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The Use of Dry Skim Milk in the Manufacture of Cultured Buttermilk

By

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The Use of Dry Skim Milk in the Manufacture of Cultured Buttermilk

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Contents

The Use of Dry Skim Milk in the Manufacture of Cultured Buttermilk

CONSUMER demand for a constant supply of high quality dairy products is the greatest asset of the dairy industry. Both producer and manufacturer, equally appreciative of this fact, are bending every effort to produce products of high quality. The manufacture of cultured buttermilk is no exception and the preparation of a uniform, high quality product is becoming increasingly important to the consuming public and to the entire dairy industry.

The Standard Milk Code, United States Public Health Service, defines cultured buttermilk as "the product resulting from the souring or treatment, by a lactic acid culture, of milk or milk products. It contains not less than 8.5% of milk solids not fat, and shall be pasteurized before adding the culture."

Various dairy products have been used for the manufacture of cultured buttermilk. One of these products, dry skim milk, is gaining rapidly in favor because of its uniformity, ease of handling, splendid keeping qualities, and general suitability.

Few attempts have been made to study the underlying factors responsible for the manufacture of a high quality buttermilk from dry skim milk. As a result wide variations have occurred in flavor, viscosity, body, texture, and stability of the finished buttermilk.

One of the most outstanding experiments dealing with its preparation and processing is that of Reid and Welch (1) who found essentially "that increasing the pasteurization temperature above 180° F. or exposing the milk for a period exceeding 30 minutes decreased the score of the aroma and flavor by causing a powder taste and odor to become apparent;" that cooling of the fermented milk prior to breaking the curd should be practiced; that the reconstructed buttermilk should be stored at temperatures lower than 42° F.; that the higher the percentage of starter used to inoculate the reconstructed buttermilk, the more desirable the flavor, aroma, body, and texture; and that the addition of normal skim milk in amounts exceeding ten per cent improved the reconstructed buttermilk in aroma, flavor, body, and texture.

Acknowledgements—Appreciation is expressed to: The American Dry Milk Institute, Inc., Chicago, Ill., for the grant of a fellowship which made these studies possible; Prof. M. L. Nichols and Messrs. F. A. and T. H. Kummer of the Department of Agricultural Engineering for the construction of much equipment used in the work; CHR. Hansen's Laboratory, Milwaukee, Wis.; Elov. Ericsson Co., St. Paul, Minn.; National Canners Laboratory, Pittsburgh, Pa.; Dairy Laboratory, St. Louis, Mo.; Dairy Products Laboratories, Pittsburgh, Pa.; Lacteal Analytical Laboratories, Buffalo, N. Y., for furnishing cultures used in part of these studies; Viking Pump Co., Cedar Rapids, Iowa; Cherry Burrell Corp., Little Falls, N. Y.; and Specialty Brass Co., Inc., Kenosha, Wis., for the loan of pumps; Mr. John L. Whatley for extending facilities of the Opelika Creamery for commercial application of these studies.

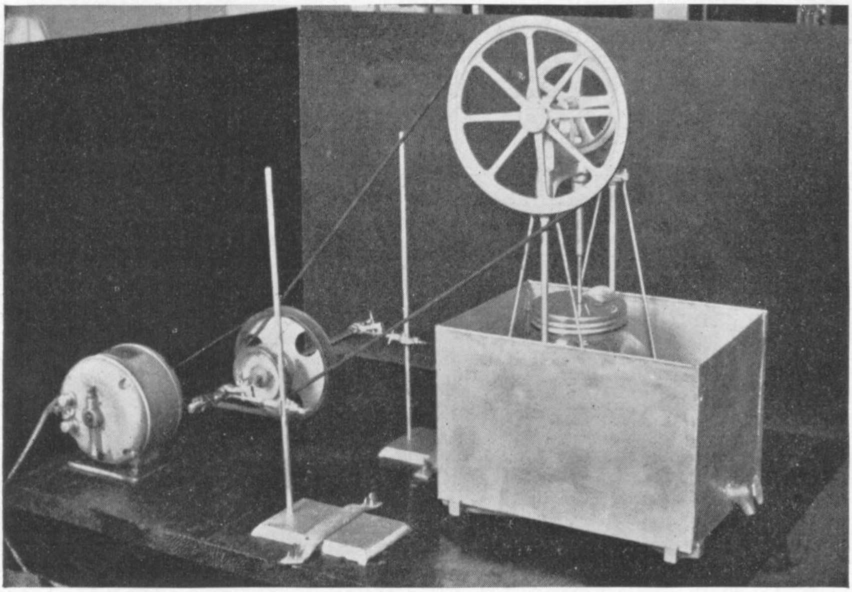

FIGURE 1.—DEVICE FOR BREAKING AND AGITATING THE CURD.

Several studies bearing indirectly on the preparation of dry skim milk buttermilk have been performed by various workers. Larsen and White (2) successfully used dry skim milk for starter making in creameries and found it to be "a suitable substitute for natural skim milk in creameries where skim milk is not easily obtainable."

Burke (3) defines good buttermilk as being of "a mild, rather sweet, acid flavor which should be viscous and creamy in appearance, pouring from a bottle much the same as thick gravy. After curdling, it should break up readily into a fine, flocculent, smooth, homogeneous mixture which contains no lumps and does not whey-off when held in storage at a low tempertaure for two days or longer." The same worker has shown vigorous agitation to be responsible for the defect of "wheying-off" in normal skim milk buttermilk.

Knaysi (4), reporting investigations on buttermilk made from normal skim milk, found no benefit as a result of homogenizing either prior to or after souring.

Hammer (5) reports a temperature range of 21° to 23° C. as being most suitable for the propagation of starters.

OBJECT

The object of these studies was to determine those factors and plant practices essential to the preparation of high quality cultured buttermilk through the use of dry skim milk.

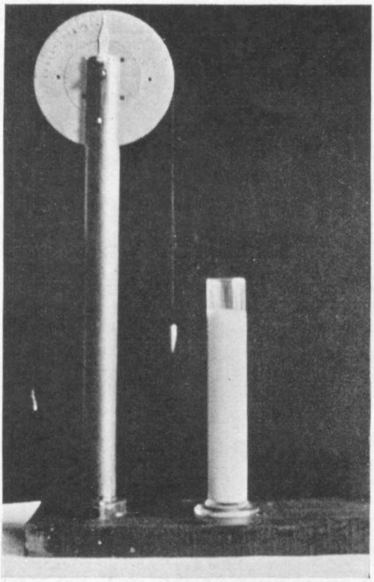

FIGURE 2.—DEVICE USED TO TEST VISCOSITY, SIMILAR TO THE BELL AND BURKEY PENETROMETER.

The effect of the following factors on the flavor and physical properties was studied:

(1) Variation in total solids content.
(2) Breaking the curd at different temperatures.
(3) Viscolization.
(4) Incorporation of air.
(5) Pumping under different conditions.
(6) Use of different lactic starters.
(7) Addition of dry skim milk to natural skim milk.

METHODS AND EQUIPMENT

Throughout the entire series of tests a careful attempt was made to control each factor. A lactic ferment, liquid type, was used throughout the series and carried forward by daily transfers. All culture for inoculation was measured with a sterilized ounce measure. Dry skim milk of the highest grade was used in the tests. The normal skim milk, used for comparison, was separated from milk obtained from the college herd of Jersey cows.

Except as noted in the text, cooling and breaking the curd for each series of tests was accomplished by means of a special device which consisted of a glass churn jar held in place by a wooden frame set in a small metal container. The jar was supported by the frame in a manner that permitted ice water to come in contact with the sides and bottom, thus affording uniform cooling of the curd, either prior or subsequent to breaking and agitating (Fig. 1).

Viscosity determinations were made with an instrument (Fig. 2) similar to that of Bell and Burkey (6) by noting the time in seconds required for a miniature plumb bob to travel downward through a column of buttermilk a distance of 70 centimeters. Analysis for total solids was made on a Mojonnier tester. Acidity was determined on weighed 9-gram samples with N/10 sodium hydroxide, using phenolphthalein as indicator.

Placings for flavor were made by persons to whom the identity of the samples was unknown.

THE EFFECT OF DIFFERENT TOTAL SOLIDS CONTENT AND TEMPERATURES OF BREAKING THE CURD ON THE PHYSICAL PROPERTIES OF CULTURED BUTTERMILK MADE FROM DRY SKIM MILK

Procedure

Test 1.—In a preliminary test the cultured buttermilk was prepared by dissolving in water various weighed quantities of dry skim milk to obtain samples of approximately 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, and 12.0 per cent of total solids, respectively. The buttermilk containing 8.0 to 9.0 per cent solids had a flat, watery flavor, low viscosity, and poor keeping qualities. Samples containing 12.0 per cent solids had an objectionable heated flavor and a gelatinous, somewhat slimy body and texture; hence, percentages above 11.0 and under 9.0, were disregarded in the succeeding experiments.

Three series of tests were made on duplicate 6-pound portions of buttermilk prepared by dissolving dry skim milk in water. The buttermilk samples of each series contained a total solids content of approximately 9.0, 10.0, and 11.0 per cent, respectively. Buttermilk made from normal skim milk was used for comparison. All samples were made in glass jars of 1-gallon capacity. The dry skim milk water mixture and the normal skim milk samples were heated to 180° F. for 30 minutes. All samples were then cooled to 68° F. and cultured with 7 per cent culture. At the end of 15 to 16 hours the samples were treated as follows:

Portion 1 was broken up at the temperature of incubation. The curd was then cooled to 50° F. and two half-pint samples taken from each of the 9.0, 10.0, and 11.0 per cent lots. One group of half-pint samples was held at room temperature; the other, at a temperature of 35° to 38° F. Portion 2 was treated the same as Portion 1 with the exception that samples of Portion 2 were cooled to 50° F. prior to breaking the curd. The curd in both portions was broken with an agitator operating at a speed of 323 R.P.M. for two minutes. Acidity and viscosity tests were made after breaking the curd of each portion. Wheying-off measurements were made at the end of 24, 48, 96, and 168 hours. Results are recorded in Table 1.

Test 2.—Results of the preceding test indicated that a total solids content in the dry skim milk buttermilk of somewhere near ten per cent was desirable from the standpoint of producing a palatable flavor and satisfactory body. Accordingly, a test was made wherein three series of 6-pound samples of buttermilk were prepared to contain approximately 9.5, 10.0, and 10.5 per cent total solids. These were compared with one sample of

TABLE 1.—Effect of 9.0, 10.0, and 11.0 Per Cent Total Solids Content and Cooling Prior to Breaking Curd on the Viscosity, Appearance, and Separation of Whey of Cultured Buttermilk Made from Dry Skim Milk Compared With Normal Skim Milk Buttermilk.

(Average of Three Tests)

Total solids per cent		Treatment	Acidity	Vis-cosity	Appear-ance after breaking curd*	Whey after standing; measured in eighths of inches							
						At room temperature				At 35° to 38° F.			
Desired	Actual		per cent	seconds		24 hours	48 hours	96 hours	168 hours	24 hours	48 hours	96 hours	168 hours
9	9.18	Uncooled	.82	9.6	Sl. foamy-smooth	8.6	13.0	14.6	16.0	4.3	6.6	7.6	9.3
		Cooled	.85	12.3	Smooth	7.3	9.3	12.0	14.0	1.3	1.3	2.0	2.6
10	10.08	Uncooled	.87	20.3	Sl. foamy-smooth	5.6	7.3	11.6	13.3	1.6	3.3	4.6	6.3
		Cooled	.92	37.6	Smooth	3.3	6.6	9.6	11.0	0.3	1.0	1.0	2.0
11	11.06	Uncooled	.95	99.3	Sl. foamy-smooth	2.0	4.6	8.6	10.6	0	0	0	2.0
		Cooled	.98	167.6	Smooth	1.3	3.3	7.6	9.6	0	0	0	0.3
Normal skim milk	9.50	Uncooled	.89	1444.0	Sl. lumpy	2.5	6.5	9.0	10.5	0	0	0	0
		Cooled	.86	Too high for test	Sl. lumpy	2.6	4.3	8.3	10.0	0	0	0	0.6

* "Sl." in column is abbreviation for "slightly".

TABLE 2.—Effect of 9.5, 10.0, and 10.5 Per Cent Total Solids Content on Viscosity, Appearance, and Separation of Whey of Cultured Buttermilk Cooled Prior to Breaking Curd Compared With Normal Skim Milk Buttermilk.

(Average of Three Tests)

Total solids per cent		Acidity	Viscosity	Appearance after breaking curd*	Whey after standing; measured in eighths of inches							
					At room temperature				At 35° to 38° F.			
Desired	Actual	per cent	seconds		24 hours	48 hours	96 hours	168 hours	24 hours	48 hours	96 hours	168 hours
9.5	9.43	.94	14.3	Smooth	11.6	13.3	14.3	15.0	6.3	7.6	8.6	9.0
10.0	9.88	.98	26.3	Smooth	11.0	13.0	14.0	14.0	5.3	6.6	7.0	8.6
10.5	10.38	1.02	49.0	Smooth	9.3	11.6	12.0	13.0	2.0	3.6	4.6	5.3
Normal skim milk	9.75	1.00	Too high for test	Sl. lumpy	6.6	8.3	9.6	10.3	0.3	1.3	1.6	2.6

* "Sl." in column is abbreviation for "slightly".

buttermilk made from normal skim milk. All samples were treated in a manner identical with those in Test 1, with the exception that 5 per cent culture was used for inoculation in order to better control the development of acid. All samples were cooled prior to breaking the curd. Results are recorded in Table 2.

Discussion of Results

The method of handling the buttermilk prior to breaking the curd is important in preventing the separation of whey. In each case it proved highly desirable to cool the curd prior to breaking. Samples cooled after breaking the curd, regardless of the rapidity with which the temperature was lowered, gave evidence of much more whey separation than the uncooled samples. In the majority of cases, even where samples were held at room temperature, it was found desirable to cool the curd prior to breaking; whereas, those samples cooled before the curd was broken and held at a temperature of 35° to 38° F. showed very little whey separation, thus confirming the findings of Reid and Welch. There was a gradual decrease in the tendency to whey-off as the percentage of solids increased in the cultured buttermilk. Typical examples of the effect of cooling and of the percentage of total solids on wheying-off are shown in Figure 3.

The acidity increased as the percentage of solids increased. However, the increased acidity was desirable as it tended to mask the slightly heated flavor of dry skim milk buttermilk, thus improving the palatability. As might be expected, the cooled samples showed a slightly higher acidity because of the extra time required to cool the curd prior to breaking.

The body and texture of the dry skim milk buttermilk was noticeably smoother and creamier than that of the control samples of cultured buttermilk prepared from normal skim milk and improved as the percentage of total solids was increased. The curd was more easily broken and entirely free from lumps; whereas, that of the normal skim milk buttermilk was very firm and somewhat lumpy when broken under the same conditions. Viscosity increased as the total solids increased.

Flavor was improved as the percentage of total solids increased up to and including a concentration of about ten per cent. Immediately after breaking and cooling the curd a heated flavor was apparent which was quite pronounced in samples containing over 10.0 per cent total solids. However, after aging at 35° to 38° F. for 24 hours the heated flavor was greatly reduced and in most cases practically eliminated. Samples containing 11 per cent total solids had a distinctly heated flavor while those containing 9 per cent were somewhat thin and flat. In all cases the viscosity of the buttermilk increased as the concentration of solids increased. The flavor of those samples containing 10.0 per cent solids compared favorably with that of the buttermilk

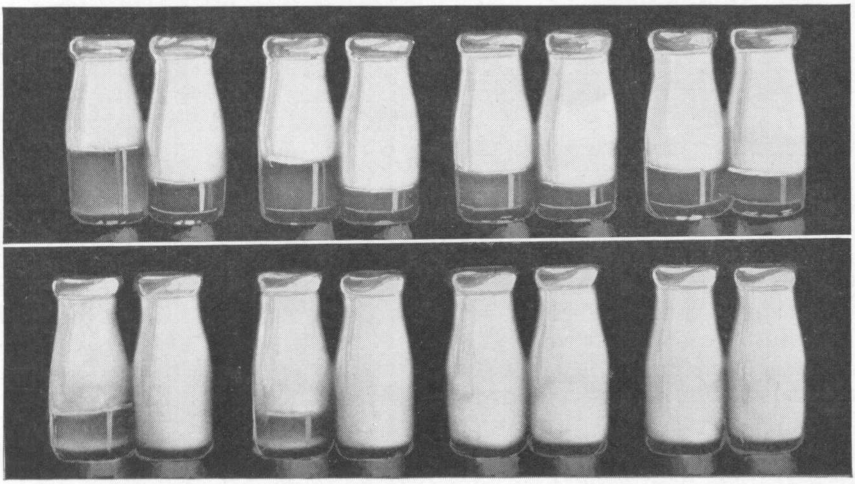

FIGURE 3.—ILLUSTRATING THE EFFECT OF TOTAL SOLIDS AND TIME OF COOLING CURD ON WHEY SEPARATION IN CULTURED BUTTERMILK.

Upper row: After 96 hours standing at room temperature.
Lower row: After 96 hours standing at 35° to 38° F.
Reading from left to right—Samples 1 and 2 contain approximately 9 per cent solids; Samples 3 and 4, 10 per cent; Samples 5 and 6, 11 per cent. Samples 7 and 8 were normal skim milk. Curd in Samples 1, 3, 5, and 7 was broken prior to cooling. Curd in Samples 2, 4, 6, and 8 was cooled prior to breaking.

made from normal skim milk and in many instances was rated as being superior.

Conclusions

(1) Cultured buttermilk made from dry skim milk should be cooled prior to breaking the curd.

(2) As the total solids content is increased the amount of whey separation decreases.

(3) An increase in acidity tends to mask the slightly heated flavor of cultured buttermilk made from dry skim milk.

(4) Body and texture were improved and viscosity was increased with each increase in the percentage of total solids up to and including approximately 11.0 per cent.

(5) A total solids content of 10.0 per cent was considered most desirable from the standpoint of flavor. Samples containing 11.0 per cent solids had a distinctly heated flavor while those containing 9.0 per cent were thin and watery in taste.

THE EFFECT OF DIFFERENT TOTAL SOLIDS CONTENT ON THE FLAVOR OF CULTURED BUTTERMILK MADE FROM DRY SKIM MILK

Procedure

Flavor tests of samples in Tests 1 and 2 showed a total solids content of approximately 10.0 per cent to be most desirable. As a further test, two lots of cultured buttermilk were prepared; Lot 1, consisting of normal skim milk, was divided into three 10-gallon samples, each of which was heated to 180° F. for 30 minutes and cooled to 70° F. At different time intervals culture was added to one of the three samples in order to vary the acidity. Lot 2, also consisting of three samples, was made of dry skim milk and each sample contained approximately 9.0, 10.0, and 11.0 per cent total solids, respectively. Both lots were tested for flavor by 100 different persons, each of whom placed the samples according to preference. Twenty-four hours later a second comparison was made of the best sample in each lot. Results are recorded in Table 3.

Discussion of Results

Data obtained in the test of both lots indicated very little preference of persons for any one of the three samples in either lot. The samples of dry skim milk buttermilk containing 9.0, 10.0, and 11.0 per cent solids (A, B, C) placed first in 33, 32, and 35 per cent of the trials, respectively; samples of normal skim milk buttermilk each of the same percentage of solids but of .86, .89, and .95 percentage of acidity (D, E, F), placed first in 36, 32, and 32 per cent of the trials, respectively. However, when first and second placings were combined the ratings for dry skim milk buttermilk were 81, 61, and 58 per cent for 10.0,

TABLE 3.—Flavor Comparisons of Dry Skim Milk Buttermilk Samples Containing Different Percentages of Solids and Normal Skim Milk Buttermilk Samples With Different Percentages of Acidity.

Total solids per cent	Acidity per cent	Appearance after breaking curd*	Placings of 100 persons: First	Second	Third
Dry skim milk buttermilk					
9.08	.96	Smooth	33	25	42
10.15	1.01	Smooth	32	49	19
11.13	1.04	Smooth	35	26	39
Normal skim milk buttermilk					
9.56	.86	Smooth	36	41	23
9.56	.89	Smooth	32	30	38
9.56	.95	Sl. lumpy	32	29	39

* "Sl." is abbreviation for "slightly".

11.0, and 9.0 per cent solids respectively; for normal skim milk buttermilk the ratings for combined first and second placings were 77, 62, and 61 per cent for acidities of .86, .89, and .95 per cent, respectively.

A second test was made in which 100 persons compared Sample B of dry skim milk buttermilk containing 10.0 per cent solids with Sample D of normal skim milk buttermilk containing .86 per cent acidity. Results showed five ties for first place with 63 firsts for Sample D and 32 for Sample B. Many persons expressed the opinion that both samples were about equal in palatability but that Sample D was placed first because "it seemed to be a little less acid." For commercial purposes either sample would have rated as "excellent". The body and texture of dry skim milk buttermilk (Sample B) was smoother than that of normal skim milk buttermilk (Sample D).

Conclusions

(1) Buttermilk which has a flavor comparable with that of normal skim milk can be made from dry skim milk.

(2) The body and texture of buttermilk made from dry skim milk is smoother and more creamy than that of buttermilk made from normal skim milk.

THE EFFECT OF VISCOLIZING RECONSTRUCTED SKIM MILK PRIOR TO CULTURING ON THE FLAVOR AND PHYSICAL PROPERTIES OF CULTURED BUTTERMILK

Procedure

Test 1.—Seven series of tests were made on buttermilk, six of which were from dry skim milk and the other from normal skim milk for comparison. Each of the six dry skim milk series was divided into two lots. Lot 1 was viscolized; Lot 2, which served as a control, was unviscolized. Lot 1 of each Series 1, 2, and 3 was divided into two portions. Portion 1 was viscolized at a temperature of 180° F. and one 6-pound sample collected at pressures of 1500, 2000, and 2500 pounds, respectively. Portion 2 of Series 1, 2, and 3 was cooled to 145° F. and samples collected at the same pressure as for Portion 1. Lot 1 of each Series 4, 5, and 6 was treated in an identical manner except that pressures of 3,000, 4,000, and 5,000 pounds were used.

Buttermilk of Series 1, 2, 3, 4, 5, and 6 contained total solids percentages of 9.72, 9.72, 9.00, 10.85, 10.68, and 9.75, respectively. The results are recorded in Table 4. These percentages were used in order to determine whether or not viscolization had any relationship to quality in cultured buttermilk of different total solids content. The equipment used for viscolizing is shown in Figure 4.

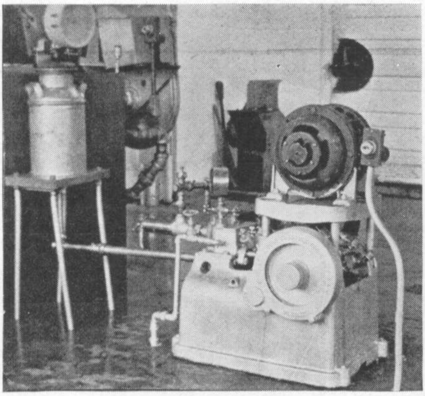

FIGURE 4.—DEVICE USED FOR VISCOLIZING TESTS.

The milk was cooled to 68° F. and cultured with 5 per cent of starter. The acidity of the various lots, prior to cooling and breaking the curd, was regulated to approximately the same percentage. This was accomplished by making an acidity test on a small sample taken from each lot with a thin-walled glass tube, ½ inch in diameter. Any lots falling below the desired acidity were held for a longer period.

When the acidity reached .93 per cent or above the samples were cooled to 50° F. and the curd broken for the time noted in the table. Two half-pint bottles were filled with buttermilk from each sample. One bottle was held at room temperature; the other, at a temperature of 35° to 38° F. Measurements were made periodically of the amount of whey appearing in the bottles. Viscosity studies were made in the usual manner. All results are recorded in Table 4.

Test 2.—As a further check on the effect of viscolization, a second test of two series was made. The reconstructed skim milk for each series was prepared to contain, as nearly as possible, 10.0 per cent total solids. It was then heated to 180° F. for 30 minutes, cooled to 145° F., and divided into two lots. Lot 1 was passed through the viscolizer under 4,000 pounds pressure and caught directly in 6-pound quantities in four separate glass jars. Lot 2 was unviscolized but like Portion 1 was taken in four 6-pound quantities.

All eight of the 6-pound samples were then cooled to 70° F., cultured, and processed in the same manner. In this test the percentage of total solids, viscolizing pressure, acidity, time and temperature of breaking curd, and period of agitation were all controlled to as nearly the same degree as possible for all of the samples of both series.

Studies of physical tests were made, as noted in the first test, and the averaged results recorded in Table 5.

Discussion of Results

So far as could be observed, viscolizing the reconstructed skim milk had no beneficial effect in preventing wheying-off in cultured buttermilk. This is in agreement with the work of Knaysi (4) whose studies on fermented milk prepared from normal skim milk revealed no beneficial results from homogenizing

TABLE 4.—Effect of Viscolizing Milk at Different Pressures and Temperatures Before Culturing on Viscosity, Appearance, and Separation of Whey of Cultured Buttermilk Made from Dry Skim Milk Compared With Normal Skim Milk Buttermilk.

(Average of Three Tests)

Viscolizer pressure	Temperature	Total solids	Time of breaking curd	Acidity	Viscosity	Appearance after breaking curd*	Flavor after		Whey after standing; measured in eighths of inches					
									At room temperature				At 35°-38°F.	
	° F.						Breaking curd	24 hours	24 hours	48 hours	96 hours	168 hours	24, 48, and 96 hours	168 hours
pounds		per cent	mins.	per cent	seconds									
1500 to 2500	145	9.72	2	1.02	122	Sl. lumpy	Acid	Acid	0.3	4.3	6.0	8.0	0	0
		9.72	5	1.00	28	Smooth	Sl. acid	Acid	0.6	3.0	6.3	7.3	0	0.6
		9.00	5	.93	12	Smooth	Heated	Good	0.0	2.0	5.0	6.0	0	0
1500 to 2500	180	9.72	2	1.01	111	Sl. lumpy	Acid	Acid	0.6	4.0	5.3	7.3	0	0
		9.72	5	.96	29	Smooth	Sl. heated	Good	2.0	4.0	6.6	7.0	0	0
		9.00	5	.92	13	Smooth	Heated	Good	0.3	2.0	5.0	6.6	0	0
3000 to 5000	145	10.85	5	.97	21	Smooth	Heated	Good	0	0	0	0.6	0	0
		10.68	5	.91	14	Smooth	Heated	Good	0.3	2.0	4.6	6.0	0	0
		9.75	5	.94	26	Smooth	Sl. heated	Good	0	0	0.6	2.6	0	0
3000 to 5000	180	10.85	5	.97	25	Smooth	Heated	Good	0	0.3	1.0	3.0	0	0
		10.68	5	.92	18	Smooth	Heated	Good	1.0	2.6	4.6	6.0	0	0
		9.75	5	.94	27	Smooth	Sl. heated	Good	0	0.6	1.6	4.3	0	0
Reconstructed milk not viscolized		9.72	2	1.02	105	Lumpy	Acid	Acid	3	6	6	7	0	0
		9.72	5	1.03	29	Sl. foamy	Sl. acid	Acid	0	3	6	7	0	2.0
		9.00	5	.95	9	Sl. foamy	Heated	Good	0	3	5	8	0	0
		10.85	5	.97	15	Smooth	Heated	Good	0	0	0	0	0	0
		10.68	5	.92	10	Smooth	Heated	Good	0	1	3	5	0	0
		9.75	5	.93	25	Smooth	Sl. heated	Good	0	0	0	3	0	0
Normal skim milk not viscolized		9.74	5	1.04	185	Sl. lumpy	Acid	Acid	6	9	10	12	0	3.0
		9.93	10	1.03	450	Sl. lumpy	Acid	Acid	3	5	7	8	0	0
		9.75	10	1.01	240	Sl. lumpy	Acid	Acid	3	6	8	8	0	0
		9.83	10	1.01	110	Sl. lumpy	Good	Good	0	1	2	4	0	0
		9.85	10	.98	95	Sl. lumpy	Good	Good	2	4	5	7	0	0
		9.62	10	1.00	155	Sl. lumpy	Good	Good	1	2	3	5	0	0

* "Sl." in column is abbreviation for "slightly".

TABLE 5.—Effect of Viscolizing Milk Before Culturing on the Viscosity, Appearance, and Separation of Whey of Cultured Buttermilk Made From Dry Skim Milk.

(Average of Eight Tests)

Treatment	Total solids	Time of breaking curd	Acidity	Viscosity	Appearance after breaking curd	Flavor after		Whey after standing; measured in eighths of inches			
								At room temperature			At 35°-38° F.
						Breaking curd*	24 hours	24 and 48 hours	96 hours	168 hours	24, 48, 96, and 168 hours
	per cent	minutes	per cent	seconds							
Viscolized at 4000 lbs. pressure, 145° F.	10.02	5	1.00	137	Smooth	Sl. heated	Good	0	1	1.7	0
Unviscolized	10.02	5	1.01	138	Smooth	Sl. heated	Good	0	1	1.1	0

* "Sl." in column is abbreviation for "slightly".

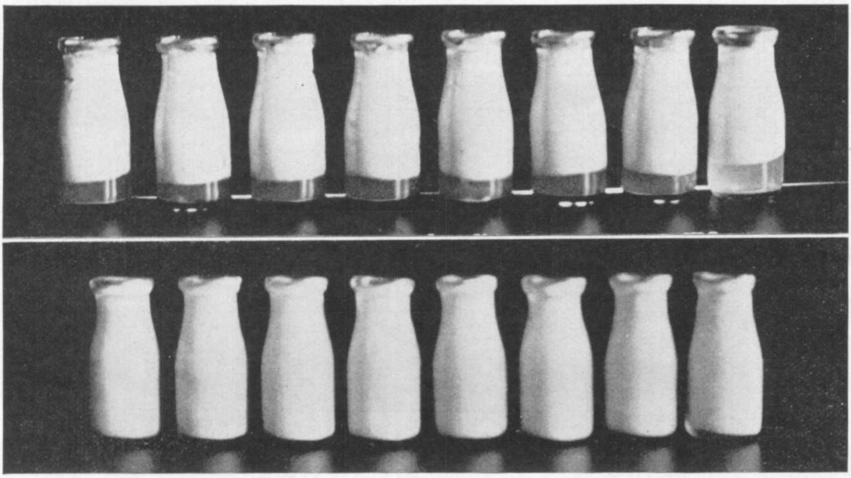

FIGURE 5.—ILLUSTRATION SHOWING THE APPARENT INEFFECTIVENESS OF VISCOLIZATION IN PREVENTING WHEYING-OFF OF CULTURED BUTTERMILK.

Upper row: After 96 hours standing at room temperature.
Lower row: After 96 hours standing at 35° to 38° F.
Reading from left to right: Sample 1 was viscolized at 1500 pounds pressure at 180° F.; Sample 2 at 2,000 pounds at 180° F.; Sample 3 at 2,500 pounds at 180° F.; Sample 4 at 1,500 pounds at 145° F.; Sample 5 at 2,000 pounds at 145° F.; Sample 6 at 2,500 pounds at 145° F.; Sample 7 was unviscolized and Sample 8 normal skim milk unviscolized.
Samples in illustration contained 9 per cent total solids.

either prior to or subsequent to souring. The only observed advantage in these studies was that the process aided in removing or breaking up any small lumps of undissolved dry skim milk (Fig. 5).

The data in Tables 4 and 5 indicate, as has already been observed, that high acidities tend to submerge the heated flavor in cultured buttermilk prepared from dry skim milk. Between the acidities of .90 and .93 per cent the heated flavor was readily distinguished, but above the limit of .95 per cent it gradually became submerged due to the preponderance of acid and a characteristic lactic flavor.

Conclusions

(1) Viscolizing the reconstructed dry skim milk prior to culturing is of no significant value or benefit in the preparation of cultured buttermilk.

(2) High acidities, .95 per cent and above, tend to mask the slightly heated flavor and thus produce a more palatable product.

THE EFFECT OF AIR INCORPORATION ON THE FLAVOR AND PHYSICAL PROPERTIES OF CULTURED BUTTERMILK MADE FROM DRY SKIM MILK

Procedure

For this work a special vacuum device was prepared. It consisted of a 1-gallon glass churn fitted with a specially designed top which could be made air tight. A vacuum gauge was constructed by fastening a glass tube to a yard stick and submerging the lower end of the tube in mercury. A small rubber hose, connected from a nipple on the special churn top to the glass tube, served to pull the mercury into the tube and indicate the number of inches of vacuum when suction was applied (Fig. 6). A high vacuum not only caused collapse of the jars, but drew buttermilk into the suction line; hence, 20 inches was the standard vacuum maintained.

Three series of tests were performed. Samples of reconstructed skim milk, prepared to contain as nearly as possible 10.0 per cent total solids, were heated to 180° F. for 30 minutes, cooled to 68° to 70° F., and cultured. Buttermilk so prepared was cooled to 50° F. and separated into three lots of two portions each. The curd from Portion 1 of each lot was broken under vacuum with agitator speeds as shown in Table 6; whereas, that from Portion 2 was broken without vacuum under the same amount of agitation. Samples of normal skim milk were used for comparison.

Studies of flavor, viscosity, and other properties were made in the usual manner. Results are recorded in Table 6.

Discussion of Results

Data in Table 6 show that excessive air incorporation, caused by prolonged or too vigorous agitation, is responsible for the defect of wheying-off in cultured buttermilk. This is clearly established, particularly in that portion of the table which shows the amount of whey separation on samples held at a storage temperature of 35° to 38° F. When agitation is sufficient to break the curd to a smooth consistency without producing excessive foaminess, separation of whey either does not occur or develops only to a negligible extent. This fact is well illustrated in Figure 7, which shows much

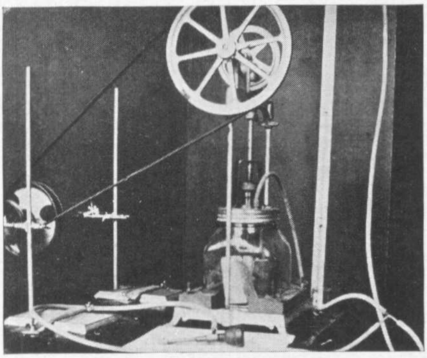

FIGURE 6.—VACUUM DEVICE USED IN REMOVING AIR FROM BUTTERMILK.

TABLE 6.—Effect of Air Incorporation on the Viscosity, Appearance, and Separation of Whey of Cultured Buttermilk Made from Dry Skim Milk.

(Average of Three Tests)

Speed of agitator	Curd broken in	Total solids	Acidity	Viscosity	Appearance after breaking curd*	Flavor after		Whey after standing; measured in eighths of inches							
								At room temperature				At 35° - 38° F.			
R.P.M.		per cent	per cent	seconds		Breaking curd*	24 hours	24 hours	48 hours	96 hours	168 hours	24 hours	48 hours	96 hours	168 hours
181	Air	10.07	.97	107	Smooth	Sl. heated	Good	0.3	3.0	7.0	8.0	0	0	0	0
	Vacuum	10.07	.97	73	Smooth	Sl. heated	Good	1.0	4.3	9.3	10.6	0	0	0	0
252	Air	10.07	.96	32	Foamy	Sl. heated	Good	8.6	10.3	12.3	13.3	0	1.6	2.6	3.3
	Vacuum	10.07	.98	45	Smooth	Sl. heated	Good	0	2.3	8.0	9.3	0	0	0	0
323	Air	10.07	.95	10	Foamy	Sl. heated	Good	12.3	13.0	14.0	14.0	4.6	6.3	8.0	9.0
	Vacuum	10.07	.98	17	Smooth	Sl. heated	Good	0	3.3	9.0	10.3	0	0	0	0
252	Air	9.57	.94	233	Sl. lumpy	Good	Good	1.0	3.0	5.0	6.3	0	0	0	0
Normal skim milk	Vacuum	9.57	.95	222	Sl. lumpy	Good	Good	1.3	3.0	5.0	6.3	0	0	0	0

* "Sl." in column is abbreviation for "slightly".

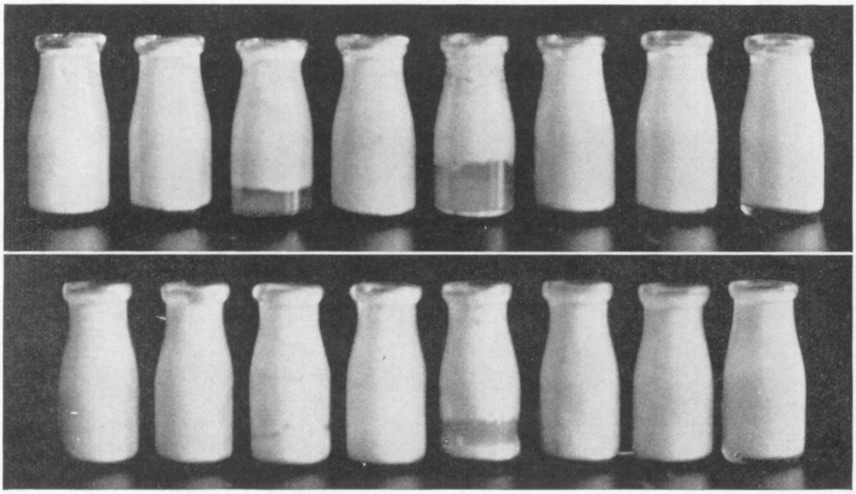

FIGURE 7.—ILLUSTRATING THE EFFECT OF VARYING SPEEDS OF AGITATION IN AIR AND UNDER VACUUM ON CULTURED BUTTERMILK.

Upper row: After 24 hours standing at room temperature.
Lower row: After 24 hours standing at 35° to 38° F.
Reading from left to right: Curd in Samples 1 and 2 was broken up at an agitator speed of 181 R.P.M.; Samples 3 and 4 at 252 R.P.M.; Samples 5 and 6 at 323 R.P.M.; Samples 7 and 8 at 252 R.P.M. Samples 1, 3, 5, and 7 were agitated in air. Samples 2, 4, 6, and 8 were agitated under a 20 inch vacuum. Samples 7 and 8 were buttermilk made from normal skim milk.

less whey separation in samples agitated in a vacuum than in those agitated excessively under normal conditions in air. It was further observed that the curd from those samples subjected to excessive or vigorous agitation became very porous, floated to the top of the container, and had the appearance of being badly contaminated with gas-producing organisms. At room temperature, mold and bacterial growth appeared to be more rapid on samples vigorously agitated in air than on similar samples which had been agitated under vacuum.

As a further check on the deleterious effect of air incorporation, two samples were agitated at a high rate of speed and allowed to stand at room temperature. A rapid separation of whey took place with the curd floating to the top. The samples were then placed under vacuum and slowly agitated until bubbles ceased to rise and free air appeared to be entirely eliminated. Half-pint bottles were filled with the agitated and vacuum treated product and held at room temperature for observation. The results are clearly shown in Figure 8.

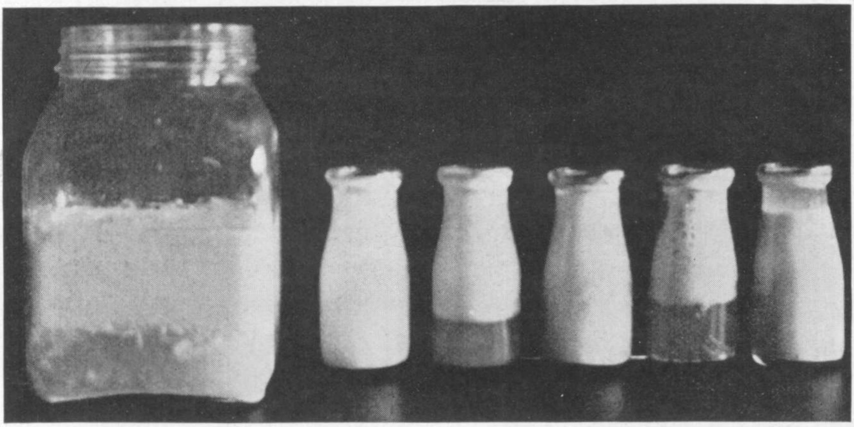

FIGURE 8.—Illustrating the Effect of Agitation and Vacuum Treatment on a Sample of Buttermilk Made from Dry Skim Milk.

Reading from left to right:

(1) Jar agitated excessively and allowed to set 48 hours.
(2) Bottle 2 is sample from jar.
(3) Bottles 1 and 3 same as in jar with air extracted under vacuum.
(4) Bottles 4 and 5 are milk from a jar similar to jar in photo, which was allowed to stand 24 hours and was then agitated enough to mix curd and whey. Bottle 5 had air removed under vacuum.

Age of milk in bottles when photo was taken:

First 3 bottles, 48 hours.
Last 2 bottles, 24 hours.

Conclusions

(1) The incorporation of excessive air in buttermilk is a major factor in causing the separation of whey.

(2) Excessive air incorporation is responsible for the broken, uneven, and "gassy" appearance of the curd in buttermilk.

(3) Excessive air incorporation seriously injures the flavor and imparts a thin, flat, watery taste.

THE EFFECT OF PUMPING WITH DIFFERENT TYPES OF PUMPS AT DIFFERENT TEMPERATURES ON THE PHYSICAL PROPERTIES OF CULTURED BUTTERMILK MADE FROM DRY SKIM MILK

In many plants the arrangement of equipment sometimes makes it necessary to pump buttermilk from the vat in which it is processed into a storage vat or bottling machine.

In order to determine the effect of pumping on the quality and physical properties of buttermilk, the following tests were made.

Procedure

Test 1.—Three series of twelve samples each were prepared to contain approximately 10.0 per cent total solids. The product was made in 10-gallon milk cans, heated to 180° F. for 30 minutes, cooled to 70° F., and cultured with 5 per cent starter. At this point the milk was thoroughly mixed by being carefully poured back and forth into a third can, due precaution being taken to avoid contamination or loss. Two full cans were then incubated until the acidity reached .95 to 1.04 per cent. The curd was then broken with an agitator identical with that used in previous tests, but made especially to fit a 10-gallon milk can and operated at a speed of 108 R.P.M. for five minutes, this being the slowest speed that could be maintained for breaking the curd to a smooth consistency with a minimum of air incorporation.

A portion of buttermilk from can No. 1 was pumped at incubation temperature (70° F.) through one of a series of five different types of pumps designated as follows:

(1) Rotary pump.

(2) Centrifugal pump A; disc type with removable one piece three blade impeller.

(3) Centrifugal pump B; disc type with fixed impeller of four curved blades.

(4) Centrifugal pump C; disc type with removable impeller of four straight blades.

(5) Steam piston pump.

The buttermilk in can No. 2 was first cooled to 55° F., separated into different portions, and passed through the pumps. Prior to pumping, a control sample was removed from each can.

All buttermilk was pumped for a vertical distance of 5 feet 3 inches, then 2 feet 6 inches horizontally, and 5 feet 3 inches downward, a total of 13 feet, into a glass jar. About one gallon of milk was allowed to pass through the pump and pipe line prior to taking the sample in order to eliminate possible contamination with a portion of the previous sample remaining in the pump or pipe and also to prevent incorporation of air from an unfilled line.

Two half-pint bottles were filled with a portion of the buttermilk from each pump; one was held at room temperature and the other at 35° to 38° F. for observation. Because of the slight variations in wheying-off observed in preliminary tests, 100 cc. graduated cylinders were also filled and held for examination at a temperature of 35° to 38° F.

Viscosity studies were made of each sample immediately after pumping. Variations in flavor as well as the effects of different types of pumps were noted also. Results are recorded in Table 7.

TABLE 7.—Effect of Pumping With Different Types of Pumps on the Viscosity, Appearance, and Separation of Whey of Cooled and Uncooled Samples of Cultured Buttermilk Made from Dry Skim Milk.

(Average of Three Tests)

Pump	Treatment	Total solids	Acidity	Viscosity	Appearance after pumping	Whey after standing; measured in eighths of inches								cc. whey	
						At room temperature				At 35° - 38° F.				At 35°-38° F.	
		per cent	per cent	seconds		24 hours	48 hours	96 hours	168 hours	24 hours	48 hours	96 hours	168 hours	24 hours	48 hours
Control not pumped	Uncooled	10.00	.97	11.6	Smooth	7.3	9.0	11.0	11.6	0	0	0	0	0	0
	Cooled	10.00	.97	24	Smooth	6.3	9.0	10.6	12.0	0	0	0	0	0	0
Rotary	Uncooled	10.00	.97	5.3	Foamy	10.0	11.6	12.6	13.6	0.6	2.0	3.3	4.6	6.0	10.6
	Cooled	10.00	.97	5	Foamy	8.0	11.6	12.6	13.3	1.0	2.0	2.0	4.0	7.3	11.0
Cen. A	Uncooled	10.00	.97	5	Foamy	9.6	11.3	13.0	14.0	0.3	0.6	2.0	4.3	4.3	9.0
	Cooled	10.00	.97	5	Foamy	9.0	11.3	12.6	13.6	1.0	1.3	2.6	5.3	11.0	16.3
Cen. B	Uncooled	10.00	.97	4	Foamy	9.0	11.3	12.3	13.0	1.0	2.6	3.6	5.6	7.0	11.3
	Cooled	10.00	.97	4	Foamy	9.0	10.6	12.0	13.0	1.0	2.3	4.0	4.6	10.0	13.3
Cen. C	Uncooled	10.00	.97	5	Foamy	9.0	10.6	11.6	12.3	0.6	2.0	3.3	4.3	8.0	12.3
	Cooled	10.00	.97	5	Foamy	8.6	10.3	11.6	12.3	1.3	1.3	2.6	3.3	7.3	11.0
Steam piston	Uncooled	10.00	.97	5	Foamy	10.0	11.6	13.0	14.0	0.6	2.3	3.3	4.0	7.3	11.3
	Cooled	10.00	.97	5.6	Foamy	9.3	11.0	12.6	13.3	1.0	1.3	3.0	4.6	10.0	14.6

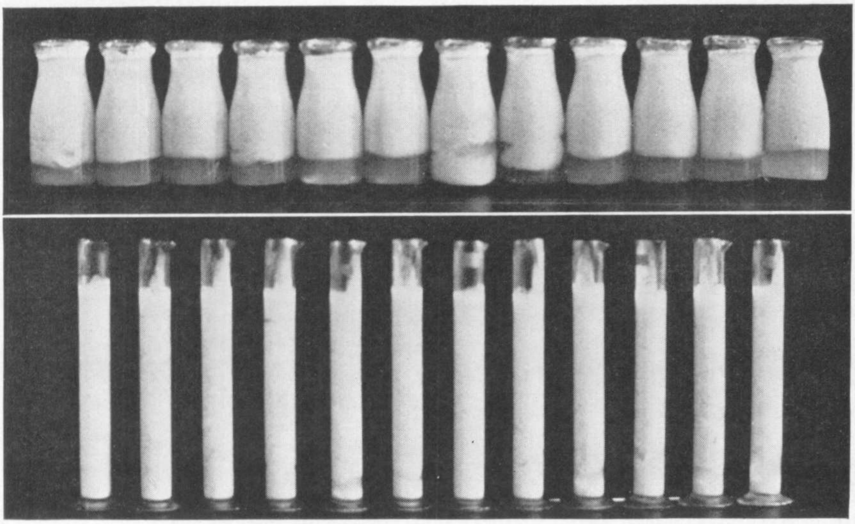

FIGURE 9.—ILLUSTRATING THE EFFECT OF PUMPING CULTURED BUTTERMILK AT 70° AND 55° F. THROUGH VARIOUS TYPES OF PUMPS.

Upper row: After 24 hours standing at room temperature.
Lower row: After 24 hours standing at 35° to 38° F.
Reading from left to right: Samples 1 and 7 were controls unpumped; Samples 2, 3, 4, 5, and 6 were pumped at 70° F. while Samples 8, 9, 10, 11, and 12 were cooled to 55° F. and pumped through rotary, centrifugal, A, B, and C, and steam piston pumps, respectively.

Test 2.—A second series of three tests was made on six samples to determine more closely the relative effect of different types of pumps. All samples were prepared as in the previous test and pumped at a temperature of 70° F. Tests of physical properties were made in the usual manner and samples set aside in half-pint bottles and 100 cc. graduated cylinders for observation as in Test 1. Results are recorded in Table 8.

Discussion of Results

The type of pump had little effect on the separation of whey. The variations that occurred were very slight and were about equal. All pumps caused the incorporation of air in the buttermilk and, although a number of samples held at ice-box temperature failed to develop a definite separation of whey, examination showed the curd to contain small mechanical openings and to be somewhat broken (Figs. 9 and 10). It lacked the desired smooth appearance of the best quality buttermilk The incorporation of air was detrimental to flavor. Pumping greatly reduced the viscosity of buttermilk as compared with that of the controls. While all pumped samples as well as the controls increased in

TABLE 8.—Effect of Pumping With Different Types of Pumps on the Viscosity, Appearance, and Separation of Whey of Uncooled Samples of Cultured Butermilk Made from Dry Skim Milk.

(Average of Three Tests)

Pump	Total solids	Acidity	Viscosity	Appearance after pumping	Whey after standing; measured in eighths of inches								cc. whey	
					At room temperature				At 35° - 38° F.				At 35°-38° F.	
	per cent	per cent	seconds		24 hours	48 hours	96 hours	168 hours	24 hours	48 hours	96 hours	168 hours	24 hours	48 hours
Control	10.11	1.01	14.0	Smooth	7.3	8.3	9.6	10.3	0	0	0.6	0.6	0	0
Rotary	10.11	1.01	5.0	Foamy	9.6	11.6	12.0	12.6	1.3	2.6	4.6	5.0	10.0	12.3
Cen. A	10.11	1.01	5.3	Foamy	9.3	11.3	12.0	13.0	1.0	1.6	3.6	4.6	6.6	9.6
Cen. B	10.11	1.01	4.3	Foamy	10.0	11.6	12.6	13.6	1.3	3.3	4.6	5.3	10.0	12.6
Cen. C	10.11	1.01	5.6	Foamy	9.0	11.0	11.6	12.6	0.6	1.6	3.0	3.3	6.3	7.6
Steam piston	10.11	1.01	4.6	Foamy	10.0	12.0	12.6	14.0	1.3	3.3	4.6	4.6	10.0	13.0

viscosity upon standing, the pumped samples failed to attain the maximum viscosity attained by the controls.

No significant differences were observed as a result of pumping the buttermilk at temperatures of 70° and 55° F. (Fig. 9). This appears contradictory to results of experiments on the desirability of cooling the curd prior to breaking. The explanation undoubtedly lies in the vigorous agitation and force to which the buttermilk was subjected in its passage through the pumps.

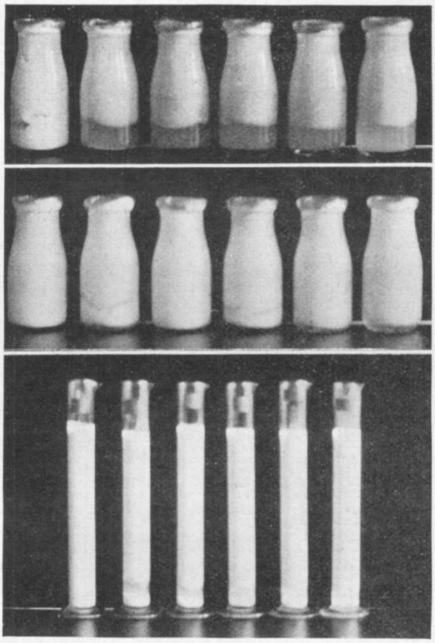

FIGURE 10.—ILLUSTRATING THE EFFECT OF PUMPING CULTURED BUTTERMILK THROUGH VARIOUS TYPES OF PUMPS.

Upper row: After 24 hours standing at room temperature.
Middle row: After 24 hours standing at 35° to 38° F.
Lower row: After 24 hours standing at 35° to 38° F.
Reading from left to right: Sample 1 control, unpumped; Samples 2, 3, 4, 5, and 6 pumped through rotary, centrifugal A, B, and C, and steam piston pumps, respectively. All samples in illustrations were pumped at 70° F.

Conclusions

(1) There was no very marked variation in the effect of different types of pumps on cultured buttermilk.

(2) All pumps caused the incorporation of air in the buttermilk.

(3) When held at 35° to 38° F. many of the pumped samples, regardless of the type of pump, developed small mechanical openings and splitting of curd.

(4) The incorporation of air due to pumping decreased palatability.

(5) Pumping greatly reduced the viscosity of cultured buttermilk made from dry skim milk.

(6) There was no very marked difference in the effect of pumping at 70° and 55° F.

THE EFFECT OF FINENESS OF THE CURD PRIOR TO PUMPING THROUGH DIFFERENT TYPES OF PUMPS ON THE PHYSICAL PROPERTIES OF CULTURED BUTTERMILK MADE FROM DRY SKIM MILK

Procedure

As a result of previous tests which showed pumping to be detrimental to buttermilk, it was assumed that the usual agitation to break the curd prior to pumping might be partly responsible. Accordingly, this factor was eliminated by the following procedure in which two series of tests were made. The buttermilk was prepared in two cans as described in previous experiments. When properly fermented the curd in can No. 1 was broken with the special agitator operating at a speed of 108 R.P.M. for 5 minutes. After saving a sample for comparison the remaining portion was divided into five samples; each sample was passed through one of the five pumps, respectively.

The curd in can No. 2 was not agitated but was broken only enough to permit easy passage of a portion through one of the respective pumps, thus effecting complete breaking of the curd and pumping all in one operation. Samples were placed in half-pint bottles and graduated cylinders and set away at room and ice-box temperature for observation. Results are recorded in Table 9.

Discussion of Results

Passage of the unagitated samples through the various types of pumps resulted in neither a significant improvement in viscosity nor a marked decrease in the separation of whey (Fig. 11). Whey separation was greater in those samples of low viscosity; the flavor was also less palatable.

Conclusions

So far as these studies are concerned no significant advantage is to be gained by passing the unbroken curd through a pump; neither is the amount of whey separation materially reduced nor the viscosity materially increased.

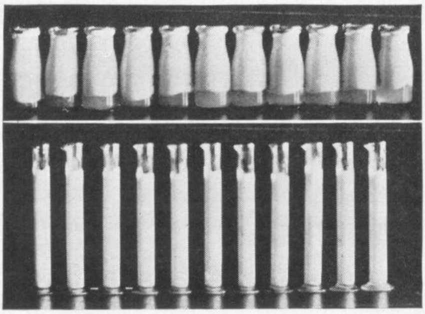

FIGURE 11.—ILLUSTRATING THE EFFECT OF FINENESS OF CURD PRIOR TO PUMPING ON THE PHYSICAL PROPERTIES OF CULTURED BUTTERMILK.

Upper row: After 24 hours standing at room temperature.
Lower row: After 24 hours standing at 35° to 38° F.
Reading from left to right: Sample 1 control. Samples 2, 4, 6, 8, and 10, curd was agitated prior to pumping. Samples 3, 5, 7, 9, and 11, curd was passed directly through pump. Samples 2 and 3 passed through rotary pump; 4 and 5 through centrifugal pump A; 6 and 7 through centrifugal pump B; 8 and 9 through centrifugal pump C; 10 and 11 through steam piston pump.

TABLE 9.—**Effect of Fineness of the Curd Prior to Pumping Through Different Types of Pumps on the Viscosity, Appearance, and Separation of Whey in Cultured Buttermilk Made from Dry Skim Milk.**

(Average of Two Tests)

Pump	Treatment	Total solids	Acidity	Viscosity	Appearance after pumping	Whey after standing; measured in eighths of inches								cc. whey	
						At room temperature				At 35° - 38° F.				At 35°-38° F.	
		per cent	per cent	seconds		24 hours	48 hours	96 hours	168 hours	24 hours	48 hours	96 hours	168 hours	24 hours	48 hours
Control not pumped	Normal	10.01	1.01	22.5	Smooth	5.0	7.5	10.0	11.5	0	0	0.5	1.0	1.0	2.0
Rotary	Normal	10.01	1.01	6.5	Foamy	9.0	11.0	12.0	13.0	1.0	1.0	2.5	3.5	8.0	11.0
	Unagitated	10.01	1.01	9.5	Foamy	9.0	11.5	12.0	13.5	1.0	2.0	3.0	3.5	10.0	13.5
Cen. A	Normal	10.01	1.01	6.0	Foamy	7.5	9.5	12.0	13.0	0.5	1.0	2.0	2.0	7.0	9.0
	Unagitated	10.01	1.01	10.5	Foamy	8.0	10.5	12.0	13.0	0.5	1.0	2.0	2.5	6.5	9.0
Cen. B	Normal	10.01	1.01	4.0	Foamy	8.5	10.5	12.0	13.0	0.5	1.5	3.0	4.0	3.0	10.0
	Unagitated	10.01	1.01	4.5	Foamy	8.0	10.5	12.0	13.0	0.5	1.5	3.0	4.0	4.0	10.0
Cen. C	Normal	10.01	1.01	6.0	Foamy	7.5	10.0	11.0	12.5	0.5	1.0	2.0	2.5	5.0	8.5
	Unagitated	10.01	1.01	7.5	Foamy	8.0	10.0	11.5	13.0	0.5	1.0	2.0	2.5	5.0	7.5
Steam piston	Normal	10.01	1.01	5.0	Foamy	8.0	10.0	11.5	13.0	0.5	1.0	2.0	3.0	1.5	6.5
	Unagitated	10.01	1.01	7.5	Foamy	9.0	11.0	12.5	13.5	0.5	1.0	2.0	3.0	5.0	8.5

THE EFFECT OF VARYING PUMP SPEEDS ON THE PHYSICAL PROPERTIES OF CULTURED BUTTERMILK MADE FROM DRY SKIM MILK

Procedure

Since the steam piston pump was the only pump that could be operated at variable speeds, other pumps were eliminated from these tests. The buttermilk was prepared from dry skim milk according to the method already described and divided into four portions, one of which was used as a control. One each of the remaining three portions was passed through the steam piston pump operated at different speeds designated as high, medium, and low, respectively. Physical tests were made in the usual manner and samples held for observation at room temperature and at 35° to 38° F. Results are recorded in Table 10.

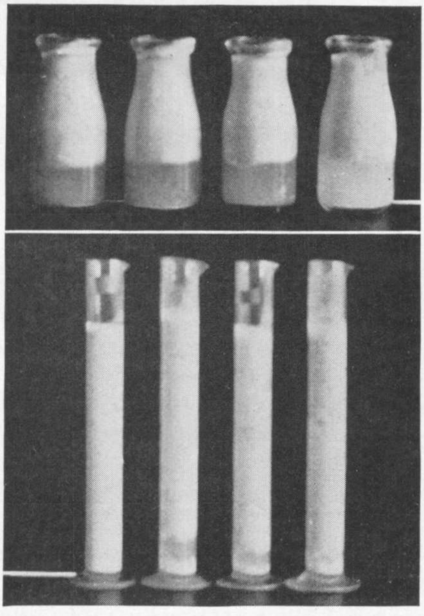

FIGURE 12.—Illustrating the Effect of Varying Pump Speeds on the Properties of Buttermilk Made from Dry Skim Milk.

Upper row: After 24 hours standing at room temperature.
Lower row: After 24 hours standing at 35° to 38° F.
Reading from left to right: Sample 1 control; Samples 2, 3, and 4 pumped at fast, medium and slow speeds, respectively.

Discussion of Results

Because of the variation in steam pressure and comparative stiffness of the new steam pump it was difficult to accurately control the speed between medium and fast. However, an examination of the table indicates results to be somewhat favorable to slow speed in so far as whey separation and improved viscosity are concerned. The improvement was too small to be of any commercial significance (Fig. 12).

Conclusions

The steam pump operating at slow speed is less detrimental to the physical properties of buttermilk than when operated at high speed; however, its effect is too slight to be of any consequence.

TABLE 10.—Effect of Varying Pump Speeds on the Viscosity, Appearance, and Separation of Whey of Cultured Buttermilk Made from Dry Skim Milk.

(Average of Three Tests)

Speed of pump	Total solids	Acidity	Viscosity seconds		Appearance after pumping	Whey after standing; measured in eighths of inches								cc. whey	
						At room temperature				At 35° - 38° F.				At 35°-38° F.	
	per cent	per cent	Immediately	After 6 hours		24 hours	48 hours	96 hours	168 hours	24 hours	48 hours	96 hours	168 hours	24 hours	48 hours
Control	10.00	.96	9	21	Smooth	8.6	10.6	12.3	12.3	0	0	0	0	0	0
Fast	10.00	.96	4	13	Foamy	10.6	12.3	13.6	13.6	1.6	3.3	5.3	6.0	11.3	16.0
Medium	10.00	.96	4	12	Foamy	10.3	12.0	13.0	13.0	1.3	2.6	5.3	6.0	9.6	13.0
Slow	10.00	.96	4	14	Foamy	11.0	12.3	13.0	13.6	0.6	1.6	4.6	5.6	7.3	10.6

THE EFFECT OF DIFFERENT CULTURES ON THE FLAVOR AND PHYSICAL PROPERTIES OF CULTURED BUTTERMILK MADE FROM DRY SKIM MILK

Procedure

Three series of tests were made using twelve different lactic cultures, obtained from 6 different firms and designated by letter.

The reconstructed milk was prepared as usual and divided into twelve 6-pound samples, each sample being placed in a glass churn jar. Five per cent culture was added as in previous tests and samples incubated until the proper curd had formed. The curd of each sample was broken with an agitator speed of 181 R.P.M. and the customary physical tests made. Results are recorded in Tables 11 and 12.

TABLE 11.—Flavor Comparison of Samples in Table 12.

Culture	First		Second		Third		Fourth		Fifth		Sixth	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
A	—	—	—	—	1	14.3	—	—	1	14.3	—	—
B	—	—	—	—	—	—	1	14.3	—	—	1	14.3
C	—	—	—	—	1	14.3	1	14.3	1	14.3	1	14.3
D	—	—	—	—	—	—	—	—	—	—	1	14.3
E	—	—	1	14.3	—	—	—	—	2	28.6	—	—
F	2	28.6	1	14.3	3	42.8	—	—	1	14.3	—	—
G	—	—	1	14.3	—	—	3	42.8	—	—	—	—
H	—	—	—	—	—	—	—	—	1	14.3	—	—
I	—	—	—	—	—	—	—	—	—	—	2	28.6
J	—	—	—	—	—	—	—	—	1	14.3	1	14.3
K	4	57.1	2	28.6	—	—	1	14.3	—	—	—	—
L	1	14.3	2	28.6	2	28.6	1	14.3	—	—	1	14.3

TABLE 11.—(continued) Flavor Comparison of Samples in Table 12.

Culture	Seventh		Eighth		Ninth		Tenth		Eleventh		Twelfth	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
A	1	14.3	—	—	1	14.3	2	28.6	—	—	1	14.3
B	—	—	1	14.3	2	28.6	—	—	2	28.6	—	—
C	1	14.3	1	14.3	1	14.3	—	—	—	—	—	—
D	1	14.3	1	14.3	1	14.3	1	14.3	1	14.3	1	14.3
E	2	28.6	2	28.6	—	—	—	—	—	—	—	—
F	—	—	—	—	—	—	—	—	—	—	—	—
G	2	28.6	—	—	1	14.3	—	—	—	—	—	—
H	—	—	—	—	—	—	1	14.3	2	28.6	3	42.8
I	—	—	1	14.3	1	14.3	2	28.6	—	—	1	14.3
J	—	—	1	14.3	—	—	1	14.3	2	28.6	1	14.3
K	—	—	—	—	—	—	—	—	—	—	—	—
L	—	—	—	—	—	—	—	—	—	—	—	—

Discussion of Results

There was a variation in both flavor and viscosity as produced by the various cultures. Some cultures (F, K, L) produced a flavor similar to ordinary churned buttermilk; others (B, C, E, G) gave clean, lactic flavors. Two cultures (H, I)

TABLE 12.—Effect of Different Cultures on the Viscosity, Appearance, and Separation of Whey in Cultured Buttermilk Made from Dry Skim Milk.

(Average of Three Tests)

Culture	Total solids	Acidity	Viscosity	Appearance after breaking curd*	Whey after standing; measured in eighths of inches						cc. whey
					At room temperature				At 35°-38° F.		At 35°-38° F.
					24 hours	48 hours	96 hours	168 hours	24, 48, 96 hrs.	168 hours	24 and 48 hours
	per cent	per cent	seconds								
A	10.01	1.04	28	Smooth Gelatinous	0	0	1.0	1.6	0	0	0
B	10.01	.94	35	Sl. lumpy	0	2.3	5.0	6.6	0	0	0
C	10.01	.98	26	Sl. lumpy	0	0.3	1.0	2.3	0	0	0
D	10.01	.92	8	Smooth	1.0	3.3	6.6	9.0	0	0.6	0
E	10.01	1.03	35	Lumpy	0.3	2.3	4.3	5.7	0	0	0
F	10.01	1.05	32	Smooth	0	0.6	2.0	3.7	0	0	0
G	10.01	1.02	23	Smooth	0	0.3	1.6	3.3	0	0	0
H	10.01	1.03	32	Sl. lumpy	0	1.0	2.6	3.7	0	0	0
I	10.01	1.02	23	Sl. lumpy	0	1.3	3.0	4.5	0	0	0
J	10.01	1.02	41	Smooth	0	0.3	2.3	4.5	0	0	0
K	10.01	1.03	35	Gelatinous Smooth	0	0.3	1.3	2.3	0	0	0
L	10.01	1.04	58	Sl. lumpy	0	0.6	2.0	3.0	0	0	0

* "Sl." in column is abbreviation for "slightly".

produced a less palatable flavor somewhat resembling that of mild Bulgarian buttermilk. The flavor imparted by two cultures (A, J) was very desirable but the body of the buttermilk was "slick" and somewhat gelatinous. One culture (D) appeared to be somewhat weak and failed to produce sufficient acid to mask the slightly heated flavor otherwise apparent in buttermilk made from dry skim milk. Placings for flavor were made by members of the dairy department and others.

Results are recorded in Table 11 which shows the number of times and respective percentage each sample was rated as first, second, third, etc.

Examination of Table 12 shows that all cultures, with the exception of D, produced buttermilk of a satisfactory viscosity which did not whey-off when held for a period of one week at a temperature of 35° to 38° F. Even at variable room temperature the separation of whey was remarkably low. Five cultures (B, E, J, K, L) produced buttermilk of high viscosity, culture L being particularly outstanding in this respect.

Throughout all of these tests wide variations in viscosity have occurred even when the same culture was used and, so far as could be determined, under identical conditions. A careful study of results of all tests reported in this bulletin appears to throw considerable light on a solution of the problem. A very close relationship exists between acidity and viscosity; viscosity and lumpiness; and lumpiness and whey separation. Each couplet of factors is in turn related to the other. For example, a buttermilk of low acidity can normally be expected to have low viscosity and be easily broken to a smooth consistency. However, much separation of whey occurs. On the other hand, a buttermilk of high acidity and of comparatively high viscosity may or may not develop whey. The evidence presented points to the fact that if buttermilk is held at a high acidity for a considerable period prior to breaking, the curd becomes very firm and is broken with difficulty, many small lumps occurring. Under such conditions wheying-off is very likely to occur. However, if the curd is broken soon after the acidity reaches the desired percentage, a smooth buttermilk results with very little or no whey formation. If a firm curd is agitated to the point where smoothness is attained with freedom from lumps, wheying-off is not likely to occur unless excessive air is incorporated. There is, thus, a certain adjustment that must be maintained between the percentage of acidity developed, the time held prior to breaking the curd, the amount and speed of agitation, and the degree of fineness to which the curd is broken if wheying-off is to be prevented and a smooth buttermilk produced (Fig. 13).

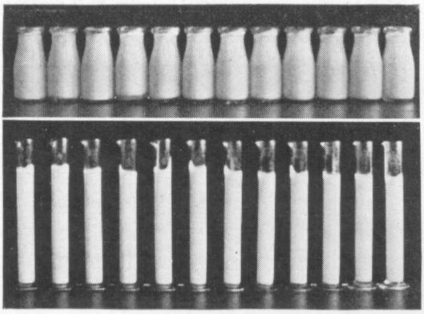

FIGURE 13.—ILLUSTRATING THE EFFECT OF DIFFERENT CULTURES ON THE PHYSICAL PROPERTIES OF CULTURED BUTTERMILK MADE FROM DRY SKIM MILK.

Upper row: After 24 hours standing at room temperature.
Lower row: After 24 hours standing at 35° to 38° F.
Reading from left to right:
Samples, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 are cultures A, B, C, D, E, F, G, H, I, J, K, and L, respectively.

Conclusions

(1) There is considerable variation in the flavor and viscosity produced by different cultures.

(2) For the preparation of high quality buttermilk from dry skim milk a vigorous, active culture is essential. Such a culture should produce a comparatively high viscosity without "slickness" or gelatinous characteristics.

(3) The curd of the fermented milk should be broken soon after the desired percentage of acidity has developed.

(4) Regardless of the culture used, an acidity of approximately .95 to 1.00 per cent was found to be most desirable in the finished buttermilk.

THE EFFECT OF ADDING DRY SKIM MILK OR RECONSTRUCTED SKIM MILK TO NORMAL SKIM MILK ON THE PROPERTIES OF CULTURED BUTTERMILK

As a result of experimental studies Reid and Welch (1) found that "the addition of normal skim milk to reconstructed milk increased the desirability of the fermented milk at the time of breaking the curd." They further report that "the scores of aroma, flavor, body, and texture were constantly higher in those lots to which normal skim milk had been added before fermentation." Results of studies reported in this bulletin suggested a possibility that the converse might likewise be true and that the addition of small quantities of dry skim milk to normal skim milk, prior to heating and fermentation, would prove beneficial.

Procedure

Three series of tests were made to check the above possibilities.

Five 6-pound samples of cultured buttermilk were prepared from the following milks:

Sample 1—Normal skim milk obtained direct from separator.

Sample 2—Normal skim milk to which had been added sufficient dry skim milk to increase the solids by one-half per cent.

Sample 3—Normal skim milk to which had been added sufficient dry skim milk to increase the solids by 1 per cent.

Sample 4—Reconstructed skim milk of approximately 10.0 per cent total solids.

Sample 5—Equal parts of normal skim milk and reconstructed skim milk of 10.0 per cent total solids.

All samples for each series were prepared in glass jars and treated in the usual manner. When fermentation had reached the desired point, the curd was cooled and broken with an agitator speed of 181 R.P.M. for five minutes. Physical tests are recorded in Table 13; flavor studies are recorded in Table 14.

Discussion of Results

An examination of Table 13 shows that for every increase in the increment of added dry skim milk there was a corresponding increase in viscosity and in the degree of smoothness. Sample 4, prepared entirely from dry skim milk, was lowest in viscosity, being followed in turn by Samples 5, 1, 2, and 3. The degree of smoothness and ease of breaking the curd was also closely related to the percentage of added dry skim milk. Sample 4, made entirely from dry skim milk, was most desirable in this respect, being followed in order by Samples 5, 3, 2, and 1. In these studies the curd of normal skim milk buttermilk, when compared with that prepared from dry skim milk, was more difficult to break and produced buttermilk of the highest viscosity, but lacking somewhat in smoothness when handled under the same conditions.

From the standpoint of acidity, Samples 1, 4, and 5 were practically identical; Sample 2 was a little higher; Sample 3, containing 1 per cent of added solids, was the highest of all. This is to be expected on account of the increase in solids.

With the exception of the normal skim milk buttermilk, whey formation was comparatively low even after a week's standing at room temperature. None of the samples wheyed off at temperatures of 35° to 38° F. (Fig. 14). As in previous tests, there was a close relationship between ease of breaking the curd, lumpiness, and the separation of whey.

Studies of flavor show the interesting fact that the samples of normal skim milk containing 1 per cent of added dry skim milk solids were placed first in 31.3 per cent of the trials; whereas, samples made entirely from dry skim milk were placed first in 26.3 per cent of the trials. In addition to being highly palatable both buttermilks were of a smooth, creamy consistency.

In all flavor studies it was found that buttermilk made entirely of dry skim milk, or of normal skim milk to which dry skim milk had been added, was less harsh and coarse in flavor than buttermilk made of normal skim milk even though acidities were the same or slightly higher.

TABLE 13.—Effect of Adding Dry Skim Milk or Reconstructed Skim Milk to Normal Skim Milk on the Viscosity, Appearance, and Separation of Whey in Cultured Buttermilk.

(Average of Three Tests)

Preparation of milk	Total solids	Acidity	Viscosity	Appearance after breaking curd****	Whey after standing; measured in eighths of inches					cc. whey
					At room temperature				At 35°-38° F.	At 35°-38° F.
					24 hours	48 hours	96 hours	168 hours	24, 48, 96 and 168 hrs.	24 and 48 hrs.
	per cent	per cent	seconds							
N.S.* control	9.68	1.01	177	Lumpy	2.7	4.7	6.7	7.3	0	0
N.S. + ½% D.S.M.S.**	10.17	1.04	267	Sl. lumpy	1.3	3.0	5.3	6.0	0	0
N.S. + 1% D.S.M.S.	10.63	1.06	301	Sl. lumpy	1.3	3.0	4.7	5.7	0	0
R.S.M.*** control	10.01	.99	41	Smooth	0	0	0	1.0	0	0
Equal parts N.S. and R.S.M.	9.85	1.01	79	Smooth	0	0	0.3	1.0	0	0

* N.S. is abbreviation for normal skim milk.
** D.S.M.S. is abbreviation for dry skim milk solids.
*** R.S.M. is abbreviation for reconstructed skim milk.
**** "Sl." is abbreviation for "slightly".

TABLE 14.—Flavor Comparisons of Samples in Table 13.

Sample	First		Second		Third		Fourth		Fifth	
	No.	%	No.	%	No.	%	No.	%	No.	%
1	3	15.8	3	15.8	7	36.8	1	5.3	5	26.3
2	3	15.8	3	15.8	3	15.8	7	36.8	3	15.8
3	6	31.6	2	10.5	5	26.3	3	15.8	3	15.8
4	5	26.3	6	31.6	1	5.3	2	10.5	5	26.3
5	2	10.5	5	26.3	3	15.8	6	31.6	3	15.8

Sample 1—Buttermilk made from normal skim milk.
Sample 2—Buttermilk made from normal skim milk plus dry skim milk to increase solids 1/2 per cent.
Sample 3—Buttermilk made from normal skim milk plus dry skim milk to increase solids 1 per cent.
Sample 4—Buttermilk made from dry skim milk.
Sample 5—Buttermilk made from equal parts of normal skim milk and reconstructed skim milk.

Conclusions

(1) The addition of dry skim milk to normal skim milk in quantities sufficient to raise the total solids 1 per cent prior to heating and fermentation, improves the body, texture, and flavor of the resulting buttermilk.

(2) The addition of dry skim milk to normal skim milk prior to heating and fermentation increases the viscosity of normal skim milk buttermilk and produces a product the curd of which is easier to break and smoother than that prepared solely from normal skim milk.

(3) The addition of dry skim milk to normal skim milk is beneficial in helping to prevent the separation of whey.

SUMMARY

(1) A total solids content in the reconstructed skim milk of 10.0 per cent with a variation allowance of 9.8 to 10.2 per cent was found most desirable from the standpoint of producing a desirable flavor, body, and texture.

(2) Whenever possible, the curd of buttermilk should be cooled to 50° F. or lower prior to breaking.

(3) In these studies 5 per cent of added starter was found to be satisfactory in the development of the proper acidity, flavor, body, texture, and viscosity.

(4) An acidity of .95 to 1.00 per cent in the finished buttermilk was most satisfactory from the standpoint of flavor. Flavor improves after 24 hours of holding in cold storage and the slightly heated taste noticeable in the freshly made product practically disappears.

(5) The curd of cultured buttermilk prepared from dry skim milk was easier to break than that produced from normal skim milk and the body and texture of the finished buttermilk was invariably smoother and more creamy.

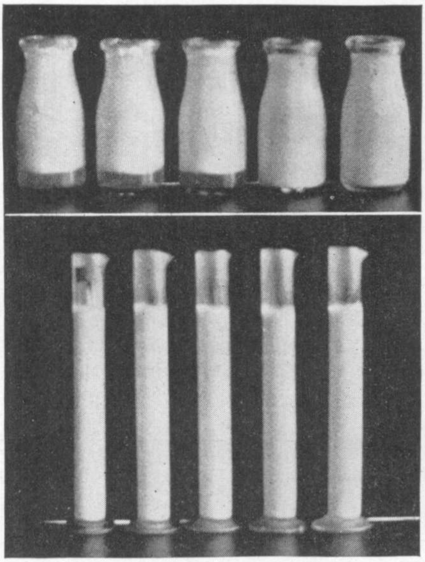

FIGURE 14.—ILLUSTRATING THE EFFECT OF ADDING DRY OR RECONSTRUCTED SKIM MILK TO NORMAL SKIM MILK ON THE PROPERTIES OF CULTURED BUTTERMILK.

Upper row: After 96 hours standing at room temperature.
Lower row: After 96 hours standing at 35° to 38° F.
Reading from left to right.
Sample 1—Buttermilk made from normal skim milk.
Sample 2—Buttermilk made from normal skim milk + ½ per cent dry skim milk solids.
Sample 3—Buttermilk made from normal skim milk + 1 per cent dry skim milk solids.
Sample 4—Buttermilk made from dry skim milk.
Sample 5—Buttermilk made from equal parts of normal skim milk and reconstructed skim milk.

(6) Viscolization of the reconstructed skim milk prior to culturing was found to be of no apparent benefit.

(7) Vigorous agitation of the curd, particularly to the point of slight foaminess, is responsible for many major defects of cultured buttermilk, especially the defect of wheying-off.

(8) It was found possible to restore a vigorously agitated and badly wheyed sample of buttermilk to its original whey-free state by removal of air under vacuum.

(9) The incorporation of excessive air in buttermilk is responsible for a porous, broken, and gassy appearance of the curd.

(10) The presence of excessive air is detrimental to flavor in that it produces a thin, flat, watery taste. Such buttermilk deteriorates rapidly.

(11) The pumping of buttermilk was found to be objectionable in that air incorporation occurred regardless of the temperature of pumping, type and speed of pump, and condition of the curd. The pumped buttermilk had a porous, open, broken appearance and lacked the smooth consistency desired.

(12) A variation was found in the flavor, viscosity, and acidity produced by different cultures.

(13) The addition of small quantities of dry skim milk to normal skim milk prior to fermentation, increases the viscosity and improves the flavor and consistency of the resulting cultured buttermilk.

(14) The flavor, aroma, and desired physical properties of the finished buttermilk can be satisfactorily maintained for several days at a storage temperature of 35° to 38° F.

(15) Cultured buttermilk of a quality practically equal to and in some respects superior to that prepared from normal skim milk can be made through the use of dry skim milk.

PRACTICAL RECOMMENDATIONS AND SUGGESTIONS FOR THE PREPARATION OF HIGH QUALITY CULTURED BUTTERMILK FROM DRY SKIM MILK

(1) Fresh dry skim milk of the highest quality should be used. In these experiments the dry skim milk remained in good condition over a period as long as four months when held under proper storage conditions, and was found satisfactory for the production of good buttermilk.

(2) A lactic starter, maintained in a vigorous active state by daily transfer and propagation, is essential. Off-flavored starters, or those which fail to produce an acidity of .95 to 1.00 per cent, may be responsible for a poor quality product.

(3) The reconstructed skim milk should be prepared to contain as nearly as possible 10.0 per cent total solids. A variation allowance of 9.8 to 10.2 per cent will not materially affect the results. In practical work it has been found desirable to weigh both water and dry skim milk and to consider dry skim milk as containing 96 per cent total solids. An example will illustrate. It is desired to make about 60 gallons or approximately 500 pounds of cultured buttermilk.
Solution:

(a) The buttermilk must contain 10 per cent of total solids.

(b) Therefore 500 pounds of buttermilk must contain $500 \times .10 = 50$ pounds of total solids.

(c) Since dry skim milk contains approximately 96 per cent total solids it will be necessary to use $50 \div .96 = 52.08$ pounds of dry skim milk and 447.92 pounds of water in the preparation of 500 pounds of cultured buttermilk.

(4) Place water at about 70° F. in vat and add dry skim milk in two or three installments, mixing thoroughly to avoid lumping and to secure complete solution.

(5) Heat to 180° F. for 30 minutes, cool to 68° to 70° F., and culture with 5 per cent starter.

(6) Allow the cultured buttermilk to stand until an acidity of .95 to 1.00 per cent has developed.

(7) Where possible, cool the curd to 50° F. prior to breaking. When this is impractical, satisfactory results can be secured by cooling the curd with slow, intermittent agitation in the vat. Satisfactory results have also been secured by breaking the curd in the vat, drawing it off into cans, and placing the cans

in ice water or in a cold room with frequent agitation to reduce it to the desired temperature of 50° F. or lower.

(8) In every case the curd of fermented reconstructed milk should be broken to a smooth consistency with an agitator operating at a speed which results in a minimum amount of air incorporation.

(9) In so far as possible, avoid pumping.

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