentations. These strains, which had previously been assumed to be representatives of *C. stellata*, were found to grow more vigorously in the presence high glucose concentrations. Analysis of rRNA gene sequences revealed that the two species differ at 39 positions (37 substitutions and 2 gaps) in the D1/D2 LSU rRNA gene and 46 positions in the ITS/5.8S region. The species is a member of the *Starmerella sensu stricto* clade (Fig. 71.1).

Candida zemplinina is physiologically similar to *C. stellata* and *C. lactis-condensi* except for the lack of growth on nitrate and a weaker growth on L-lysine as nitrogen sources. Note that the original description reported growth on L-lysine to be negative. Three strains isolated from grape must in the Niagara region (Holloway et al. 1992) were unusual by their ability to utilize 2-keto-D-gluconate, to grow weakly at 37°C and to form pseudohyphae. Initially identified as *C. stellata*, they were reassigned to *C. zemplinina* based on D1/D2

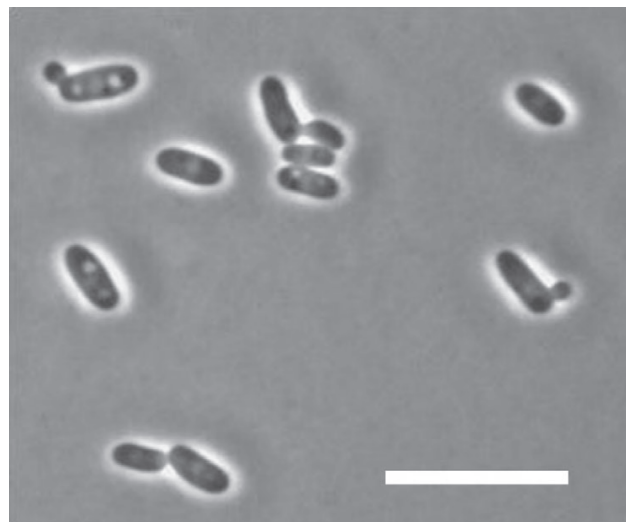


FIGURE 90.203 *Candida zemplinina* CBS 9494. Budding cells after 3 days, 25°C, YM agar. Bar = 10 µm.

sequences determined in this study. CBS 4729 was reassigned by CBS staff from *C. stellata* to *C. zemplinina*, also based on sequence analyses.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: The strains studied by Holloway et al. (1992) were representative of an abundant species found in a fermenting Riesling must (Holloway et al. 1990). The yeast persisted until the fermentation reached completion, at which time the alcohol concentration was measured at 7.4% and the density of most other yeast species had declined to a low value. A strain that differed from the type by only two nucleotides in the D1/D2 region was observed in a wine fermentation from botrytized grapes in California (Mills et al. 2002). The strain, designated EJ1, was found to persist through most of the fermentation, unlike other “wild” yeasts. The persistence of the strain was attributed to its highly fructophilic nature. The yeast was eventually overshadowed by *Saccharomyces cerevisiae*. Sipiczki (2003) also identified an unusual ability to grow vigorously in the presence of 60% glucose and of 8% ethanol and at lower temperatures (10°C) as important properties affecting the occurrence of the species in botrytized grape must.

Clinical importance: Unknown.

90.314. *Candida zeylanoides* (Castellani) Langeron & Guerra (1938)

Phylogenetic placement: Kurtzman *clade* (Figs 40.1, 90.2).

Synonyms:

Monilia zeylanoides Castellani (1920)

Mycotorula zeylanoides (Castellani) Redaelli & Ciferri (Ciferri and Redaelli 1935)

Parendomyces zeylanoides (Castellani) Dodge (1935)

Pseudomonilia zeylanoides (Castellani) Dodge & Moore (1936)

Azymocandida zeylanoides (Castellani) Novák & Zsolt (1961)

Cryptococcus macroglossiae Castellani (1925)

Monilia macroglossiae Castellani (1925)

Torulopsis macroglossiae (Castellani) Castellani & Jacono (1933)

Mycocandida macroglossiae (Castellani) Redaelli & Ciferri (Ciferri and Redaelli 1935)

Blastodendron macroglossiae (Castellani) Langeron & Guerra (1935)

Parendomyces macroglossiae (Castellani) Dodge (1935)

Monilia zeylanoides Castellani var. *macroglossiae* Castellani (1937a)

Cryptococcus uvae Pollacci & Nannizzi (Motta 1926)

Monilia uvae (Pollacci & Nannizzi) Vuillemin (1931)

Torulopsis uvae (Pollacci & Nannizzi) Lodder (1934)

Syringospora uvae (Pollacci & Nannizzi) Dodge (1935)

Blastodendron von Szilvinyi (1934)

Monilia parazyloides Castellani (1937a)

Pichia dubia Dietrichson (1954)

Trichosporon piscium Siepmann (Siepmann and Höhnk 1962)

Candida iberica C. Ramírez & C. González (1972)

Candida krissii S. Goto & Iizuka (Goto et al. 1974)¹

¹ Synonymy is based on rDNA sequence analysis (Kurtzman and Robnett 1997, Sugita and Nakase 1999, and this study).

Growth in glucose–yeast extract–peptone broth: After 3 days at 25°C, the cells are ovoid to elongate, 2.5–7 × 4–10 μm, and occur singly, in pairs and short chains (Fig. 90.204 top). After 1 month a pellicle may be present.

Dalmau plate culture on corn meal agar: After 14 days at 25°C, pseudohyphae consist of branched chains of cylindrical cells, often with verticils of ovoid blastoconidia (Fig. 90.204 bottom). Aerobic growth is off-white to cream colored, shiny, smooth to wrinkled and entire, undulating or fringed.

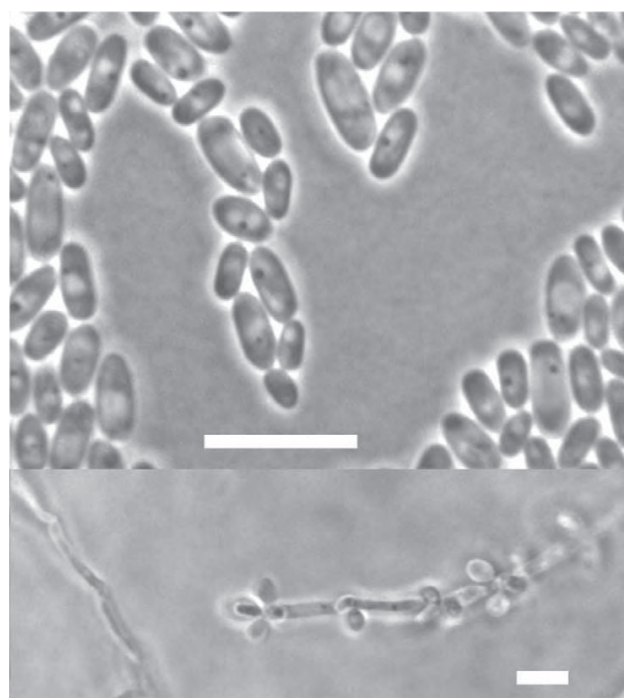


FIGURE 90.204 *Candida zeylanoides* CBS 619. Budding cells after 3 days, 25°C, YM agar (top) and pseudohyphae after 14 days, 18°C, YCBAS agar (bottom). Bars = 10 μm.

Fermentation: Absent.

Growth (on Agar)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	–	Ethanol	–/w
Raffinose	–	Glycerol	+
Melibiose	–	Erythritol	–
Galactose	–	Ribitol	v
Lactose	–	Galactitol	–
Trehalose	v	D-Mannitol	+
Maltose	–	D-Glucitol	+
Melezitose	–	myo-Inositol	–
Methyl-α-D-glucoside	–	D,L-Lactate	–
Soluble starch	–	Succinate	+
Cellobiose	v	Citrate	v
Salicin	s	D-Gluconate	v
L-Sorbose	s	D-Glucosamine	v
L-Rhamnose	–	N-Acetyl-D-glucosamine	+
D-Xylose	–	Hexadecane	–
L-Arabinose	–	Nitrate	–
D-Arabinose	–	Vitamin-free	–

Additional Growth Tests and Other Characteristics

Xylitol	–	Starch production	–
2-Keto-D-gluconate	+	DBB	–
D-Gluconate	–	Gelatin	–
Glucono-δ-lactone	v	Casein	–
Amino acid-free	+	Lipase	–
Nitrite	–	Acid production	–
Ethylamine	+	Cycloheximide 0.01%	+
L-Lysine	+	Cycloheximide 0.1%	+

Cadaverine	+	1% Acetic acid	–
10% NaCl	+	Growth at 30°C	+
50% Glucose	v	Growth at 37°C	–

CoQ: 9 (Yamada and Kondo 1972a).

Mol% G + C: 57.6, CBS 619 (T_m : Stenderup and Bak 1968); 54.5, two strains (T_m : Nakase and Komagata 1968); 55.9, ATCC 7351 (CBS 619); 54.7, AJ 4741 (T_m : Nakase and Komagata 1971f); 43.4, CBS 6519 (T_m : Meyer et al. 1984).

Gene sequence accession number, type strain: D1/D2 LSU rRNA = U45832.

Cell carbohydrates: Glucose and mannose are present in whole-cell hydrolysates (Suzuki and Nakase 1998).

Origin of the strains studied: CBS 619, neotype, Diddens and Lodder 1942, p. 304, isolated from blastomycotic macroglossia, Sri Lanka; CBS 6519, type strain of *C. krissii*, from seawater, Pacific Ocean.

Other strains available: CBS 641 and CBS 2328, from chilled beef, Australia; CBS 947, from human throat; CBS 2000, from sputum, Norway; CBS 2326, from dog's skin, Austria; CBS 2329, origin unknown; CBS 4909, from seawater, Florida; CBS 5122, from human skin, Germany; CBS 5262, from skin of blue dolphin, Atlantic Ocean; CBS 5446, 5447, from winter salami, Croatia; CBS 5718, from red clover, Canada; CBS 6134, 6135, from human feces, Finland; CBS 6165, from human, Finland; CBS 6391, 6408, 6409, 6410, 6411, all from sausages, Spain.

Type strain: CBS 619.

Systematics: *Candida krissii* and *C. zeylanoides* have identical sequences in the D1/D2 LSU rRNA gene (Kurtzman and Robnett 1997) and their SSU sequences differ by a single base (Sugita and Nakase 1999), indicating possible conspecificity. The ITS/5.8S rDNA gene (AY542871) sequences of the two type strains were determined and found to be identical as well. Lopandic et al. (2001) reported differences in RAPD-PCR profiles generated with five arbitrary primers and considered the type strains to represent different species. As the significance of such differences is unknown, and in view of the identity of rRNA gene sequences and the similarity in growth characteristics, the only known strain of *C. krissii* is treated as a member of *C. zeylanoides*. Sequence analyses further indicate a connection with *Debaryomyces hansenii* and related species. CBS 1922, isolated from sputum in Norway, was transferred to *C. norvegensis* on the basis of D1/D2 sequences.

In the description of *C. krissii*, Goto et al. (1974) noted some similarities with *Trichomonascus (Candida) ciferrii* and *C. diddensiae*, but found them sufficiently different to consider them separate species. However, the utilization of sugars reported in the original description was at considerable variance with the results obtained by replica plating or those given by Meyer et al. (1998). In this study, the two type strains were found to be generally similar, but to differ in the assimilation of trehalose, ethanol, citric acid, D-gluconic acid and glucono- δ -lactone, as well as growth in the presence of 50% glucose. Several of these characteristics were reported as variable by Meyer et al. (1998), where they were based on the examination of many more strains.

Ecology: The ITS sequence of *C. zeylanoides* (AY542871) differs by only one substitution from a sequence deposited in GenBank (AF035675) under the label *Lacazia loboi* (syn. *Loboa loboi*) and obtained from direct amplification of material in lesions of a diseased bottlenose dolphin. This casts doubt on the suggestion that the DNA belonged to *Cladosporium sphaerocarum*, as suggested by Haubold et al. (1998). The putative agent of the infection is thought to be the authentic *Lacazia loboi*, an unrelated dimorphic mold in the order Onygenales (Herr et al. 2001). Taken together with the known

sources of isolation of *C. zeylanoides*, an association with warm-blooded animals, including marine species, is probable.

Biotechnology: Unknown.

Agriculture and food: *Candida zeylanoides* is often found in animal food products. Some recent examples include the report by Ismail et al. (2000) that the species is a major contaminant in refrigerated poultry meat products and the occasional finding by Suzzi et al. (2003) of the species in Manteca, a buttery whey cheese produced in southern Italy.

Clinical importance: The list of isolation sources includes a few specimens of clinical origin, suggesting that *C. zeylanoides* might act as an opportunistic pathogen. In a review of rare and emerging *Candida* species of clinical significance, Johnson (2009) listed *C. zeylanoides* among species that occur at a moderate frequency.

COMMENTS ON THE GENUS

The history of *Candida* is rich and complex. A glance at the list of synonyms for *C. albicans* or *C. tropicalis* will convince the reader that a proper nomenclatural account of the genus would be inordinately large. The first description of a *Candida* species is attributed to Bonorden, who in 1851 formalized the much older name *Monilia* (Donk 1963). However, whether or not *Monilia candida* has any real connection to the contemporary *Candida tropicalis* remains an open question. Other *Monilia* species included molds, some with zygomycetous affinities. Transfer of species that are truly yeasts into a separate genus (*Candida*) is owed to Berkhout's doctoral thesis (1923), but the latter was never published. Berkhout's concept of *Candida* was recognized by Diddens and Lodder (1939) but disputed by Mackinnon and Artagaveytia-Allende (1945), who stated that the correct name should be *Syringospora*. Donk (1963) proposed the conservation of the name *Monilia* to accommodate *M. cinerea* and a few similar fruit pathogens. The name *Monilia* is still in use for some of those species, but several others are also found in the literature and Donk's type is now called *Botrytis cinerea*. To complicate matters, the name *Monilia albicans* is still employed on occasion in the medical literature. Barnett (2004), in his history of research on yeast taxonomy, reviewed some of the highlights, reaching the conclusion that the correct name of the genus is probably *Pseudomonilia*, although he fell short of making a formal proposal to that effect. As did a few others, he chastised Yarrow and Meyer (1978) for enlarging the genus *Candida* by eliminating the genus *Torulopsis*. However, a retrospective examination of the phylogenetic distribution of pseudohypha formation, the criterion used to separate *Torulopsis* from *Candida* species, shows that the retention of two genera was not tenable. Although non-pseudohyphal species predominate in the *Starmerella* (Fig. 71.1) and *Wickerhamiella* (Fig. 79.1) clades (Fig. 90.3), species formerly assigned to *Torulopsis* are also interspersed among members of the Saccharomycetaceae and neighboring clades (e.g., *C. glabrata*), the *Metschnikowia* clade (e.g., *C. mogii*) or the *Pichia* clade (e.g., *C. inconspicua*), as shown in Fig. 90.1, as well as the *Nakazawaea* clade (e.g., *C. anatomiae*) or the *Ogataea* clade (e.g., *C. pini*), as shown in Fig. 90.4.

The genus *Candida* is a highly polyphyletic taxon made up of yeast species that exhibit clear ascomycetous affinities but do not form ascospores. As DNA sequence analysis now allows us to estimate anamorph–teleomorph connections, it is possible to formulate hypotheses as to the eventual assignment of many species to teleomorphic genera. One can even imagine a time when the genus will no longer serve a useful purpose. Among the various alternatives that could be examined, one would be to define teleomorphic genera purely on the basis of sequence-based phylogenies and assign

species to those genera regardless of their sexual life cycle. History often being the best predictor of the future, such a typological approach should be viewed with great unease. Past attempts to define taxa on anything but the whole organism have given rise to recurrent nomenclatural changes that reduce the usefulness of yeast taxonomy to its users. Another option would be to subdivide *Candida* into a number of smaller anamorphic genera based on sequence phylogenies, pending the discovery of their various teleomorphs. Broad application of such an approach would have the same devastating effect on continuity in the literature. Some compelling cases could be made for the transfer of certain *Candida* species to existing teleomorphic genera. For example, *Candida ipomoeae* is clearly a *Metschnikowia* species, strains of which give a mating response with some of its congeners, as is also the case for *Candida orba* and some species of the genus *Phaffomyces*. These species are heterothallic and fail to sporulate because complementary mating types have not been isolated. The description of several species that are undoubtedly members of the genus *Sporopachydermia* was deferred by Lachance et al. (2001c) in order to avoid their temporary description as *Candida* species. Many other cases are not so clear. The situation is exacerbated by the observation that phylogenetic inferences based on the analysis of short sequences or even a small number of genes are hypothetical and provisional. The five trees presented in this chapter (Figs 90.1 to 90.5) are a case in point. They are derived entirely from D1/D2 LSU rRNA gene sequences, because these are the only orthologues currently available for all known *Candida* species. A credible alignment of all these sequences simultaneously was nearly impossible because of the highly divergent nature of the variable domains. As a result, the deep branches of these trees are uncertain at best. To use these branchings to define phylogenetically based genera would eventually result in more rearrangements and more nomenclatural confusion.

More confusion would arise also from the frivolous lumping or splitting of species based purely on the indiscriminate application of a narrow criterion. Here, the underlying philosophy has been one of cautious conservatism. Except where the evidence was multifarious and overwhelming, sibling species bearing distinct epithets were kept separate provided that a clear basis for separation was available (e.g., *C. humilis* and *C. milleri*). Similarly, polymorphic taxa for which arguable splitting proposals had been put forward were kept intact (e.g., *C. albicans* and *C. africana*).

For the same reasons of nomenclatural continuity, the correction of incorrect orthography has been kept to a minimum. Latin experts differ in opinions, for example, on the matter of elision of *ae* and *oe* in the formation of epithets with the termination *-ensis*. The case of *Candida rancensis* is discussed explicitly for that species, but several other cases are not (e.g., *ontarioensis*, *tanzawaensis*). It is hoped that most journals that serve as a vehicle for the publication of species descriptions will scrutinize new names and epithets to prevent incorrect orthographies, but there is little to be gained by deliberately introducing orthographic variants. On the contrary, to do so would only result in reducing the efficiency of electronic literature searches.

Returning to the topic of phylogenies, a discussion of the trees is warranted. When possible, teleomorph connections were identified. In cases where trees presented in the discussions of teleomorphic genera contained all *Candida* species related to those genera, only a few representative teleomorphic species were retained in the trees included in the present chapter. Fig. 90.1 contains mostly representatives of some of the most divergent clades in the genus *Candida*. Note that for the *Metschnikowiaceae*, four species included in the tree (*C. gelsemii*, *C. ipomoeae*, *C. kipukae* and *C. rancensis*) are representative of a monophyletic assemblage that includes *Metschnikowia*

species. Two other species, *C. oregonensis* and *C. melibiosica*, are moderately related to *Clavispora* species. The species included in Fig. 90.2 are probably part of a monophyletic unit connected mostly with the traditional concept of the genus *Debaryomyces*. Fig. 90.3 regroups several orphan clades, a growing number of species with affinities in the *Sugiyamaella/Trichomonascus* clade as proposed by Kurtzman and Robnett (2007), and some recently described species with affinities with the genus *Yarrowia*. Fig. 90.4 comprises many species that would have fitted well within certain sections of the former genus *Hansenula* plus two species with affinities in the *Saccharomycopsidaceae*. Fig. 90.5 groups affiliates of the expanding *Lodderomyces–Spathaspora* clade, with species of major clinical interest, and those in the *C. tanzawaensis* and *C. kruisii* clades, both of which have recently exploded as a result of an accrued interest in yeasts found in the digestive tract of Coleoptera.

Species with firmly established anamorph–teleomorph connections were not listed in this chapter. In view of recent revisions to Article 59 of the International Code of Botanical Nomenclature, it was felt that the maintenance of two names when a teleomorph has been clearly identified is undesirable. Readers that know of a species only through the name of the anamorph will easily find the appropriate discussion by searching the index of species names or epithets.

Last is the matter of identification keys. Considerable variation exists between different laboratories in the results of growth tests. As the number of *Candida* species exceeds by nearly one order of magnitude the number of available tests, identification based on growth characteristics has become difficult at best and cannot be regarded as definitive. Researchers wishing to obtain a reliable identification should determine the sequence of the D1/D2 region of the large subunit rRNA gene and seek to obtain a match with a sequence whose accession number is included in the chapter.

SPECIES RECEIVED TOO LATE FOR INCLUSION IN THIS CHAPTER

- Candida abiesophila* Kurtzman (2006)
- Candida aechmeae* Landell & Valente (Landell et al. 2010)
- Candida alocasiicola* F.-Y. Bai & S.-A. Wang (Wang S.-A. and Bai. 2008)
- Candida andamanensis* Am-In, Limtong, Yongmanitchai & Jindamorakot (2010)
- Candida ascalaphidarum* N.H. Nguyen, S.-O. Suh & M. Blackwell (2007)
- Candida asiatica* Limtong, Kaewwichian, Am-In, Nakase & Lee (Limtong et al. 2010b)
- Candida auris* Satoh & Makimura (Saito et al. 2009b)
- Candida awuuii* Nielsen, Jakobsen & Jespersen (2010b)
- Candida blackwelliae* F.Y. Bai & Z.H. Ji (Ji et al. 2009)
- Candida blattae* N.H. Nguyen, S.-O. Suh & M. Blackwell (2007)
- Candida chanthaburiensis* Limtong & Yongmanitchai (2010)
- Candida chaulodes* N.H. Nguyen, S.-O. Suh & M. Blackwell (2007)
- Candida corydalis* N.H. Nguyen, S.-O. Suh & M. Blackwell (2007)
- Candida dosseyi* N.H. Nguyen, S.-O. Suh & M. Blackwell (2007)
- Candida golubevii* Rosa, Jindamorakot, Limtong, Nakase, Pagnocca & Lachance (2010)
- Candida hainanensis* F.-Y. Bai & S.-A. Wang (Wang S.-A. et al. 2008)
- Candida halmiae* Nielsen, Jakobsen & Jespersen (2010b)
- Candida hasegawae* Nakase, Jindamorakot, Limtong, Amin & Imanishi (Nakase et al. 2007b)
- Candida heveicola* F.-Y. Bai & S.-A. Wang (Wang S.-A. et al. 2008)

- Candida jaroonii* Imanishi, Jindamorakot, Nakagiri, Limtong & Nakase (Imanishi et al. 2008)
- Candida jiufengensis* F.Y. Bai & Z.H. Ji (Ji et al. 2009)
- Candida kashinagacola* Endoh, M. Suzuki, Benno & Futai (2008c)
- Candida kazuoi* Nakase, Jindamorakot, Limtong, Amin & Imanishi (Nakase et al. 2007b)
- Candida khaoyaiensis* Jindamorakot, Limtong, Yongmanitchai, Tuntirungkij, Potacharoen, Kawasaki & Nakase (2008)
- Candida kungkraensis* Limtong & Yongmanitchai (2010)
- Candida laemsonensis* Am-In, Limtong, Yongmanitchai & Jindamorakot (2010)
- Candida lignicola* Jindamorakot, Limtong, Yongmanitchai, Tuntirungkij, Potacharoen, Kawasaki & Nakase (2007b)
- Candida materiae* Barbosa, Cadete, Gomes, Lachance & Rosa (2009)
- Candida morakotiae* (*Lodderomyces* clade) Nakase, Jindamorakot, Ninomiya, Imanishi & Kawasaki (2009b)
- Candida musiphila* F.-Y. Bai & S.-A. Wang (Wang S.-A. et al. 2008)
- Candida nonsorbophila* Nakase, Jindamorakot, Am-In, Ninomiya, Kawasaki & Limtong (2009a)
- Candida olivae* Nisiotou, Panagou & Nychas (2010)
- Candida oxycetoniae* F.Y. Bai & Z.H. Ji (Ji et al. 2009)
- Candida parazyza* Lachance (Lachance et al. 2010)
- Candida phangngensis* Limtong, Yongmanitchai, Kawasaki & Seki (2008c)
- Candida prachuapensis* Nitiyon, Boonmak, Am-In, Jindamorakot, Kawasaki, Yongmanitchai et Limtong (2010)
- Candida pseudohaemulonii* Sugita, Takashima, Poonwan & Mekha (2006b)
- Candida pseudojiufengensis* F.Y. Bai & Z.H. Ji (Ji et al. 2009)
- Candida pseudovanderkliftii* Endoh, M. Suzuki, Benno & Futai (2008c)
- Candida ranongensis* Am-In, Limtong, Yongmanitchai & Jindamorakot (2010)
- Candida ratchasimensis* Jindamorakot, Limtong, Yongmanitchai, Tuntirungkij, Potacharoen, Kawasaki & Nakase (2008)
- Candida sanitii* Limtong, Am-In, Kaewwichian, Boonmak, Jindamorakot, Yongmanitchai, Srisuk, Kawasaki & Nakase (Limtong et al. 2010a)
- Candida saraburiensis* Nitiyon, Boonmak, Am-In, Jindamorakot, Kawasaki, Yongmanitchai et Limtong (Nitiyon et al. 2010)
- Candida sekii* Limtong, Am-In, Kaewwichian, Boonmak, Jindamorakot, Yongmanitchai, Srisuk, Kawasaki & Nakase (Limtong et al. 2010a)
- Candida songkhlaensis* Imanishi, Jindamorakot, Nakagiri, Limtong & Nakase (Imanishi et al. 2008)
- Candida suratensis* Limtong & Yongmanitchai (2010)
- Candida suwanaritii* Limtong, Am-In, Kaewwichian, Boonmak, Jindamorakot, Yongmanitchai, Srisuk, Kawasaki & Nakase (Limtong et al. 2010a)
- Candida thailandica* Jindamorakot, Limtong, Yongmanitchai, Tuntirungkij, Potacharoen, Kawasaki & Nakase (2007b)
- Candida vanderkliftii* Endoh, M. Suzuki, Benno & Futai (2008c)
- Candida vriesiae* Landell & Valente (Landell et al. 2010)
- Candida wancherniae* (sister to *M. agaves*) Nakase, Jindamorakot, Ninomiya, Imanishi & Kawasaki (2009b)

Geotrichum Link: Fries (1832)

G. Sybren de Hoog and Maudy Th. Smith

DIAGNOSIS OF THE GENUS

Asexual reproduction: Colonies are white, farinose or hairy, usually dry, and consist of true hyphae, which branch at broad or right angles, have rounded apices, and disarticulate into arthroconidia. Sympodially produced blastoconidia may also be present. Budding is absent. Chlamydospores may be formed. Septa have micropores.

Sexual reproduction: *Dipodascus* and *Galactomyces* represent the teleomorphic states of *Geotrichum*.

Physiology/biochemistry: Fermentation is often absent. D-Xylose is assimilated. Nitrate is not assimilated. Extracellular starch is not produced. The diazonium blue B reaction is negative. Small subunit rRNA gene sequences are without deletions.

Phylogenetic placement: Saccharomycetales. *Geotrichum* and its teleomorphic states *Dipodascus* and *Galactomyces* are sister genera to *Magnusiomyces* and its anamorphic state *Saprochaete* (Figs 13.1, 91.1).

TYPE SPECIES

Geotrichum candidum Link: Fries

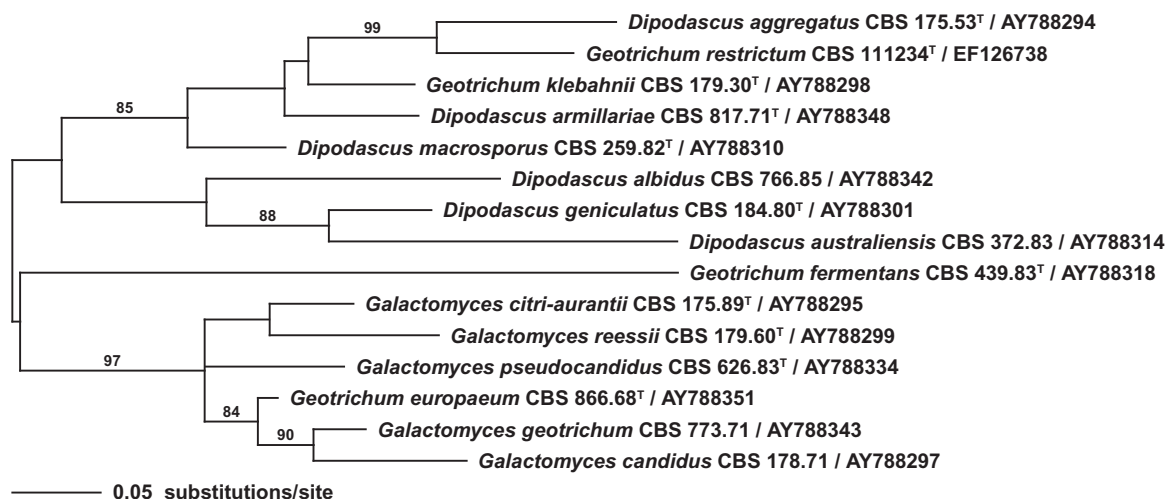


FIGURE 91.1 Phylogenetic tree showing the relationship of species of the genus *Geotrichum* and its teleomorphic genera *Dipodascus* and *Galactomyces* determined from maximum likelihood analysis of ITS sequences using RaxML (Stamatakis et al. 2008). Bootstrap values (>80%) are from 1000 replicates. GenBank accession numbers follow strain numbers.

SPECIES ACCEPTED

1. *Geotrichum candidum* Link: Fries (1832)
2. *Geotrichum carabidarum* S.-O. Suh & M. Blackwell (2006)
3. *Geotrichum citri-aurantii* (Ferraris) E.E. Butler (1988)
4. *Geotrichum cucujoidarum* S.-O. Suh & M. Blackwell (2006)
5. *Geotrichum decipiens* (L.R. Tulasne & C. Tulasne) W. Gams (1983)

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