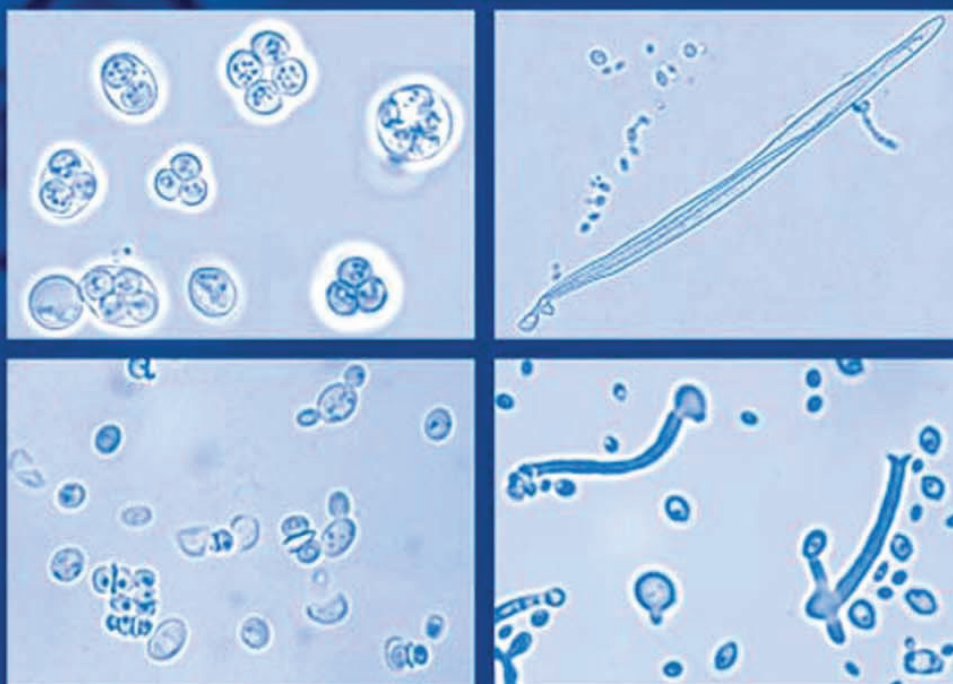




THE YEASTS

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



ELSEVIER

Amsterdam • Boston • Heidelberg • London • New York • Oxford
Paris • San Diego • San Francisco • Singapore • Sydney • Tokyo

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

Copyright © 2011 Elsevier B.V. All rights reserved

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.

No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means electronic, mechanical, photocopying, recording or otherwise without the prior written permission of the publisher. Permissions may be sought directly from Elsevier's Science & Technology Rights Department in Oxford, UK: phone (+44) (0) 1865 843830; fax (+44) (0) 1865 853333; email: permissions@elsevier.com. Alternatively, visit the Science and Technology Books website at www.elsevierdirect.com/rights for further information

Notice

No responsibility is assumed by the publisher for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions or ideas contained in the material herein. Because of rapid advances in the medical sciences, in particular, independent verification of diagnoses and drug dosages should be made

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)

For information on all Elsevier publications
visit our website at www.elsevierdirect.com

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

Printed and bound in United States of America

10 11 12 13 14 15 10 9 8 7 6 5 4 3 2 1

Working together to grow
libraries in developing countries

www.elsevier.com | www.bookaid.org | www.sabre.org

ELSEVIER

BOOK AID
International

Sabre Foundation

Blastobotrys von Klopotek (1967)

Maudy Th. Smith, G. Sybren de Hoog, Adele Statzell-Tallman and Cletus P. Kurtzman

DIAGNOSIS OF THE GENUS

Asexual reproduction: Colonies are restricted, dry, dull, snow-white, cream to tannish, and consist of appressed hyphal growth. Budding cells are absent or present. Conidiophores are suberect, sympodial, and produce conidia in clusters on a rachis or alongside hyphae. Conidia are borne on pedicels or denticles, or are sessile. Primary conidia produce smaller, secondary conidia, either synchronously or sympodially in short, acropetal chains; primary conidia often bear setae. Septa have micropores.

Sexual reproduction: *Trichomonascus* represents the teleomorphic state of *Blastobotrys*.

Physiology/biochemistry: Sugars are often fermented. Nitrate is assimilated by some species. Where known, coenzyme Q-9 is produced. The diazonium blue B reaction is negative.

Phylogenetic placement: Saccharomycetales, Trichomonascaceae (Figs 13.1, 87.1).

TYPE SPECIES

Blastobotrys nivea von Klopotek

SPECIES ACCEPTED

1. *Blastobotrys adenivorans* (Middelhoven, Hoogkamer-Te Niet & Kreger-van Rij) Kurtzman & Robnett (2007)
2. *Blastobotrys americana* Kurtzman (2007c)
3. *Blastobotrys arbuscula* de Hoog, Rantio-Lehtimäki & M.Th. Smith (1985)
4. *Blastobotrys aristata* Marvanová (1976)
5. *Blastobotrys attinorum* (Carreiro, Pagnocca, Rosa & Lachance) Kurtzman & Robnett (2007)
6. *Blastobotrys capitulata* de Hoog, Rantio-Lehtimäki & M. Th. Smith (1985)
7. *Blastobotrys chiropterorum* (Grose & Marinkelle) Kurtzman & Robnett (2007)
8. *Blastobotrys elegans* de Hoog, Rantio-Lehtimäki & M.Th. Smith (1985)
9. *Blastobotrys illinoisensis* Kurtzman (2007c)
10. *Blastobotrys indianensis* (Kurtzman) Kurtzman & Robnett (2007)
11. *Blastobotrys malaysiensis* Kurtzman (2007c)
12. *Blastobotrys mokoenaai* (Mokwena, Jansen van Rensburg & Myburgh) Kurtzman & Robnett (2007)
13. *Blastobotrys muscicola* Kurtzman (2007c)
14. *Blastobotrys nivea* von Klopotek (1967)
15. *Blastobotrys parvus* (Fell & Statzell) Kurtzman & Robnett (2007)
16. *Blastobotrys peoriensis* Kurtzman (2007c)
17. *Blastobotrys proliferans* Marvanová (1976)
18. *Blastobotrys raffinosisfermentans* Kurtzman (2007c)
19. *Blastobotrys robertii* Middelhoven & Kurtzman (2007)
20. *Blastobotrys serpentis* Bhadra, Rao & Shivaji (2008b)
21. *Blastobotrys terrestris* (van der Walt & Johannsen) Kurtzman & Robnett (2007)

KEY TO SPECIES OF *BLASTOBOTRYS* AND ITS TELEMORPHIC GENUS *TRICHOMONASCUS*

1.	a.	Growth at 37°C.....	2	
	b.	Growth is absent at 37°C.....	13	
2(1).	a.	Nitrate is assimilated	3	
	b.	Nitrate is not assimilated	5	
3(2).	a.	Melibiose and melizitose are assimilated.....	4	
	b.	Melibiose and melizitose are not assimilated.....	<i>B. terrestris</i> :	p. 976
4(3).	a.	Trehalose is assimilated	<i>B. adeninivorans</i> :	p. 966
	b.	Trehalose is not assimilated	<i>B. raffinosifermentans</i> :	p. 974
5(2).	a.	D-Xylose is assimilated	6	
	b.	D-Xylose is not assimilated	<i>B. muscicola</i> :	p. 970
6(5).	a.	Vitamins are not required for growth	7	
	b.	Vitamins are required for growth	9	
7(6).	a.	Lactose is assimilated.....	<i>B. malaysiensis</i> :	p. 969
	b.	Lactose is not assimilated.....	8	
8(7).	a.	D-Arabinose is assimilated	<i>B. illinoisensis</i> :	p. 967
	b.	D-Arabinose is not assimilated.....	<i>B. mokoensis</i> :	p. 969
9(6).	a.	Glucose is fermented	10	
	b.	Glucose is not fermented	20	
10(9).	a.	Melibiose is assimilated	11	
	b.	Melibiose is not assimilated	12	
11(10).	a.	Raffinose is assimilated	22	
	b.	Raffinose is not assimilated	<i>B. nivea</i> :	p. 971
12(10).	a.	Galactose is fermented	<i>B. capitulata</i> :	p. 965
	b.	Galactose is not fermented	<i>B. attinorum</i> :	p. 965
13(1).	a.	Nitrate is assimilated	<i>B. peoriensis</i> :	p. 973
	b.	Nitrate is not assimilated	14	
14(13).	a.	Glucose is fermented	15	
	b.	Glucose is not fermented	18	
15(14).	a.	Sucrose is assimilated	23	
	b.	Sucrose is not assimilated	16	
16(15).	a.	myo-Inositol is assimilated	17	
	b.	myo-Inositol is not assimilated	<i>B. arbuscula</i> :	p. 963
			<i>Tr. farinosus</i> :	p. 878
17(16).	a.	Erythritol is assimilated	<i>B. americana</i> :	p. 962
	b.	Erythritol is not assimilated	<i>B. indianensis</i> :	p. 968
18(14).	a.	Lactose is assimilated.....	19	
	b.	Lactose is not assimilated.....	21	
19(18).	a.	D-Xylose is assimilated	<i>B. elegans</i> :	p. 967
	b.	D-Xylose is not assimilated	<i>B. robertii</i> :	p. 975
20(9).	a.	D-Glucosamine is assimilated.....	<i>B. chiropterorum</i> :	p. 966
	b.	D-Glucosamine is not assimilated.....	<i>Tr. ciferrii</i> :	p. 877
21(18).	a.	Raffinose is assimilated	<i>B. serpentis</i> :	p. 975
	b.	Raffinose is not assimilated	<i>B. parvus</i> :	p. 971
22(11).	a.	Sucrose is assimilated	<i>B. proliferans</i> :	p. 973
	b.	Sucrose is not assimilated	<i>Tr. petasosporus</i> :	p. 880
23(15).	a.	Maltose is fermented	<i>B. aristata</i> :	p. 964
	b.	Maltose is not fermented	<i>Tr. apis</i> :	p. 876

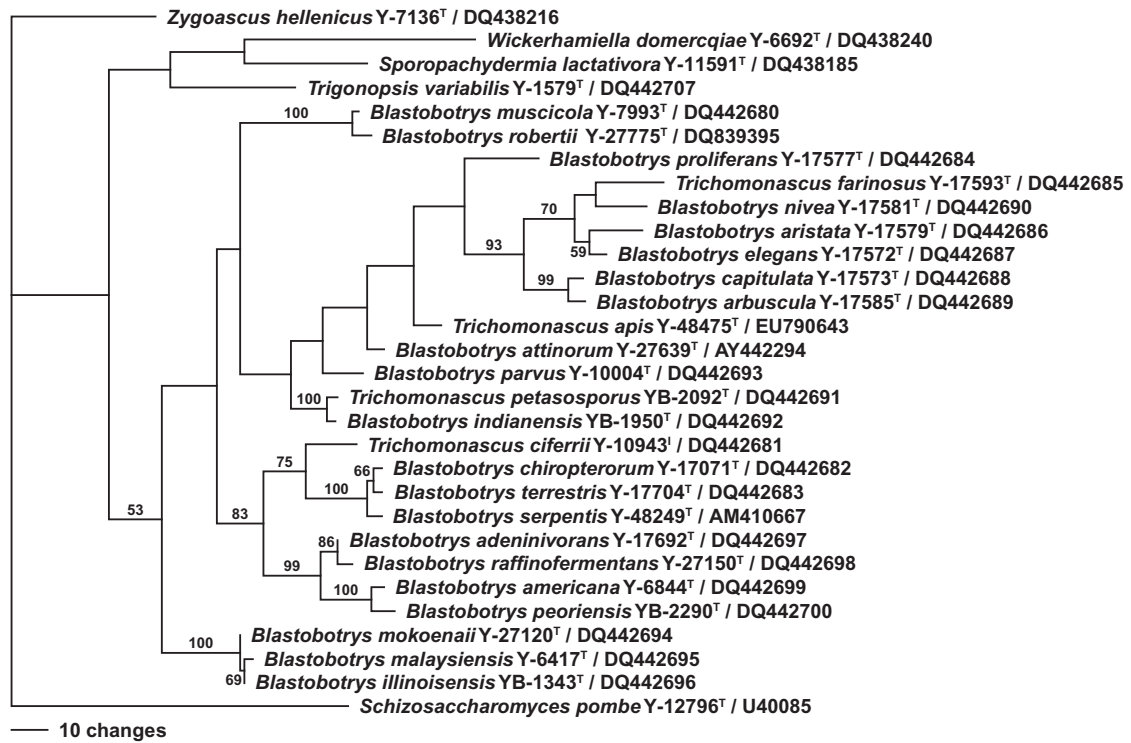


FIGURE 87.1 Phylogenetic placement of species of *Blastobotrys* and its teleomorphic genus *Trichomonascus* among members of the Saccharomycetales, on the basis of maximum parsimony analysis of D1/D2 LSU rRNA gene sequences. GenBank accession numbers follow strain numbers. Bootstrap values are from 1000 replicates. Bootstrap support for the *Trichomonascus*/*Blastobotrys* clade and internal nodes is much greater from multigene sequence analysis (Kurtzman and Robnett 2007). The multigene analysis did not include *B. attinorum*, *B. robertii* and *B. serpentis*. ^T = type strain, ^I = isotype strain.

TABLE 87.1 Key Characters of Species Assigned to the Genus *Blastobotrys* and its Teleomorphic Genus *Trichomonascus*

Species	Fermentation				Growth														
	Gluc	Gal	Mal	Raf	D-Gl	Suc	Raf	Mlb	Lac	Tre	Mlz	D-Xyl	D-Arab	Ery	Inos	Nitrate	Vit-Free	37°C	
<i>B. adeninivorans</i>	s	s	s	s	+	+	+	+	s	+	+	+	+	+	+	+	—	+	
<i>B. americana</i>	+	—	—	—	+	—	+	+	—	+	—	+	+	+	+	—	—	—	
<i>B. arbuscula</i> *	+	+	+	—	+	—	—	—	—	+	—	+	—	+	—	—	—	—	
<i>B. aristata</i>	+	v	+	—	+	+	v	v	+	+	—	+	+	+	v	—	—	—	
<i>B. attinorum</i>	+	—	v	—	n	—	—	—	—	—	—	+	+	+	—	—	—	+	
<i>B. capitulata</i>	+	+	v	—	+	v	v	—	v	+	—	+	v	+	+	—	—	+	
<i>B. chiropterorum</i>	—	—	—	—	+	+		—	+	—	—	+		+	+	—	—	+	
<i>B. elegans</i>	—	—	—	—	v	—	—	—	+	+	—	+	—	+	—	—	—	—	
<i>B. illinoisensis</i>	+	+	+	—	+	+	—	—	—	—	—	+	+	+	+	—	+	+	
<i>B. indianensis</i>	+	+	+	—	+	—	+	+	—	+	—	+	+	—	+	—	—	—	
<i>B. malaysiensis</i>	+	+	+	—	+	+	—	—	+	+	w	+	+	+	+	—	+	+	
<i>B. mokoensis</i>	s	s	—	—	+	+	—	—	—	+	—	+	—	+	+	—	+	+	
<i>B. muscicola</i>	—	—	—	—	v	+	v	v	+	v	+	—	—	—	—	—	v	+	
<i>B. nivea</i>	+	+	+	—	+	v	—	+	+	+	—	+	+	+	+	—	—	+	
<i>B. parvus</i>	—	—	—	—	s	s	—	—	—	s	—	+	v	+	s	—	—	—	
<i>B. peoriensis</i>	+	+	—	—	+	+	+	+	+	—	+	+	+	+	+	+	—	—	
<i>B. proliferans</i>	+	+	+	+	+	+	+	+	+	+	v	+	+	+	+	—	—	+	
<i>B. raffinosifermentans</i>	+	+	+	+	+	+	+	+	—	+	+	+	+	+	+	+	—	+	
<i>B. robertii</i>	—	—	—	—	—	+	+	+	+	+	—	—	—	—	—	—	—	—	
<i>B. serpentis</i>	—	—	—	—	+	+	+	+	—	+	—	w	+	+	+	—	—	—	
<i>B. terrestris</i>	—	—	—	—	—	+	+	—	—	+	—	+	+	+	+	+	—	+	
<i>Tr. apis</i>	s	w	—	—	+	+	v	w	v	+	v	+	w	+	+	—	—	—	
<i>Tr. ciferrii</i>	—	—	—	—	—	+	+	v	—	+	—	+	+	+	+	—	—	+	
<i>Tr. farinosus</i> *	w	v	v	—	v	—	v	v	v	+	—	v	v	v	v	—	—	—	
<i>Tr. petasosporus</i>	+	+	+	—	+	—	+	+	—	+	—	+	+	—	+	—	—	+	

^aAbbreviations: Gluc, glucose; Gal, galactose; Mal, maltose; D-Gl, D-glucosamine; Suc, sucrose; Raf, raffinose; Mlb, melibiose; Lac, lactose; Tre, trehalose; Mlz, melezitose; D-Xyl, D-xylose; D-Arab, D-arabinose; Ery, erythritol; Inos, myo-inositol; I, latent; n, not determined; s, slow; v, variable; w, weak.

B. arbuscula and *Tr. farinosus* cannot be differentiated by phenotypic characteristics.

SYSTEMATIC DISCUSSION OF THE SPECIES

87.1. *Blastobotrys adeninivorans*
(Middelhoven, Hoogkamer-Te Niet & Kreger-van Rij) Kurtzman & Robnett (2007)**Synonyms:**

Trichosporon adeninovorans Middelhoven, Hoogkamer-Te Niet & Kreger-van Rij (1984)

Arxula adeninivorans (Middelhoven, Hoogkamer-Te Niet & Kreger-van Rij) van der Walt, M.Th. Smith & Y. Yamada (1990c)

Growth in glucose-yeast extract-peptone water: After 3 days at 25°C, budding cells are short-ovoid to long-ovoid, 2.2–3.6 × 2.4–5.6 µm. Branched, septate hyphae, 2.4 µm in diameter, and arthroconidia are also present. Sediment and a white, dry pellicle are formed.

Growth on glucose-yeast extract-peptone agar: After 1 month at room temperature, the streak culture is yellowish-white, partly soft, partly tough and restricted. The edge is fringed with hyphae.

Dalmau plate cultures on potato and corn meal agars: True, branched, septate hyphae are abundantly formed. The hyphae may disarticulate in arthroconidia. Spherical or short-ovoid blastoconidia occur in chains, sometimes on short denticles on the hyphae, but generally between the septa. Aerial hyphae are also present.

Formation of endospores: Spherical to ovoid endospores of variable size and number (three to six) were observed on Difco malt agar.

Fermentation

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

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	—
Sucrose	+	Ethanol	+
Raffinose	+	Glycerol	+
Melibiose	+	Erythritol	+
Galactose	+	Ribitol	+
Lactose	s	Galactitol	—
Trehalose	+	D-Mannitol	+
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	+
L-Rhamnose	s	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	+
D-Arabinose	+	Vitamin-free	—

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	+	Cycloheximide 0.1%	+
5-Keto-D-gluconate	n	Starch formation	—
Saccharate	—	Gelatin liquefaction	n
10% NaCl/5% glucose	n	Growth at 40°C	+
60% (w/w) glucose	+		

CoQ: 9 (van der Walt et al. 1990c).

Mol % G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442697, mitochondrial SSU rRNA = DQ442776, cytochrome oxidase II = DQ443104, ITS = DQ898168.

Cell carbohydrates: Not determined.

Origin of the strains studied: CBS 7350, isolated from ensiled from whole-crop chopped maize, Netherlands, W.J. Middelhoven; CBS 7370 (NRRL Y-17693), from soil; CBS 7377, from garden soil, South Africa, J.P. van der Walt; CBS 7766, from liver and intestines of a Gila monster (*Heloderma suspectum*, Helodermatidae), Sweden, R. Mattson; CBS 8244 (NRRL Y-17692), type strain of *Trichosporon adeninivorans*, from soil, Netherlands, W.J. Middelhoven.

Type strain: CBS 8244.

Systematics: *Blastobotrys adeninivorans* was initially assigned to the anamorphic yeast genus *Trichosporon* by Middelhoven et al. (1984) because of the production of arthroconidia from septate hyphae and the occurrence of budding cells. However, on the basis of whole-cell monosaccharide composition, Weijman (1979b) restricted *Trichosporon* to basidiomycetous arthroconidial anamorphs, and *Geotrichum* was restricted to ascomycetous arthroconidial anamorphs. In a revision of the genus *Geotrichum* and its teleomorphs, de Hoog et al. (1986) did not transfer *T. adeninivorans* to *Geotrichum* because of its distinctive nutritional profile. Later, the species was assigned to the genus *Arxula*, a genus introduced by van der Walt et al. (1990c) to accommodate two arthroconidial, xerotolerant, ascomycetous yeast species, *T. terrestre*, as type species of the genus, and *T. adeninivorans*. *A. adeninivorans* has been the subject of various genomic studies. Kunze and Kunze (1994) characterized the karyotype by pulsed field gel electrophoresis. Samsonova et al. (1996) analyzed the linkage of 27 genes and localized some of the linkage groups on separate chromosomes. The genome organization of mitochondrial DNA was characterized by Pich and Kunze (1992). The phylogenetic studies of Kurtzman and Robnett (1998a, 2007) showed that the species is a member of the clade that includes *Trichomonascus* and its anamorph *Blastobotrys*. Consequently, these authors transferred *A. adeninivorans* to *Blastobotrys*.

Ecology: The ecology of *A. adeninivorans* is uncertain because, as listed under "Origin of the strains studied", isolates have been from soil, silage and an apparently infected Gila monster.

Biotechnology: Middelhoven et al. (1991) reported that *A. adeninivorans* was able to utilize for growth such atypical compounds as aliphatic organic acids and benzene compounds. The species has been used as gene donor for biotechnological applications as well as for heterologous gene expression (Terentiev et al. 2004b, Wartman et al. 2002, Wartman and Kunze 2003).

Agriculture and food: Unknown.

Clinical importance: Unknown.

87.2. *Blastobotrys americana* Kurtzman (2007)

Growth on 5% malt extract agar: After 3 days at 25°C, budding cells are elongate, 1.3–3.5 × 2–12 µm, occasionally spherical, 2.3–4.1 µm, and occur singly, in pairs and in short chains.

Dalmau plate cultures on yeast morphology agar: After 7 days at 25°C, pseudohyphae bearing infrequent blastoconidia are present (Fig. 87.2). After 7–10 days of incubation, the culture begins to show true hyphae. Occasionally, intercalary hyphal cells become enlarged and spherical.

Fermentation

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

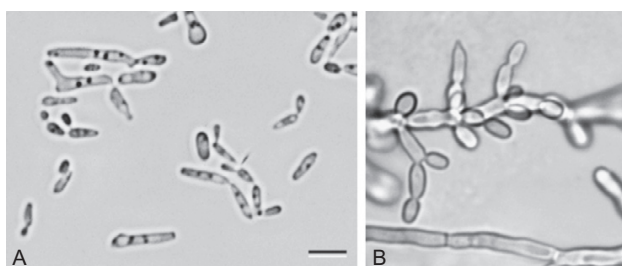


FIGURE 87.2 *Blastobotrys americana* NRRL Y-6844 CBS 10337. (A) Budding cells, 3 days, 5% malt extract agar, 25°C. (B) Pseudohyphae, yeast morphology agar, 7 days, 25°C. Bar = 5 μ m. (Kurtzman 2007).

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	+
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	–	Cycloheximide 0.01%	+
5-Keto-D-gluconate	+	Starch formation	–
Saccharate	–	Gelatin liquefaction	–
10% NaCl/5% glucose	+	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442699, mitochondrial SSU rRNA = DQ442778, cytochrome oxidase II = DQ443106.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 10337 (NRRL Y-6844), unknown substrate and location, L. Batra.

Type strain: NRRL Y-6844 CBS 10337.

Systematics: *Blastobotrys americana* can be differentiated from its sister species *B. peoriensis* by its inability to grow on sucrose, lactose and nitrate.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

87.3. *Blastobotrys arbuscula* de Hoog, Rantio-Lehtimäki & M.Th. Smith (1985)

Growth on 4% malt extract/0.5% yeast extract agar: After 10 days at 20–22°C, colonies are 1 mm in diameter, butyrous, and cream colored. Budding cells are abundant, in coherent chains, and form star-shaped pseudomycelial microcolonies. Hyphae are hyaline, straight and stiff, 2.5–3.5 μ m wide, and with clusters of minute conidium-bearing denticles at the apex and just below distal septa. Primary conidia are broadly ellipsoidal to subglobose, about 4–6 μ m wide, without setae, and produce densely crowded, globose secondary conidia, 2.5–3.5 μ m in diameter, generally in synchronous order (Fig. 87.3).

Fermentation

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

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	v	Methanol	n
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	+	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	–

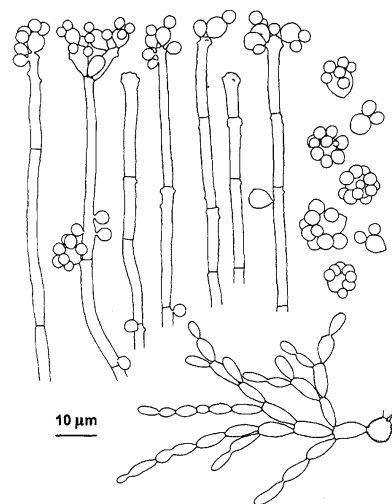


FIGURE 87.3 *Blastobotrys arbuscula* CBS 227.83. Conidiophores with primary and secondary conidia and initial growth with multilateral budding. MEYA, 22°C, 10 days (de Hoog and Smith 1998a).

Additional Growth Tests and Other Characteristics

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

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442689, mitochondrial SSU rRNA = DQ442768, cytochrome oxidase II = DQ44309.

Cell carbohydrates: Glucose, mannose and galactose are present in cell hydrolysates (Weijman and de Hoog 1985).

Origin of the strain studied: CBS 227.83 (NRRL Y-17585), isolated from house air, Finland, E. Tunnela.

Type strain: CBS 227.83.

Systematics: de Hoog et al. (1985) described two species, *Blastobotrys arbuscula* for a strain from air in Finland, and *B. gigas* for an isolate from a frozen mummy. Of the latter species, Traquair et al. (1988a) reported that it showed a teleomorph state similar to *Stephanoascus farinosus*. In their review of the genus *Blastobotrys*, de Hoog and Smith (1998a) commented that *B. arbuscula* is close to *B. gigas* and that both taxa may be conspecific with *S. farinosus*, but they stated that genomic studies are needed to clarify the relationships. Kurtzman and Robnett (1998a, 2007) showed from gene sequence comparisons that *B. arbuscula* is a species distinct from *S. farinosus*, but *B. gigas* was not compared and it is presently listed as a possible synonym of *Trichomonascus farinosus*.

Ecology: The single known strain was isolated from indoor air in Finland.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

87.4. *Blastobotrys aristata* Marvanová (1976)

Growth on 4% malt extract/0.5% yeast extract agar: After 10 days at 20–22°C, colonies are 10 mm in diameter, dry, farinose, snow-white, and consist of a compact hyphae; budding cells are often absent. Hyphae are hyaline and 2–3 µm wide. Conidiophores are ascending, up to 100 µm long, and bear one to three conidia at the apex; each is borne on a 2- to 4-µm long denticle. Primary conidia are pear-shaped, 3–8 × 4.5–9 µm, with one or two sterile setae, and bear synchronously produced, densely crowded, globose secondary conidia of 1.5–3.5 µm in diameter (Fig. 87.4).

Fermentation

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

Growth (in Liquid Media)

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

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

Additional Growth Tests and Other Characteristics

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

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442686, mitochondrial SSU rRNA = DQ442765, cytochrome oxidase II = DQ443093.

Cell carbohydrates: Glucose, mannose and galactose are present in cell hydrolysates (Weijman and de Hoog 1985).

Origin of the strain studied: CBS 521.75 (NRRL Y-17579), isolated from moldy plaster, former Czechoslovakia (Marvanová 1976).

Type strain: CBS 521.75.

Systematics: Physiological characteristics of this species are often difficult to judge because of formation of hyphal pellets. Primary conidia are borne on long, tapering pedicels that are formed singly or in small groups at the apex of conidiophores. Phylogenetically, the species is close to *B. elegans* (Kurtzman and Robnett 2007), from which it can be recognized by its ability to assimilate sucrose and D-arabinose.

Ecology: The only strain available was isolated from moldy plaster in Central Europe.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

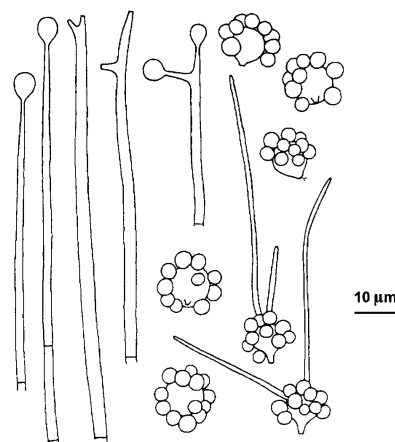


FIGURE 87.4 *Blastobotrys aristata* CBS 521.75. Conidiophore tips with primary conidium initials and primary conidia with secondary conidia and setae. MEYA, 22°C, 10 days (de Hoog and Smith 1998a).

87.5. *Blastobotrys attinorum* (Carreiro, Pagnocca, Rosa & Lachance) Kurtzman & Robnett (2007)

Synonym:

Sympodiomyces attinorum Carreiro, Pagnocca, Rosa & Lachance (2004)

Growth in glucose-yeast extract broth: After 4 days at 25°C, budding cells are elongate, ovoid and subglobose, 2–3.5 × 5.5–7 μm, and occur singly, in pairs or in short branched chains with formation of true hyphae.

Growth on malt extract/yeast extract agar: After 2 days at 25°C, colonies are dull cream, convex, rugose and butyrous.

Dalmat plate cultures on corn meal agar: After 2 weeks, true hyphae are formed with distinct septa and clusters of conidia.

Fermentation

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

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	w	Succinate	–
Cellobiose	+	Citrate	–
Salicin	+	D-Gluconate	w
L-Sorbose	+	D-Glucosamine	n
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	–	Cycloheximide 0.1%	+
5-Keto-D-gluconate	n	Starch formation	–
Saccharate	n	Gelatin liquefaction	n
10% NaCl/5% glucose	n	Growth at 37°C	+
50% (w/w) glucose	+		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AY442294.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 9734 (NRRL Y-27639), isolated from older sponge material of a laboratory nest of a leaf-cutting ant (*Atta sexdens*), São Paulo, Brazil, S.C. Carreiro.

Type strain: CBS 9734.

Systematics: *Blastobotrys attinorum* was described as a species of *Sympodiomyces* (Carreiro et al. 2004) because D1/D2 LSU rRNA gene sequence comparisons placed it near *S. parvus*. However, analysis of D1/D2 sequences suggested that *Sympodiomyces*, *Blastobotrys* and *Arxula* should be considered congeneric (Kurtzman and Robnett 1995), a suggestion that was later supported by multilocus sequence analysis (Kurtzman and Robnett 2007). Since the genus *Blastobotrys* has taxonomic priority over *Sympodiomyces* and *Arxula*, *S. attinorum* was transferred to *Blastobotrys*.

Ecology: *Blastobotrys attinorum* has been found frequently in nests of the leaf-cutting ants (Carreiro et al. 2004).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

87.6. *Blastobotrys capitulata* de Hoog, Rantio-Lehtimäki & M.Th. Smith (1985)

Growth on 4% malt extract/0.5% yeast extract agar: After 10 days at 20–22°C, colonies are 5 mm in diameter, snow-white, dry, and evenly farinose. Budding cells are absent; hyphae are hyaline and 2.5–3.5 μm wide. Conidia are sessile and produced in dense clusters at the apex of poorly differentiated cells. Primary conidia are obovoid, 5 × 10 μm, and bear one or two sterile, flexuose setae, 0.5 μm wide and up to 200 μm long. Secondary conidia are synchronously produced in dense packets on primary conidia; they are hygrophobic, globose and 2.5–3.5 μm in diameter. Similar conidia are produced alongside the hyphae (Fig. 87.5).

Fermentation

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

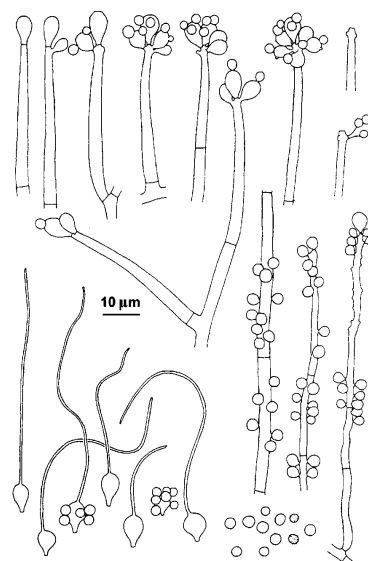


FIGURE 87.5 *Blastobotrys capitulata* CBS 287.82. Conidiophores with terminal groups of primary conidia bearing secondary conidia, primary conidia with secondary conidia and setae, and sessile conidiation on hyphae, MEYA, 22°C, 10 days (de Hoog and Smith 1998).

Growth (in Liquid Media)

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

Additional Growth Tests and Other Characteristics

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

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442688, mitochondrial SSU rRNA = DQ442767, cytochrome oxidase II = DQ443095.

Cell carbohydrates: Glucose, mannose and galactose are present in cell hydrolysates (Weijman and de Hoog 1985).

Origin of the strains studied: CBS 286.82, isolated from straw, USA, B.W. Horn; CBS 287.82 (NRRL Y-17573), type strain, from rotting candela tree (*Euphorbia ingens*, Euphorbiaceae), South Africa, J.P. van der Walt.

Type strain: CBS 287.82.

Systematics: *Blastobotrys capitulata* was described by de Hoog et al. (1985) to accommodate a strain isolated from a euphorb in South Africa. On the basis of multilocus sequence analysis (Kurtzman and Robnett 2007), the species was found to be closely related to *B. arbuscula* from which it can be distinguished by its ability to grow at 37°C.

Ecology: Strains of the species are only known from plant material.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

87.7. *Blastobotrys chiropterorum* (Grose & Marinkelle) Kurtzman & Robnett (2007)

Synonym:

Candida chiropterorum Grose & Marinkelle (1968)

Growth in glucose-yeast extract-peptone broth: After 3 days at 25°C, the cells are globose to ovoid, 2.2–2.8 $\times$ 4.4–7 μ m, and occur in branched chains and small branched clusters. Few single cells or budding cells are present. After 1 month, a thick sediment is evident.

Dalmeu plate culture on corn meal agar: After 7 days at 25°C, branched septate hyphae with small chains or clusters of

blastoconidia are present. Aerobic growth is white to cream colored and dry in appearance. Filamentous outgrowths give a feathery “fuzzy” appearance, and the margin is fringed.

Fermentation: Absent.

Growth (in Liquid Media)

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

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	+	Cycloheximide 0.1%	l
5-Keto-D-gluconate	+	Starch formation	n
Saccharate	—	Gelatin liquefaction	n
50% Glucose	+	Growth at 37°C	+
10% NaCl/5% glucose	+	Growth at 40°C	—
Cycloheximide 0.01%	+		

CoQ: 9 (Suzuki and Nakase 1998).

Mol% G + C: 48.0, CBS 6064 (T_m : Meyer et al. 1984).

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442682, mitochondrial SSU rRNA = DQ442761, cytochrome oxidase II = DQ443089.

Cell carbohydrates: Glucose and mannose are present (Suzuki and Nakase 1998).

Origin of the strain studied: CBS 6064 (NRRL Y-17071, IFO 10271, JCM 9597), isolated from liver of a bat (*Mormoops megalophylla*), Colombia, C.J. Marinkelle.

Type strain: CBS 6064 (NRRL Y-17071).

Systematics: *Blastobotrys chiropterorum* was previously assigned to the genus *Candida* by Grose and Marinkelle (1968). However, on the basis of multilocus sequence analysis, Kurtzman and Robnett (2007) demonstrated that this species belongs to the teleomorph/anamorph clade of *Trichomonascus*/*Blastobotrys*. Consequently *C. chiropterorum* was transferred to the genus *Blastobotrys*.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Furman and Ahearn (1983) reported the occurrence of *B. chiropterorum* in peritoneal dialysis fluid of a patient exhibiting no overt evidence of yeast infection. The original strain of *B. chiropterorum* came from a bat liver.

87.8. *Blastobotrys elegans* de Hoog, Rantio-Lehtimäki & M.Th. Smith (1985)

Growth on 4% malt extract/0.5% yeast extract agar: After 10 days at 20–22°C, colonies are 3–5 mm in diameter, cerebriiform, whitish and, in later stages, with snow-white, farinose patches. Budding cells are mostly absent; hyphae are hyaline, 2–3 µm wide. Conidia are formed on loose apical clusters of cylindrical denticles that are up to 3 µm long. Primary conidia are subglobose, 2.8–4.2 µm wide, without setae, and densely crowded with globose, synchronously formed secondary conidia that are 1.8–3.4 µm in diameter (Fig. 87.6).

Fermentation: Absent.

Growth (in Liquid Media)

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

2-Keto-D-gluconate	n	Cycloheximide 0.1%	n
5-Keto-D-gluconate	n	Starch formation	n
Saccharate	n	Gelatin liquefaction	n
10% NaCl/5% glucose	n	Growth at 37°C	–

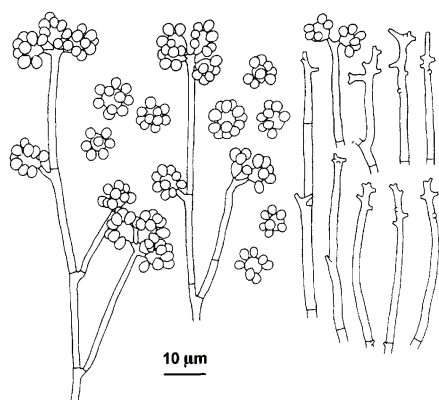


FIGURE 87.6 *Blastobotrys elegans* CBS 530.83. Conidiophores with and without clusters of primary conidia that bear secondary conidia; denticles remain after detachment, MEYA, 22°C, 10 days (de Hoog and Smith 1998a).

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442687, mitochondrial SSU rRNA = DQ442766, cytochrome oxidase II = DQ443094.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 530.83 (NRRL Y-17572), isolated from house air, Finland, A. H. Rantio-Lehtimäki.

Type strain: CBS 530.83.

Systematics: *Blastobotrys elegans* was described by de Hoog et al. (1985) for a strain isolated from house air in Finland. From multilocus sequence analysis (Kurtzman and Robnett 2007) the species was found to be close to *B. aristata*, from which it can be separated by its inability to assimilate sucrose and D-arabinose.

Ecology: The single known strain of *B. elegans* was isolated from indoor air in Finland.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

87.9. *Blastobotrys illinoisensis* Kurtzman (2007c)

Growth on 5% malt extract agar: After 3 days at 25°C, cells are spherical, 2–4 µm, to elongate, 2–3 × 2.5–8 µm, often teardrop-shaped, and occur singly or in pairs. Frequently, cells measuring 4–5 × 6–8 µm have a tapered seta-like extension that has a basal diameter of 1–1.3 µm and a length of 18–125 µm. Seta-bearing cells often produce buds (Fig. 87.7).

Dalmau plate cultures on yeast morphology agar: After 7 days at 25°C, pseudohyphae and abundant true hyphae with side branches having denticulate tips bearing blastoconidia. Hyphal cells also produce denticles with conidia.

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	w	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	+

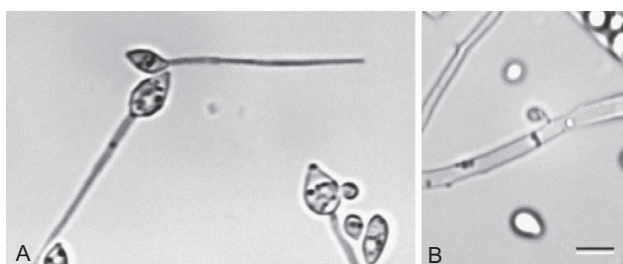


FIGURE 87.7 *Blastobotrys illinoisensis* NRRL YB-1343. (A) Cells, some with buds, showing a seta-like cell wall extension, 3 days, 5% malt extract agar, 25°C. (B) Denticulate hypha with a blastoconidium, 7 days, yeast morphology agar, 25°C. Bar = 5 μ m. (Kurtzman 2007c).

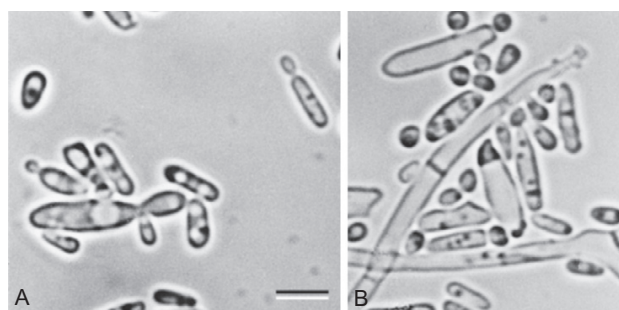


FIGURE 87.8 *Blastobotrys indianensis* NRRL YB-1950 = CBS 10339. (A) Budding cells, 3 days, YM agar, 25°C. (B) Septate hyphae with terminal denticles, 10 days, YM agar, 25°C. Bar = 5 μ m. (Kurtzman and Robnett 2007).

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	+	Cycloheximide 0.01%	+
5-Keto-D-gluconate	+	Starch formation	–
Saccharate	–	Gelatin liquefaction	+
10% NaCl/5% glucose	+	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442696, mitochondrial SSU rRNA = DQ442775, cytochrome oxidase II = DQ443103, ITS = DQ898169.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 10339 (NRRL YB-1343), isolated from debris surrounding the base of a standing, dead deciduous tree, Marion, Illinois, USA, L.J. Wickerham.

Type strain: NRRL YB-1343 = CBS 10339.

Systematics: *Blastobotrys illinoisensis* was recognized as a distinct species from D1/D2 LSU rRNA sequences as well as from multilocus gene analysis (Kurtzman 2007c, Kurtzman and Robnett 2007). The taxon was described from a single strain isolated from a dead standing tree in Marion, Illinois, USA. *B. illinoisensis* is most closely related to *B. malaysiensis* and *B. mokoensis*, isolated from habitats in Malaysia and South Africa, respectively.

Ecology: The only known strain of *B. illinoisensis* was isolated from a dead deciduous tree in the USA.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

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-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	+	Cycloheximide 0.01%	+
5-Keto-D-gluconate	+	Starch formation	–
Saccharate	–	Gelatin liquefaction	–
10% NaCl/5% glucose	+	Growth at 37°C	–

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442692, mitochondrial SSU rRNA = DQ442771, cytochrome oxidase II = DQ443099.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 9600 (NRRL YB-1950), isolated from an unidentified white fungus growing on the bark of a fallen pine tree (*Pinus* sp., Pinaceae), Indiana, USA, L.J. Wickerham.

Type strain: NRRL YB-1950, CBS 9600.

87.10. *Blastobotrys indianensis* (Kurtzman) Kurtzman & Robnett (2007)

Synonym:

Symphodiomyces indianensis (as *indianaensis*) Kurtzman (2004)

Growth on 5% malt extract agar: After 3 days at 25°C, yeast cells are spherical, 2–4.6 μ m, to elongate, 1.4–2.5 $\times$ 2.8–10 μ m. Conidiophores often have terminal denticles. Blastoconidia are generally ovoid. Pseudohyphae and true hyphae are present (Fig. 87.8).

Dalmat plate cultures on yeast morphology agar: After 7 days at 25°C, pseudohyphae and true hyphae bearing blastoconidia are formed.

Systematics: On the basis of D1/D2 LSU rRNA gene sequence analysis, Kurtzman (2004) initially assigned *B. indianensis* to the genus *Sympodiomyces*. However, from multigene analysis, Kurtzman and Robnett (2007) showed that *Sympodiomyces* species were members of the *Trichomonascus/Blastobotrys* clade. Therefore, *S. indianensis* was transferred to the genus *Blastobotrys*.

Ecology: The only strain known was isolated from an unidentified white fungus growing on the bark of a fallen pine tree (*Pinus* sp.), Indiana, USA.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

87.11. *Blastobotrys malaysiensis* Kurtzman (2007c)

Growth on 5% malt extract agar: After 3 days at 25°C, cells divide by multilateral budding, are spherical, 3–5.5 µm, to ellipsoidal, 2.5–4 × 3.5–6 µm, and occur singly or in pairs. Cells bearing a seta-like extension are also present. The length of the extension is seldom greater than 25 µm.

Dalmau plate cultures on yeast morphology agar: After 7 days at 25°C, few pseudohyphae are present, but true hyphae are abundant. Hyphae often show a spherical, inflated terminal cell that may produce buds. Blastoconidia often formed on short denticles on the hyphal cells (Fig. 87.9).

Fermentation

Glucose	+	Lactose	–
Galactose	+	Raffinose	–
Sucrose	w	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	w	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	+	Cycloheximide 0.01%	+
5-Keto-D-gluconate	+	Starch formation	–
Saccharate	–	Gelatin liquefaction	+
10% NaCl/5% glucose	+	Growth at 37°C	+

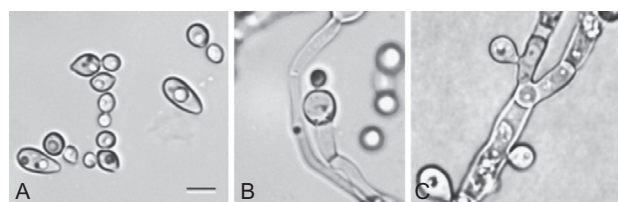


FIGURE 87.9 *Blastobotrys malaysiensis* NRRL Y-6417. (A) Budding cells, and (B) Hypha with budding inflated tip cell, 3 days, 5% malt extract, 25°C. C. Hypha with blastoconidia formed on denticles, 7 days, yeast morphology agar, 25°C. Bar = 5 µm. (Kurtzman 2007c).

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442695, mitochondrial SSU rRNA = DQ442774, cytochrome oxidase II = DQ443102, ITS = DQ898170.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 10336 (NRRL Y-6417), isolated from soil in a cave in Malaysia, C.W. Emmons.

Type strain: NRRL Y-6417 CBS 10336.

Systematics: On basis of multigene sequence analysis, *B. malaysiensis* was recognized to be a new member of the teleomorph/anamorph clade *Trichomonascus/Blastobotrys* close to *B. illinoensis* and *B. mokoensis* (Kurtzman 2007c). *B. malaysiensis* can be distinguished from *B. illinoensis* by its ability to assimilate trehalose and, from *B. mokoensis* by its ability to utilize lactose.

Ecology: The only known strain of *B. malaysiensis* was isolated from soil in a cave in Malaysia.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

87.12. *Blastobotrys mokoensis* (Mokwena, Jansen van Rensburg & Myburgh) Kurtzman & Robnett (2007)

Synonym:

Candida mokoensis Mokwena, Jansen van Rensburg & Myburgh (2000)

Growth in glucose-yeast extract-peptone water: After 3 days at 25°C, multilateral budding cells are ovoid, elongate or spherical, 2.8–4.1 × 4.1–9.4 µm, and occur singly, in pairs or in clusters. Septate cells are occasionally observed; pseudohyphae are abundantly formed.

Dalmau plate cultures on corn meal agar: Pseudohyphae consisting of branched chains of elongated cells are sparsely formed. True hyphae were observed in glucose-yeast extract-peptone water.

Fermentation

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

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	+/-w	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	–
Soluble starch	+	Succinate	+
Cellobiose	+	Citrate	+
Salicin	–	D-Gluconate	+/w
L-Sorbose	+	D-Glucosamine	+
L-Rhamnose	+/s	N-Acetyl-D-glucosamine	n
D-Xylose	+	Hexadecane	n
L-Arabinose	+	Nitrate	–
D-Arabinose	–	Vitamin-free	+

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	+	Starch formation	n
5-Keto-D-gluconate	n	Gelatin liquefaction	n
Saccharate	n	Cycloheximide 0.1%	+
50% Glucose	–	Growth at 45°C	+
10% NaCl/5% glucose	+		

CoQ: Not determined.

Mol% G + C: 47.8, CBS 8435 (T_m : Mokwena et al. 2000).

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442694, mitochondrial SSU rRNA = DQ442773, cytochrome oxidase II = DQ443101, ITS = DQ898171.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 8435 (NRRL Y-27120), isolated from soil, South Africa, T.A. Mokwena

Type strain: CBS 8435.

Systematics: From the presence of an ascomycetous cell wall, septa with uncapped dolipore-like structures and the absence of ascospore production, Mokwena et al. (2000) assigned *B. mokoena* to the genus *Candida*. However, multigene sequence analysis placed the species in the genus *Blastobotrys* close to *B. malaysiensis* (Kurtzman and Robnett 2007). Consequently, Kurtzman (2007c) transferred the species to *Blastobotrys*. Physiologically, the species can be distinguished from *B. malaysiensis* by its inability to grow on lactose.

Ecology: The single known strain of *B. mokoena* was isolated from soil in South Africa.

Biotechnology: Mokwena et al. (2000) reported that the type strain is remarkable for its high optimum growth temperature of 45°C, and its high secretion of xylanase, which was used industrially in biobleaching and bioprocessing of wood pulps (Techapun et al. 2003).

Agriculture and food: Unknown.

Clinical importance: Unknown.

87.13. *Blastobotrys muscicola* Kurtzman (2007c)

Growth on 5% malt extract agar: After 3 days at 25°C, multilateral budding cells are infrequently spherical, 2–4.1 μ m, but the majority are elongate and often spindle-shaped, 1.5–2.5 $\times$ 8–22 μ m, and occur singly or in pairs. Larger elongated cells often form terminal denticles with blastoconidia (Fig. 87.10).

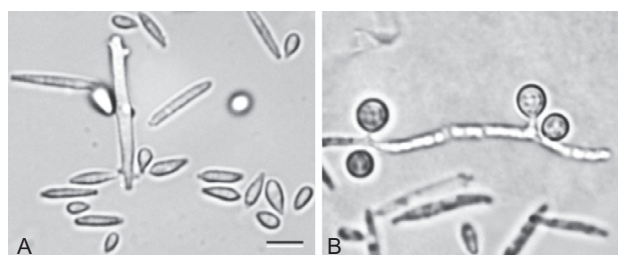


FIGURE 87.10 *Blastobotrys muscicola* NRRL Y-7993. (A) Spindle-shaped, budded cells and an elongated cell with terminal denticles. (B) Hypha with spherical cells borne on denticles. After 3 days, 5% malt extract agar, 25°C. Bar = 5 μ m. (Kurtzman 2007c).

Dalmau plate cultures on yeast morphology agar: After 7 days at 25°C, pseudohyphae and true hyphae are formed. Inflated spherical cells may arise from short denticles on the hyphae.

Fermentation: Absent.

Growth (in Liquid Media)

Glucose	+	D-Ribose	–
Inulin	–	Methanol	–
Sucrose	+	Ethanol	–
Raffinose	v	Glycerol	+
Melibiose	v	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	+
Cellobiose	+	Citrate	+
Salicin	v	D-Gluconate	–
L-Sorbose	–	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

2-Keto-D-gluconate	–	Cycloheximide 0.01%	+
5-Keto-D-gluconate	–	Starch formation	–
Saccharate	–	Gelatin liquefaction	+
10% NaCl/5% glucose	–	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442680, mitochondrial SSU rRNA = DQ442759, cytochrome oxidase II = DQ443087.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 10338 (NRRL Y-7993), isolated from an unidentified moss on a fallen log in a wilderness area, Louisiana, USA, C.P. Kurtzman.

Type strain: NRRL Y-7993 CBS 10338.

Systematics: On the basis of multigene sequence analysis, *B. muscicola* is most closely related to *B. robertii* (Kurtzman 2007c).

Ecology: The only known strain of *B. muscicola* was isolated from an unidentified moss on a fallen log in a wilderness area in Louisiana, USA.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

87.14. *Blastobotrys nivea* von Klopotek (1967)

Growth on 4% malt extract/0.5% yeast extract agar: After 10 days at 20–22°C, colonies are 14 mm in diameter, dry, farinose, somewhat folded, snow-white, and consist of compact hyphae; budding cells are absent. Hyphae are hyaline and 2–3 µm wide. Conidiophores are ascending, up to 230 µm high, and the apical parts have distant geniculations with cylindrical denticles at the edges. Primary conidia are globose, 2.5–4.5 µm wide, without setae, and synchronously produce globose, densely crowded secondary conidia that are 2–2.5 µm in diameter (Fig. 87.11).

Fermentation

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

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	v	Methanol	n
Sucrose	v	Ethanol	+
Raffinose	–	Glycerol	+
Melibiose	+	Erythritol	+
Galactose	+	Ribitol	+
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	n
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

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

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442690, mitochondrial SSU rRNA = DQ442769, cytochrome oxidase II = DQ443097.

Cell carbohydrates: Mannose, glucose and galactose are present in cell hydrolysates (Weijman and de Hoog 1985).

Origin of the strain studied: CBS 163.67 (NRRL Y-17581, ATCC 18420), isolated from compost, Germany, A. von Klopotek.

Type strain: CBS 163.67.

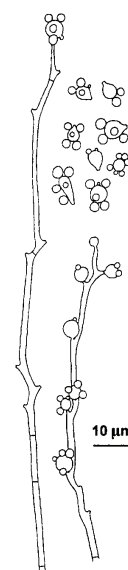


FIGURE 87.11 *Blastobotrys nivea* CBS 163.67. Conidiophores with primary conidia bearing secondary conidia. MEYA, 22°C, 10 days (de Hoog and Smith 1998a).

Systematics: Morphologically, *B. nivea* is recognized by slender conidiophores with a long geniculate rachis. Conidia are borne on widely spaced cylindrical denticles. Physiologically, this species is close to *B. proliferans* but it does not ferment sucrose and is unable to grow on raffinose (de Hoog et al. 1985).

Ecology: The single known strain was isolated from compost in Germany.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

87.15. *Blastobotrys parvus* (Fell & Statzell) Kurtzman & Robnett (2007)

Synonym:

Sympodiomyces parvus Fell & Statzell (1971)

Growth in 5 % malt extract: After 5 days at 12°C, single cells are polymorphic (Fig. 87.12); they are spherical, ovoid or subglobose, 1–1.3 × 1.3–3.4 µm. The cells occur singly, in pairs and in short branched chains. The cells in chains are generally larger, 2.6–3.4 × 4.7–5.4 µm, and ovoid in shape. The conidiophores at this stage are short and give the appearance of budding yeast cells, or they are elongated to 4 µm. After 1 month, the conidiophores have elongated to 11 µm with numerous bud scars and one or more conidia. There is moderate sediment in the culture tube.

Growth on 5% malt agar: After 1 month at 12°C, the streak culture is dull cream, the surface is smooth, and the texture is soft but not mucoid. The colony is convex and the periphery is entire, apart from tufts of non-aerial hyphae at the edges (Fig. 87.13).

Dalmau plate culture on corn meal agar: After 1 month at 12°C, true hyphae with distinct septa are present and form clusters of conidia. The conidia form in the same manner as single cells; i.e., the new bud forms terminally on a conidiophore that elongates sympodially to produce new conidia. The hyphae are approximately 2 µm

in width; there are often spherical intercalary cells in the range of $5 \times 7 \mu\text{m}$. The hyphae are inconspicuous, and somewhat more extensive on malt agar than on corn meal agar.

Fermentation: Absent.

Growth (in Liquid Media)

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

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	n	Starch formation	—
5-Keto-D-gluconate	n	Urease	—
Saccharate	—	Gelatin liquefaction	—
50% (w/w) glucose	—	Growth at 25°C	+
10% NaCl/5% glucose	—	Growth at 30°C	—
Cycloheximide 0.01%	n		

CoQ: 9 (Sugiyama et al. 1991).

Mol % G + C: 46.3 (T_m : Sugiyama et al. 1991).

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442693, mitochondrial SSU rRNA = DQ442772, cytochrome oxidase II = DQ443100.

Cell carbohydrates: Glucose, mannose, galactose, fucose, ribose and arabinose are present in cell hydrolysates (Sugiyama et al. 1991).

Origin of the strain studied: CBS 6147 (NRRL Y-10004, IFO 10132), isolated from the Antarctic Ocean; 51 other strains were isolated from open waters of the southern Indian and Pacific Oceans (Fell 1976, Fell and Statzell 1971).

Type strain: CBS 6147.

Systematics: Because of its unique morphology and marine habitat, *S. parvus* was placed in the monotypic genus *Sympodiomyces* (Fell and Statzell 1971). The diazonium blue B reaction of *S. parvus* was reported by van der Walt and Hopsu-Havu (1976), and Sugiyama and coworkers (1991) examined the cell wall structure. The phylogenetic relationship of *S. parvus* to various hyphal ascomycetous yeasts and yeast-like taxa was examined by Kurtzman and Robnett (1995). On the basis of D1/D2 LSU rRNA gene sequence analysis, *Sympodiomyces*, *Blastobotrys*, *Arxula* and *Stephanoascus* were closely related and it appeared that the genera might be congeneric. Later, this suggestion was confirmed by multigene sequence analysis, and the species was transferred to *Blastobotrys*, the genus of taxonomic priority (Kurtzman and Robnett 2007).

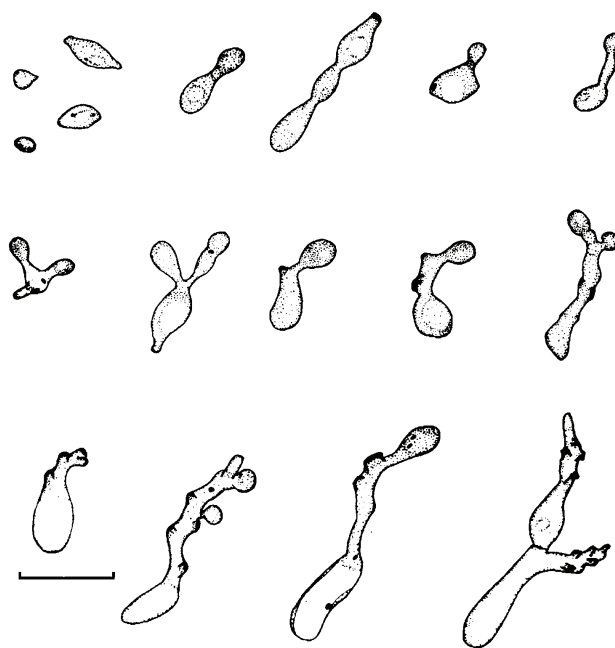


FIGURE 87.12 *Blastobotrys parvus* CBS 6147. Yeast phase with the symphydial formation of conidia from a culture grown for 1–4 weeks in malt extract at 12°C. Bar = 10 μm . Camera lucida drawings reproduced from Statzell-Tallman and Fell (1998a), with permission.

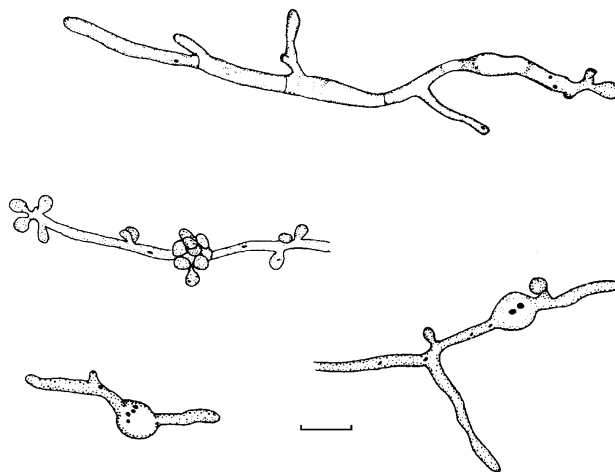


FIGURE 87.13 (*Blastobotrys parvus* CBS 6147). Hypha formation after 1 week on malt agar at 12°C. Bar = 10 μm . Camera lucida drawings reproduced from Statzell-Tallman and Fell (1998a), with permission.

Ecology: The species may be endemic to marine waters. Fell and Statzell (1971) and Fell (1976) reported the occurrence of this species in waters of Antarctic origin in the southern Pacific and Indian Oceans, in the Antarctic Intermediate, Sub Antarctic and South Pacific Central water masses from approximately 100°W westward to 118°E, and 62°S northward to 42°S. Isolations were from depths of 16 to 748 meters where water temperatures ranged from 3.07–10.55°C and salinities were 33.94–34.85°C.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

87.16. *Blastobotrys peoriensis* Kurtzman (2007c)

Growth on 5% malt extract agar: After 3 days at 25°C, multilateral budding cells are spherical, 2–5 µm, or ovoid and elongate, 2–4 × 2.5–12 µm, and occur singly or in pairs (Fig. 87.14).

Dalmay plate cultures on yeast morphology agar: After 7 days at 25°C, pseudohyphae with clusters of blastoconidia are abundantly present. True hyphae are infrequently produced. Rachis-like extensions with blastoconidia are formed by hyphae and individual cells (Fig. 87.14).

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	w	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	+	Cycloheximide 0.01%	+
5-Keto-D-gluconate	+	Starch formation	–
Saccharate	–	Gelatin liquefaction	–
10% NaCl/5% glucose	+	Growth at 37°C	–
60% (w/w) glucose	n		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442700, mitochondrial SSU rRNA = DQ442779, cytochrome oxidase II = DQ443107.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 10340 (NRRL YB-2290), isolated from an unidentified fungal growth on a rotted log, Peoria, Illinois, USA, L.J. Wickerham.

Type strain: NRRL YB-2290 CBS 10340.

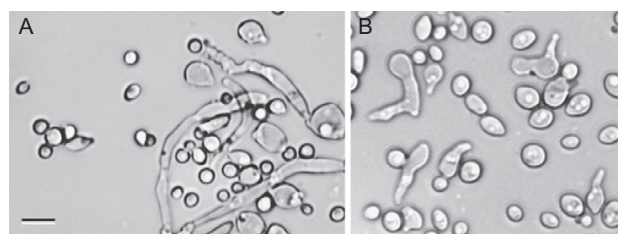


FIGURE 87.14 *Blastobotrys peoriensis* NRRL YB-2290. (A) Budding cells and a pseudohyphal cell with a rachis-like tip, 3 days, 5% malt extract agar, 25°C. (B) Budding cells, some of which have tapered extensions that formed blastoconidia, 7 days, yeast morphology agar, 25°C. Bar = 5 µm. (Kurtzman 2007c).

Systematics: Physiologically, *B. peoriensis* can be distinguished from its sister species *B. americana* by its ability to utilize sucrose, lactose and nitrate.

Ecology: The only known strain of *B. peoriensis* was isolated from unidentified fungal growth on a rotten log in Peoria, Illinois, USA.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

87.17. *Blastobotrys proliferans* Marvanová (1976)

Synonym:

Blastobotrys navarrensis Sesma & C. Ramirez (1978)¹

¹ Synonymy determined from phenotype.

Growth on 4% malt extract/0.5% yeast extract agar: After 10 days at 20–22°C, the colonies are 10 mm in diameter, dry, thinly hairy, soft and snow-white; budding cells are absent. Hyphae are hyaline, and 1.5–2.5 µm wide. Conidiophores are ascending, up to 80 µm long, and barely differ from the remaining hyphae; apically, they produce one to three pedicles up to 5 µm long that bear conidia. Primary conidia are pear-shaped, 3–4.5 × 4.5–8 µm, contain a refractive granular body, and bear a seta which again produces one to three similar conidia at its apex. The primary conidia synchronously produce densely crowded globose secondary conidia that are 1.5–2.5 µm in diameter (Fig. 87.15).

Fermentation

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

Growth (in Liquid Media)

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

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

Additional Growth Tests and Other Characteristics

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

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442684, mitochondrial SSU rRNA = DQ442763, cytochrome oxidase II = DQ443091.

Cell carbohydrates: Glucose, mannose and galactose are present in cell hydrolysates (Weijman and de Hoog 1985).

Origin of the strains studied: CBS 522.75 (NRRL Y-17577), type strain of *Blastobotrys proliferans*, isolated from a mite-infested nut, Brazil, L. Marvanová; CBS 139.77, type strain of *B. navarrensis*, from black pepper (*Piper nigrum*), Spain; CBS 527.79, from garden soil, South Africa, J.P. van der Walt; CBS 520.83, from linoleum, London, UK, I.B. Murray; CBS 293.84, from cystic lesion of human ankle, G. Schär; CBS 232.85, from house dust, Stockholm, Sweden.

Type strain: CBS 522.75.

Systematics: Key features of *B. proliferans* are primary conidia that contain granular, highly refractive bodies and setae that bear new, similar

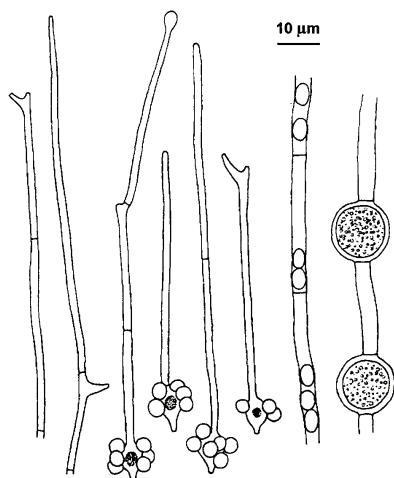


FIGURE 87.15 *Blastobotrys proliferans* CBS 522.75. Conidiophores and primary conidia bearing secondary conidia and setae, endoconidia in hyphae, and intercalary chlamydospores. MEYA, 22°C, 10 days (de Hoog and Smith 1998a).

conidia. Physiologically, this species is similar to *B. nivea*, but it does ferment sucrose and is able to grow on raffinose (de Hoog et al. 1985).

Ecology: *Blastobotrys proliferans* has been isolated from a wide variety of habitats, as listed under “Origin of the strains studied”.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Quirin et al. (2007) reported a case of peritonitis due to *B. proliferans* in a 46-year-old man undergoing peritoneal dialysis.

87.18. *Blastobotrys raffinosifermentans* Kurtzman (2007c)

Growth on 5% malt extract agar: After 3 days at 25°C, cells divide by multilateral budding and are spherical, 2–4 μm, to elongate, 2–3.5 × 3–13 μm, and occur singly, in pairs and in small clusters. Some cells produce blastoconidia on short denticles (Fig. 87.16).

Dalmau plate cultures on yeast morphology agar: After 7 days at 25°C, abundant well-branched pseudohyphae with blastoconidia are present. Septate hyphae are not formed.

Fermentation

Glucose	+	Lactose	—
Galactose	+	Raffinose	+
Sucrose	w	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-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	—

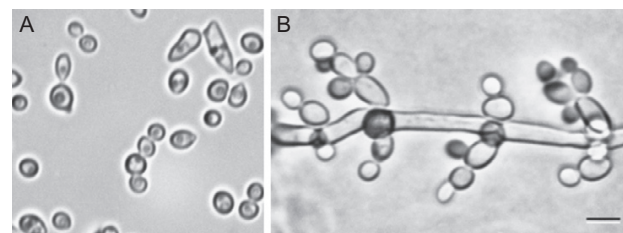


FIGURE 87.16 *Blastobotrys raffinosifermentans* NRRL Y-27150. (A) Budding cells, 3 days, 5% malt extract agar, 25°C. (B) Pseudohypha with blastoconidia, 7 days, yeast morphology agar, 25°C. Bar = 5 μm (Kurtzman 2007c).

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	+	Cycloheximide 0.01%	+
5-Keto-D-gluconate	+	Starch formation	—
Saccharate	—	Gelatin liquefaction	—
10% NaCl/5% glucose	+	Growth at 37°C	+

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: LSU rRNA (incl. D1/D2) = DQ442698, mitochondrial SSU rRNA = DQ442777, cytochrome oxidase II = DQ443105; ITS = DQ898172.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 6800 (NRRL Y-27150), unknown habitat, J. Shennan.

Type strain: NRRL Y-27150.

Systematics: The species was described as *B. raffinosifermentans* because of its ability to ferment raffinose, a rare characteristic among species of the *Trichomonascus/Blastobotrys* clade (Kurtzman 2007c). Additionally, *B. raffinosifermentans* can be distinguished from its close relative *B. adenivorans* by its ability to utilize trehalose.

Ecology: Unknown.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

Dalmau plate cultures on yeast morphology agar: After 7 days at 25°C, septate hyphae are formed that produce blastoconidia on short denticles. Hyphal cells may detach at the septa.

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

87.19. *Blastobotrys robertii* Middelhoven & Kurtzman (2007)

Growth on 5% malt extract agar: After 3 days at 25°C, budding cells, pseudohyphae and septate hyphae are present. Budding is multilateral. Blastoconidia may occur on short denticles that often form on the tips of elongated cells. Cells are elongate and tapered, $2.3\text{--}3 \times 4\text{--}12\text{ }\mu\text{m}$, rarely ellipsoidal, and occur singly or in pairs (Fig. 87.17).

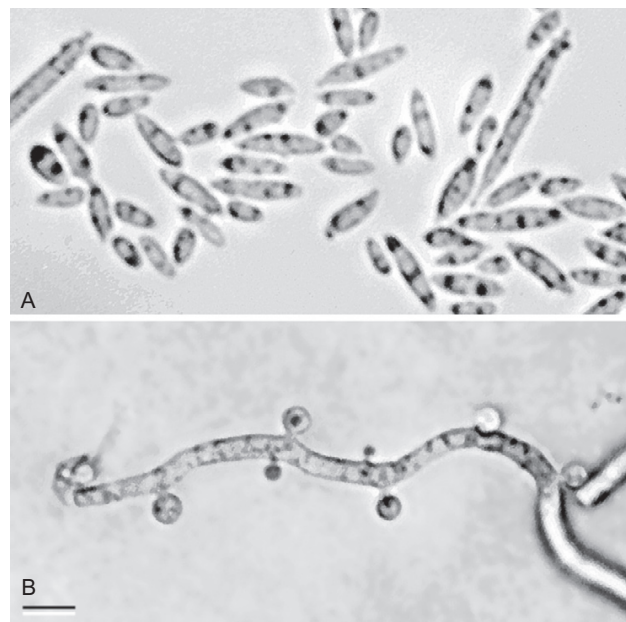


FIGURE 87.17 *Blastobotrys robertii* NRRL Y-27775. (A) Budding cells, 3 days, 5% malt extract agar, 25°C. (B) Septate hypha with blastoconidia formed on short denticles, yeast morphology agar, 7 days, 25°C. Bar = 5 μm (Middelhoven and Kurtzman 2007).

Additional Growth Tests and Other Characteristics

2-Keto-D-gluconate	n	Starch formation	n
5-Keto-D-gluconate	n	Gelatin liquefaction	n
Saccharate	n	Growth at 32°C	+
10% NaCl/5% glucose	n	Growth at 35°C	—
Cycloheximide 0.01%	n		

CoQ: Not determined.

Mol% G + C: Not determined.

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = DQ839395.

Cell carbohydrates: Not determined.

Origin of the strain studied: CBS 10106 (NRRL Y-27775), isolated from a rotted Scotch pine (*Pinus sylvestris*, Pinaceae), The Netherlands, W.J. Middelhoven.

Type strain: CBS 10106 (NRRL Y-27775).

Systematics: *Blastobotrys robertii* can be distinguished from its sister species *B. muscicola* by its inability to grow on melizitose and at 37°C.

Ecology: The only known strain was isolated from rotted pine wood.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

87.20. *Blastobotrys serpentis* Bhadra, Rao & Shivaji (2008)

[The morphological description and physiological data are from Bhadra et al. (2008)]

Growth on YM agar: After 5 days at 28°C, budding is multilateral and cells are spherical, $5\text{--}7\text{ }\mu\text{m}$, or elongate, $3\text{--}4 \times 7\text{--}11\text{ }\mu\text{m}$, and occur singly or in pairs. Colonies are white and butyrous in texture.

Dalmau plate cultures on corn meal agar: After 7 days at 28°C, pseudohyphae with blastoconidia were abundant. Septate hyphae were not observed.

Fermentation: Absent.

Growth (in Liquid Media)

Glucose	+	D-Ribose	+
Inulin	—	Methanol	—
Sucrose	+	Ethanol	—
Raffinose	+	Glycerol	+
Melibiose	+	Erythritol	+
Galactose	+	Ribitol	+
Lactose	—	Galactitol	+
Trehalose	+	D-Mannitol	n
Maltose	+	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	n
D-Xylose	w	Hexadecane	n
L-Arabinose	+	Nitrate	—
D-Arabinose	+	Vitamin-free	—

Additional Growth Tests and Other Characteristics

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

CoQ: 9 (Bhadra et al. 2008).

Mol% G + C: 50.2 (T_m : Bhadra et al. 2008).

Gene sequence accession numbers, type strain: D1/D2 LSU rRNA = AM410667, mitochondrial SSU rRNA = AM773806, cytochrome oxidase II = AM773804.

Cell carbohydrates: Not determined.

Origin of the strains studied: NRRL Y-48249 (W113A, MTCC 8332, CBS 10541), W113B, both strains were isolated from the intestine of a dead Trinket snake (*Elaphe* sp., Colubridae), Hyderabad, India (Bhadra et al. 2008).

Type strain: NRRL Y-48249 CBS 10541.

Systematics: Bhadra et al. (2008) reported *B. serpentis* to be most closely related to *B. chiropterorum* and *B. terrestris*, as shown in Fig. 87.1.

Ecology: The two known strains of *B. serpentis* were isolated from the intestine of a dead Trinket snake in India (Bhadra et al. 2008).

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

87.21. *Blastobotrys terrestris* (van der Walt & E. Johannsen) Kurtzman & Robnett (2007)

Synonyms:

Trichosporon terrestre van der Walt & E. Johannsen (1975d)

Geotrichum terrestre (van der Walt & Johannsen) Weijman (1979b)

Arxula terrestris (van der Walt & E. Johannsen) van der Walt, M.Th. Smith & Y. Yamada (1990c)

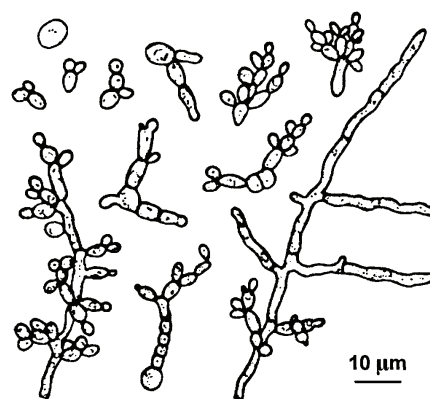


FIGURE 87.18 *Blastobotrys terrestris* CBS 6697. Budding cells, pseudohyphae and septate hyphae. Reproduced from Smith (1998d), after van der Walt and Johannsen (1975d), with permission.

Growth in glucose-yeast extract-peptone water: After 3 days at 25°C, branched, septate hyphae, 2–3.5 μ m in diameter, arthroconidia and pseudohyphae are abundantly formed. Budding yeast cells are ovoid, ellipsoid or cylindrical, 2.5–6.5 $\times$ 3–1 μ m, and occur singly, in pairs or small clusters (Fig. 87.18). A flocculent sediment and incomplete ring are present.

Growth on glucose-yeast extract-peptone agar: After 1 month at 25°C, the streak culture is cream colored, dry, soft, restricted, raised and delicately wrinkled, with a lobate margin.

Dalmau plate cultures on potato and corn meal agar: Pseudohyphae, septate hyphae and arthroconidia are abundantly formed. Blastoconidia occur on the hyphae at the septa or between septa, and may be single or in short chains. Arthroconidia vary in length, and may be short and spherical.

Formation of endospores: Endospores, which are formed by endoplasmic cleavage, were observed in old cultures on YM agar.

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	s	DL-Lactate	s
Soluble starch	s	Succinate	s
Cellobiose	s	Citrate	s
Salicin	s	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

2-Keto-D-gluconate	–	Cycloheximide 0.1%	+
5-Keto-D-gluconate	n	Starch formation	–
Saccharate	–	Gelatin liquefaction	n
60% (w/w) glucose	+	Growth at 37°C	+
10% NaCl/5% glucose	n	Growth at 40°C	+

CoQ: 9 (van der Walt et al. 1990c).

Mol% G + C: Not determined.

Gene sequence accession numbers, NRRL Y-17704: LSU rRNA (incl. D1/D2) = DQ442683, mitochondrial SSU rRNA = DQ442762, cytochrome oxidase II = DQ443090.

Cell carbohydrates: Glucose, mannose, galactose and glucosamine are present (Weijman 1979b).

Origin of the strains studied: CBS 278.86 (CBS 6697, IFO 10828), type strain of *T. terrestre*, isolated from grassland soil; CBS 7376 (IFO 10859, NRRL Y-17704), from soil, South Africa, J.P.van der Walt.

Type strain: CBS 278.86.

Systematics: *Blastobotrys terrestre* produces arthroconidia and budding cells, and the species was initially assigned to the genus *Trichosporon* (van der Walt and Johannsen 1975d). Weijman (1979b), however, revised the genus *Trichosporon* on the basis of whole-cell monosaccharide composition, restricted it to basidiomycetous arthroconidial yeast anamorphs, and restricted the genus *Geotrichum* to ascomycetous arthroconidial anamorphs. Consequently, Weijman (1979b) introduced the combination *G. terrestre*. However, this species was excluded by de Hoog et al. (1986) in their revision of *Geotrichum* on the basis of scant production of septate hyphae and its pronounced yeast-like appearance. Later, the species was placed in the genus *Arxula* as *A. terrestris* (van der Walt et al. 1990c). Multigene sequence analysis (Kurtzman and Robnett 2007) demonstrated the phylogenetic relationship of this species with the teleomorph/anamorph genera *Trichomonascus*/*Blastobotrys*. Consequently, *G. terrestre* was transferred to *Blastobotrys*.

Ecology: The two known strains of *B. terrestre* were isolated from soil.

Biotechnology: Unknown.

Agriculture and food: Unknown.

Clinical importance: Unknown.

COMMENTS ON THE GENUS

The genus *Blastobotrys* von Klopotek (1967), which may bud sparingly or not at all, was originally treated as a hyphomycete, and it was believed to be closely related to the genus *Sporothrix* Hektoen & Perkins (1900) from which it was distinguished on morphological criteria. However, members of *Blastobotrys*, as well as some *Sporothrix* species, were found to contain mannose as the predominant cell carbohydrate, whereas rhamnose and xylose were absent (Weijman and de Hoog 1985). Additionally, septa were reported to have micropores (Smith and Batenburg-van der Vegte 1985, 1986b), the coenzyme system was Q-9 (Suzuki and Nakase 1986, Yamada and Smith 1985), and a *Stephanoascus* (*Trichomonascus*) teleomorph was found for some species (de Hoog et al. 1985, Smith et al. 1976). Consequently, *Sporothrix* was reserved for anamorphs of the Ophiostomatales, and *Blastobotrys* was maintained for saccharomycetous fungi (de Hoog 1992). On the basis of D1/D2 LSU rRNA gene sequences, Kurtzman and Robnett (1995) placed the genus *Blastobotrys* in the Saccharomycetales, and suggested that *Blastobotrys*, *Arxula* and *Sympodiomyces* may represent the same anamorphic genus. In a later study, using multilocus analysis, this suggestion was confirmed (Kurtzman and Robnett 2007), and therefore species of *Arxula* and *Sympodiomyces* were transferred to *Blastobotrys*, the genus of nomenclatural priority.

Middelhoven et al. (1984) reported that *B. adenivorans* was able to utilize adenine, xanthine and similar compounds as a sole source of carbon. The preceding compounds are not widely utilized by yeasts, and Middelhoven and Kurtzman (2003) examined species that were phylogenetically related to *B. adenivorans* to determine if they could also utilize these compounds. This work showed that a majority of species able to utilize a suite of compounds that included adenine, glycine, uric acid, n-hexadecane, putrescine and branched-chain aliphatic compounds, such as isobutanol, leucine and isoleucine, were members of the *Trichomonascus*/*Blastobotrys* clade. *Candida blankii*, which appears distantly related to this clade (Kurtzman and Robnett 1998a, 2007), proved to be an exception, and assimilated many of these compounds. A conclusion from the work was that a relationship may exist between physiology and phylogeny when apparently unique metabolic pathways are examined.

This page intentionally left blank