

Bacteriological Aspects of Microfiltration of Cheese Whey^{1,2}

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ABSTRACT

Microfiltration of cheese whey using 1.2- μ m pore size membranes reduced bacterial counts by one to three times. Increased fat concentration in the feed stream governed the decrease in bacterial counts. Fat was trapped onto the membrane proportionally to its amount in the feed stream, and thus, formed a barrier to microorganism penetration into the permeate.

INTRODUCTION

Microfiltration is a pressure driven membrane process, like ultrafiltration and reverse osmosis, for separating or concentrating particulate streams of colloids in the submicron range (7). Microfiltration operates like ultrafiltration and is susceptible to fouling and concentration polarization, although to a lesser extent, because of the particulate nature of most feed streams applied (4, 5, 7, 8). At present, microfilters are commercially available from several manufacturers in different configurations. Some of the more suitable configurations for microfiltration are pleated tangential crossflow capsules and cartridges and hollow tubes. These achieve high crossflow velocities on the membrane surface to facilitate scraping the membrane surface in order to avoid formation of a concentration polarization layer or a dynamically formed membrane. Flat sheet membranes of the appropriate pore size also could be used in any existing plate-and-frame or flat-sheet tangential flow membrane units with the limits of the laminar flow of these units. The cost of commercial units varies

by company and materials of construction (stainless steel for the food industry or plastics for other uses). Membrane lifetime is according to the manufacturers' claims and is dependent, as in any other membrane process, on the nature of the feed stream and the cleaning and handling practice.

A typical process train for production of whey protein concentrates (WPC) was described by Goldsmith (2). This process includes fat and casein removal followed by high temperature, short time heat treatment (HTST) for reduction of the bacterial population.

Microfiltration with tangential flow modules was introduced for several biotechnical processes, such as bacterial harvesting (8), tissue homogenate filtration, and whey prefiltration (3, 7), and for cheese brine clarification (4). It was demonstrated that bacteria and yeasts and molds are retained by microporous membranes in the .2 to 1.2- μ m pore size (4). The reduction in bacterial counts in cheese whey was the end result of bacteria rejection by a microporous membrane in an ultrafiltered enriched permeate (3). Recently, a preliminary study indicated that bacterial counts of cheese whey were reduced by one to three times using microfiltration (5).

Removal of fat from cheese whey prior to concentration and production of WPC is necessary to obtain a high quality product with long shelf-life (1, 2, 3).

In our work the bacterial quality of microfiltered acid and sweet cheese whey was studied with emphasis on the role of fat in retaining bacteria in microfiltered feed streams.

MATERIALS AND METHODS

Acid and sweet cheese wheys before and after fat separation were obtained from a local dairy. The chemical composition of these wheys was determined as described previously (3, 4). Bacterial count was performed as standard plate count (6). Fat content of the whey and in the membranes was determined by the

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²The author is not advocating the use of any instruments or suppliers.

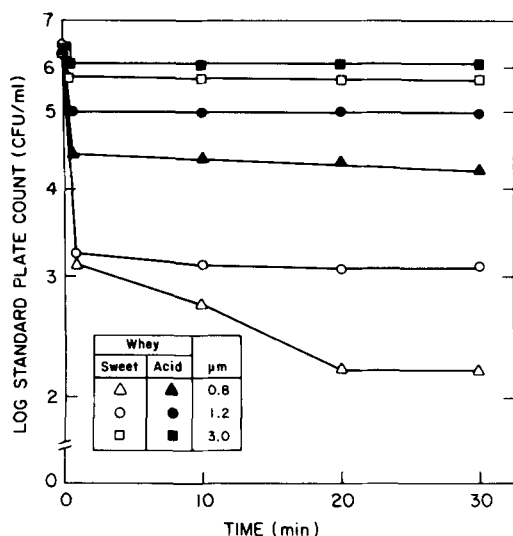


Figure 1. Bacterial reduction in acid and sweet cheese whey by microfiltration.

Roese-Gottlieb method (6). The membrane was removed from the filtration apparatus, rinsed thoroughly with deionized water, and placed in the Roese-Gottlieb bottle and analyzed. A clean membrane was analyzed as a blank. Fat content was calculated as grams of fat per effective filtering area. Microporous membranes with pore sizes of .8, 1.2, and 3.0 μm were obtained from GSI (Gelman Sciences, Ann Arbor, MI). Microfiltration was performed using Amicon

TCF 2A ultrafiltration cell (Amicon Inc., Lexington, MA), operating at 150 kPa, with .7 m/s crossflow pumping rate.

RESULTS AND DISCUSSION

The reduction in bacterial count of microfiltered cheese whey, using different pore size membranes, is shown in Figure 1 for both acid and sweet cheese whey. Bacterial reduction of sweet whey was greater than that of acid whey with every membrane. Permeate from microfiltered sweet whey (1.2- μm membrane) counted 1200 cfu/ml compared with 8700 cfu/ml in heat treated sweet whey (65° C for 20 min). Although the .8- μm membrane gave the best bacterial rejection (4 $\times$), it was not used for further experiments due to increased protein rejection (3).

Acid and sweet whey differ in their chemical composition, such as fat content and bacteriological population, due to their different starter cultures and pH. Preliminary experiments indicated fat content was the crucial parameter for reduction of bacterial counts by microfiltration (3); fat content was the variable studied in this work. Three types of microfiltered cheese whey were compared. Results are presented in Table 1. Fat content of whey appears to contribute most to reduced bacterial counts. The chemical composition of the microfiltered stream, except fat, is not altered by the filtration procedure, and the minor

TABLE 1. Chemical composition¹ and bacterial counts¹ of whey before and after microfiltration².

	Fat	Protein ³	Dry matter	Ash	Bacterial count
	(%)				(cfu/ml)
Acid whey					
Before filtration	0	.73	5.33	.42	2.8×10^6
After filtration	0	.72	5.36	.42	2.7×10^5
Separated sweet whey					
Before filtration	.09	.70	4.92	.50	3.4×10^6
After filtration	.01	.67	4.93	.50	5.7×10^4
Nonseparated sweet whey					
Before filtration	.34	.79	5.64	.50	5.5×10^6
After filtration	.01	.72	5.76	.53	3.0×10^3

¹ Results are means of triplicates.

² Microfiltration was performed using a 1.2- μm pore size membranes.

³ N $\times$ 6.38.

TABLE 2. Accumulation of fat on the membrane after whey filtration and reduction of bacteria in the permeate stream.

Membrane pore size	Feed stream	pH	Fat in feed	Fat on membrane ¹	Reduction of bacteria
(μm)			(%)	(g/m ²)	(OOM) ²
1.2	Acid whey	4.5	.0	.0	1
1.2	Sweet whey ³	6.2	.09	6.37	2
1.2	Sweet whey ⁴	6.2	.34	11.07	3

¹ After filtration of 70 ml of whey.

² Orders of magnitude.

³ Separated whey.

⁴ Nonseparated whey.

decrease in protein content is due to removal of casein fines by the membrane filter as previously described (3). To account for fat losses, membranes were analyzed at the end of the experiment. The presence of a "fouling" fat layer, which accumulated on the membrane surface and in the membranes pores, could explain some of the bacteria rejection. Fat was trapped on the membrane; quantity was proportional to the fat content in the feed stream (Table 2). The fat layer formed on the membrane is the main barrier to penetration by microorganisms, and the higher the fat content, the better the rejection of bacteria by the membrane.

CONCLUSIONS

The quality of WPC is a function of the whey used for its production. Because most of the WPC powder produced in the world is from sweet whey, it is suggested that sweet cheese whey could be treated by microfiltration to remove fat and reduce bacterial population, thus eliminating the need for fat separation and heat treatment of whey prior to concentration.

ACKNOWLEDGMENTS

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