The Influence of Filtration of Inoculated Wash Water on Bacterial Count and Keeping Qualities of Butter¹

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ILTRATION of butter wash water usually involves only the elimination of extraneous material. The removal of bacteria has received little attention due, presumably, to the infrequent occurrence of defects in butter in which contaminated water is responsible. The tendency in recent years for increasing the production of low salted and of unsalted butter, in which the restraining action of the salt is partially or wholly eliminated, emphasizes the necessity for reducing bacterial contamination of butter. The object of the work herein reported was to study the efficiency of a filter designed to remove bacteria from water and to determine the influence of filtration of contaminated butter wash water on the keeping qualities of butter.

METHODS

The general procedure was as follows: Plate counts were made on the inoculated water before and after filtration; a portion of butter was washed with the unfiltered water and another portion washed with the filtered water. Plate counts were made on the fresh salted and unsalted butter from each lot, the butter then stored at various temperatures and examined periodically for flavor defects, and bacterial counts again made after storage.

For each trial a few gallons of water were inoculated with a broth culture of a test organism and half of the water filtered through a Seitz filter² that had been treated with flowing steam for about 30 minutes. Two

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² The filter was obtained through the courtesy of Dr. B. Lichtenberger, American Seitz Filter Corporation, 31 Union Square, New York, N. Y.

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lots of butter churned from sweet cream without butter culture added were removed from a churn after draining the buttermilk and one was washed with the unfiltered water while the other was washed with the filtered water. The butter was worked in sterile granite pans with sterile paddles, a portion of each lot salted and the butter then packed in sterile glass jars each holding about one-third of a pound. Plate counts were made on the unfiltered and filtered water and on the fresh salted and unsalted butter from each lot, after which samples from each lot of butter were stored at 21° C. for 7 days, 15° C. for 14 days, 5° C. for 28 days and 0° C. for 56 days; the storage temperatures were approximate rather than actual. Examinations for flavor defects were made at intervals during the storage periods and plate counts were made on the samples after storage. For the plate counts the medium used was beef-infusion agar with 0.5 percent sterile skim milk added; the plates were incubated at approximately 21° C. for 4 days.

ORGANISMS USED

The test organisms used were from stock cultures and were known to be able to produce definite defects in unsalted butter. They were: Serratia marcescens, Pseudomonas fluorescens, Achromobacter lipolyticum, Alcaligenes viscosus, and Pseudomonas fragi, which produce primarily rancidity, and Achromobacter putrefaciens, which produces surface taint.

RESULTS

Data were secured in which each of the six test organisms was used in two trials. The counts on the unfiltered and the filtered water and on the fresh salted and unsalted butter are presented in table 1.

EFFICIENCY OF FILTRATION

The counts on the unfiltered and the filtered butter wash water given in the table indicate a high degree of efficiency for the filter employed. The treatment of the filter with flowing steam would not be expected to destroy all the organisms, and this may account for the few bacteria detected in the filtered water; it must also be recognized that air contamination probably contributed a few organisms. When a test organism developing distinctive colonies, such as *Serratia marcescens*, was used, no colonies of the inoculated organism appeared on the plates poured from the filtered water.

BACTERIAL COUNTS ON THE FRESH BUTTER

Salted butter. The results in the table show that the counts on the fresh salted butter washed with the unfiltered water were, in general, slightly higher than the counts on the butter washed with the filtered water but there was no great difference between the counts in any trial regardless of the counts on the wash water used. The butter washed with

Trial No.	Organism used	Organisms per ml. of					
		Butter wash water		Fresh salted butter washed with		Fresh unsalted butter washed with	
		Unfiltered	Filtered	Unfiltered water	Filtered water	Unfiltered water	Filtered water
1 2 3 4 5 6	S. marcescens Ps. fluorescens Ach. lipolyticum Ach. putrefaciens Alc. viscosus Ps. fragi	510,000 185,000 370,000 448,000 283,000 1,020,000	2 4 12 8 1 1	210,000 188,000 268,000 330,000 370,000 284,000	$\begin{array}{c} 240,000\\ 194,000\\ 174,000\\ 310,000\\ 360,000\\ 245,000 \end{array}$	490,000 295,000 360,000 400,000 490,000 450,000	355,000 283,000 180,000 420,000 510,000 420,000
7 8 9 10 11 12	S. marcescens Ps. fluorescens Ach. lipolyticum Ach. putrefaciens Alc. viscosus Ps. fragi	$\begin{array}{c} 1,800,000\\ 1,720,000\\ 7,300,000\\ 1,760,000\\ 275,000\\ 250,000\end{array}$	11 8 4 12 19 35	$\begin{array}{r} 940,000\\ 1,000,000\\ 1,210,000\\ 4,500,000\\ 5,600,000\\ 4,300,000\end{array}$	$\begin{array}{c} 690,000\\ 820,000\\ 1,150,000\\ 4,300,000\\ 6,000,000\\ 5,200,000\end{array}$	$\begin{array}{c} 1,170,000\\ 1,820,000\\ 4,100,000\\ 4,000,000\\ 5,400,000\\ 5,700,000\\ \end{array}$	$\begin{array}{c} 1,220,000\\ 1,690,000\\ 2,030,000\\ 4,300,000\\ 5,300,000\\ 6,200,000\end{array}$

TABLE 1. Plate counts on the butter wash water and on the fresh butter

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the unfiltered water had the higher count in seven trials, whereas the butter washed with the filtered water had the higher count in five.

The salt content of the butter washed with the unfiltered water ranged from 1.53 to 4.08 and averaged 2.48 percent; the salt content of the butter washed with the filtered water ranged from 1.57 to 4.68 and averaged 2.67 percent.

Unsalted butter. The data given in the table show that the counts on the unsalted butter washed with the unfiltered water were, in general, slightly higher than the counts on the butter washed with the filtered water; but in only two comparisons (trials 3 and 9) were the differences significant. In one of these trials (trial 3) the count on the unfiltered water was similar to that in many of the trials, but in the other (trial 9) the count was by far the highest of all the trials. The butter washed with the unfiltered water had the higher count in seven trials, whereas the butter washed with the filtered water had the higher count in five.

In general, the counts on the unsalted butter were considerably higher than those on the salted butter and the influence of filtration of the wash water was more conspicuous in the counts on the unsalted product. It might be emphasized that the numbers of bacteria in the wash water appeared to have no significant effect on the bacterial content of the fresh butter.

KEEPING QUALITIES OF THE BUTTER AT VARIOUS TEMPERATURES

Salted butter. In the salted butter stored at 21° C. for seven days, extensive changes in flavor were not common, but in four trials (trials 5, 7, 8 and 9) the butter washed with the unfiltered water became rancid; none of the samples of butter washed with the filtered water developed defects due to bacterial action. After storage the counts on the butter washed with the unfiltered water ranged from 70,000 to 105,000,000 per ml., whereas those on the butter washed with the filtered water ranged from 25,000 to 57,000,000 per ml.; the butter washed with the unfiltered water had the higher count in five trials and the butter washed with the filtered water the numbers of bacteria increased during storage in eight trials and decreased in four.

In general, the salted butter stored at 15° C. for 14 days kept well, but in two trials (trials 7 and 9) the butter washed with the unfiltered water became rancid and in one trial (trial 12) cheesy; none of the butter washed with the filtered water showed defects due to bacterial action. After storage the counts on the butter washed with the unfiltered water ranged from 40,000 to 20,400,000 per ml., whereas those on the butter washed with the filtered water ranged from 30,000 to 32,000,000 per ml.; the butter washed with the unfiltered water had the higher count in four trials, and the butter washed with the filtered water had the higher count in eight. The counts on the butter washed with the unfiltered water increased during storage in six trials and decreased in six, whereas the counts on the butter washed with the filtered water increased in seven and decreased in five.

In the salted butter stored at 5° C. for 28 days no definite defects due to bacterial action occurred in either the butter washed with the unfiltered or with the filtered water. After storage the counts on the butter washed with the unfiltered water ranged from 45,000 to 11,500,000 per ml., whereas those on the butter washed with the filtered water ranged from 57,000 to 6,100,000 per ml.; the butter washed with the unfiltered water had the higher count in five trials and the butter washed with the filtered water had the higher count in seven. During storage the counts on the butter washed with the unfiltered water increased in four trials and decreased in eight and those on the butter washed with the filtered water increased in five and decreased in seven.

During storage at 0° C. for 56 days the salted butter washed with the unfiltered water became rancid in two trials (trials 9 and 12) but none of the samples of butter washed with the filtered water developed defects. After storage the counts on the butter washed with the unfiltered water ranged from 44,000 to 12,500,000 per ml. and those on the butter washed with the filtered water ranged from 38,000 to 4,200,000 per ml.; the butter washed with the unfiltered water had the higher count in seven trials and the butter washed with the filtered water had the higher count in five. During storage the counts on the butter washed with the unfiltered water increased in three trials and decreased in nine, whereas those on the butter washed with the filtered water increased in four and decreased in eight.

Unsalted butter. The unsalted butter stored at 21° C. for seven days commonly showed pronounced deterioration but, in general, the butter washed with the filtered water was distinctly superior in keeping quality to the butter washed with the unfiltered water. In nine trials (trials 1, 2, 3, 5, 6, 7, 8, 9 and 11) the butter washed with the unfiltered water became rancid, yet none of the samples of butter washed with the filtered water showed this defect. In two trials (trials 4 and 10) the defect characterized as surface taint developed in the butter washed with the unfiltered water while in the butter washed with the filtered water the slight cheesiness that appeared was not characteristic of the organism (Ach. putrefaciens) which had been used in these trials. In several trials, cheesiness developed in both the butter washed with the unfiltered and with the filtered water; in fact, this defect appeared in nearly all of the butter in the last six trials in which the bacterial counts on the fresh butter were rather high. After storage the counts on the unsalted butter washed with the unfiltered water ranged from 8,100,000 to 180,000,000 per ml.; the counts on the butter washed with the filtered water ranged from 28,500,000 to 520,000,000 per ml. The butter washed with the unfiltered water had the higher count in two comparisons, and the butter washed with the filtered water had the higher count in 10. All the

samples of butter showed large increases in bacterial content during storage.

The butter stored at 15° C. for 14 days showed essentially the same changes that occurred in the butter stored at 21° C. for seven days. The butter washed with the unfiltered water became rancid in nine trials (trials 1, 2, 3, 5, 6, 7, 8, 9 and 11) but none of the samples of butter washed with the filtered water showed this defect. In two trials (trials 4 and 10) surface taint appeared in the butter washed with the unfiltered water but not in the butter washed with the filtered water. After storage, counts on the butter washed with the unfiltered water ranged from 14,000,000 to 190,000,000 per ml., whereas those on the butter washed with the filtered water ranged from 26,000,000 to 120,000,000 per ml.; the butter washed with the unfiltered water had the higher count in two trials while the butter washed with the filtered water had the higher count in ten. Large increases in bacterial count were noted in all the samples during storage.

The unsalted butter stored at 5° C. for 28 days showed less deterioration than the butter stored at the higher temperatures. The butter washed with the unfiltered water became rancid in five trials (trials 1, 2, 3, 8 and 12) and developed surface taint in two trials (trials 4 and 10); none of the samples of butter washed with the filtered water developed definite defects. After storage the counts on the butter washed with the unfiltered water ranged from 6,000,000 to 137,000,000 per ml., whereas the counts on the butter washed with the filtered water ranged from 8,500,000 to 141,000,000 per ml.; the butter washed with the unfiltered water had the higher count in three trials and the butter washed with the filtered water had the higher count in nine. Large increases in bacterial count were noted in all the samples during storage.

The unsalted butter stored at 0° C. for 56 days showed no conspicuous deterioration after 28 days' storage, but by the end of the holding period definite defects were evident in a few of the samples of butter washed with the unfiltered water. The butter washed with the unfiltered water developed rancidity in four trials (trials 1, 2, 3 and 9), surface taint in two (trials 4 and 10), and pronounced cheesiness in one (trial 12), but none of the rest of the samples developed defects beyond a slight cheesy or slight unclean flavor. After storage the counts on the butter washed with the unfiltered water ranged from 7,600,000 to 227,000,000 per ml., while the counts on the butter washed with the filtered water ranged from 18,000,000 to 310,000,000 per ml.; the butter washed with the unfiltered water had the higher count in three trials, whereas the butter washed with the filtered water had the higher count in nine. Large increases in bacterial content occurred in all the samples during storage.

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DISCUSSION AND SUMMARY

Results were obtained in 12 trials in each of which a portion of inoculated water was filtered through a Seitz filter and the unfiltered and filtered water each used to wash a small lot of freshly churned butter; bacterial counts were made on the unfiltered and the filtered water and on the fresh salted and unsalted butter from each lot and samples of the butter then stored at various temperatures to determine their keeping qualities and changes in bacterial content.

The counts on the unfiltered and the filtered water indicate very efficient filtration and the few organisms detected in the filtered water apparently resulted from contamination rather than from passage through the filter.

The bacterial counts on both the fresh salted and fresh unsalted butter washed with the unfiltered water were, in general, slightly higher than the counts on the butter washed with the filtered water and the influence of filtration was more conspicuous with the unsalted than with the salted butter. In this connection it should be emphasized that the bacterial content of the butter wash water did not greatly influence the number of bacteria in the fresh butter. In only two comparisons were there significant differences between the count on the butter washed with the unfiltered water and on the butter washed with the filtered water even though in many trials the unfiltered water contained enormous numbers of organisms while the filtered water contained very few.

The results obtained with the salted butter indicate that pronounced deterioration was not common under the storage conditions employed but that when deterioration occurred the defects involved the butter washed with the unfiltered water. In general, the bacterial content of the salted butter increased during storage at 21° C. for 7 days or at 15° C. for 14 days but decreased during storage at 5° C. for 28 days or at 0° C. for 56 days. Unfortunately, the conditions for working and salting the butter did not permit accurate composition control and, consequently, the salt content varied considerably. The inhibitory influence of the salt was roughly proportional to the concentration but in some instances conspicuous increases in bacterial content and definite deterioration were noted in samples having fairly high salt content.

The results obtained with the unsalted butter indicate that deterioration occurred more frequently and more extensively than with the salted butter and that the butter washed with the filtered water was distinctly superior in keeping quality to the butter washed with the unfiltered water. The defects that involved the butter washed with the unfiltered water were usually the ones expected from the organisms used, while the defects that appeared in the butter washed with the filtered water were usually not. Deterioration was more common in the butter stored at 21° C. for 7 days or at 15° C. for 14 days than in the butter stored at 5° C. for 28 days or at 0° C. for 56 days. Enormous increases in bacterial content

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were common in all the samples of unsalted butter during storage at the various temperatures and, in general, the butter washed with the unfiltered water had lower counts at the end of the storage period than did the butter washed with the filtered water. In this connection it was noted that the samples having pronounced defects often had low counts due, presumably, to the toxic effect of the products formed and that the samples of butter washed with the filtered water often had high counts but showed little or no deterioration.

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