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The Effect of Added Salt on the Deterioration of High-Fat Cream Stored Without Refrigeration

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Deterioration or spoilage of cream is a problem that concerns the whole butter industry, but the problem is more acute in the southern states. Butter made in the southern states generally grades lower on the market than does that from the northern states because of the deterioration of the cream before it reaches the butter plant. In general, cream production in the south is secondary to other enterprises on the farm, and facilities for cooling cream, such as mechanical refrigeration, are not generally available. Generally higher temperatures prevail in the southern states than in the northern states, and the higher ground water temperature makes well water less efficient for cooling cream.

The fact that salt has been found useful in improving the keeping quality of a number of foods, including butter, suggests the possibility of its use in the preservation of cream on the farm. Since the salt is dissolved only in the serum of cream, the production and marketing of high-fat cream might be practical because the weight of the cream marketed would be reduced, more skim milk would be left on the farm for animal feeding, and less salt would be required for preserving the cream than would be the case with lower fat cream.

High-fat, salted cream may have another practical use in the production of cream for the continuous butter-making process now being studied on a commercial basis, because one of the first steps involved in this process is the separation of cream to a high fat content. The work herein reported was undertaken to determine the influence of salt on the rate and extent of deterioration of high-fat cream stored without refrigeration. A method of testing salted cream for fat content is also presented.

REVIEW OF LITERATURE

The inhibitory effect of salt in butter upon the growth of bacteria has been reported by numerous investigators, including Washburn and Dahlberg (14), Spitzer and Parfitt (11), and Macy (8).

Williams (1) patented a process for preserving cream with salt. His process involved the addition of 7 percent salt, which would keep cream fresh for seven days at room temperature.

Thompson and Macy (13) found that 7.5 percent to 10 percent salt on a serum basis added to cream was effective in retarding bacterial growth and acid development. Staleness was the only off-flavor that developed. Castell and Garrard (2) found that 7 percent salt on a serum basis almost completely inhibited the deterioration of cream stored eight days at 60 degrees to 70 degrees F. Caulfield, Nelson, and Martin (3), working with 30 percent cream, found that the amount of salt necessary to preserve freshness was determined by time and temperature of storage. They found that 10 percent salt on a serum basis added at the time of separation was effective in inhibiting deterioration of the flavor.

Caulfield, Nelson, and Martin (3) reported that the Babcock test for fat in salted cream was unsatisfactory because hydrogen chloride gas was given off from the reaction of the sulfuric acid with the salt. The foaming action of the liberated gas often caused some of the sample to boil out the neck of the test bottle. They proposed a modified method of the Babcock test that requires the addition of the acid in several portions, with intervals of waiting between additions. Hansen and Snyder (5) reported considerable danger in testing salted cream for fat with the conventional Babcock method because the HCl given off from a single fat test on cream with 10 percent salt was above the maximum allowable concentration for prolonged exposure in an area of 1,000 cubic feet.

Several modifications of the Babcock test have been recommended for various dairy products, particularly ice cream, but no reference could be found of any of these tests having been used on salted cream. Among the modified methods are: the Pennsylvania method (12); the Illinois method (9); the California method (7); the Minnesota method (10); and the glacial acetic-sulfuric acid method (6).

EXPERIMENTAL

Separation of High-Fat Cream

A practical and efficient method of producing high-fat cream with the small separators now in use on many farms would of necessity be the first step in any program for marketing high-fat cream. Therefore, methods for separation of high-fat cream were investigated.

The separator used in these tests was an electrically driven, bench type with 300 pounds per hour capacity. In a few preliminary trials, it was found that by adjusting the cream screw the fat content of the cream could be increased considerably; but above the range of 50 to 55 percent the fat content of the skim milk increased to the extent that this method appeared impractical.

Ten trials were run in which the fat tests of cream obtained with normal inflow to the separator were compared with those obtained when the rate of inflow was reduced to approximately one-half normal. With the inflow valve fully opened, the fat tests of the cream averaged 40.3 percent and those of the skim milk .022 percent. With the milk inflow reduced one-half, the average fat test on 10 samples obtained was 53.2 percent for the cream and .032 percent for the skim milk. The reduced inflow method was considered impractical because approximately twice as much time was required for this type of separation over ordinary separation.

Another method that involved successive separations of cream was investigated. Whole milk was preheated to 95 degrees F. and separated, and the cream obtained from the first separation was reseparated. Fat tests by the Babcock method were run on the cream and on the combined skim milk after each separation. The influence of successive separations on the fat content of cream and the skim milk is shown in Table 1.

The average fat tests of the cream and of the skim milk obtained were as follows: Single separation, cream 43.64 percent, skim milk .027 percent; second separation, cream 61.92 percent, combined skim milk of first and second separations .035 percent; third separation (five trials only), cream 68.20 percent, combined skim milk of first, second and third separations .10 percent.

The data show that double separation produced high-fat cream with only a slight increase in the fat content of the skim milk over that of the single separation. This double separation procedure appeared to be the most practical and efficient method studied for the production of high-fat cream on the farm.

Deterioration of Salted Cream

The rate and extent of deterioration of cream with various amounts of salt added was determined in five trials. Cheese milk was used as a source of high-fat cream in three of these trials, and in the other two trials Grade A milk was used. For each trial the high-fat cream was obtained by double separation of 20 gallons of milk. The fat content of the cream in the five trials ranged from 58 percent to 62 percent and averaged 60 percent. The cream was divided into seven lots

weighing 675 gm each. One lot served as a control and no salt was added. Salt was added to the other lots to give concentrations of 4, 6, 8, 10, 12, and 14 percent in the serum portion of the cream. The samples were stirred frequently for a period of about 30 minutes after adding the salt, to insure uniform distribution. Three 200-gm samples of cream from each lot were weighed into 8-oz. glass sample jars, and stored at room temperature (about 80 degrees F.).

Acid Development

The acidity was determined by weighing a 9-gm sample of cream into a flask, diluting with approximately an equal amount of hot distilled water and titrating with .10N NaOH using phenolphthalein as the indicator.

The influence of various concentrations of added salt on the development of acid in high-fat, raw cream during seven days storage at room temperature (about 80 degrees F.) is shown in Table 2. The acidity was determined daily, but only the increase in acidity during seven days storage is shown in the table.

Table 1.—The Influence of Successive Separations on the Fat Content of Cream.
(Butterfat test; percent)

Trial No.	First separation		Second Separation		Third separation*	
	Cream	Skim Milk	Cream	Skim Milk	Cream	Skim Milk
1	38.0	.02	60.0	.03	67.0	.09
2	38.0	.02	58.0	.03	60.0	.16
3	36.0	.02	62.0	.025	74.0	.08
4	39.0	.02	62.0	.025	70.0	.07
5	38.0	.02	60.0	.03	70.0	.10
6	42.0	.02	60.0	.03		
7	43.5	.03	60.5	.05		
8	44.0	.035	62.0	.035		
9	44.0	.025	62.5	.035		
10	43.0	.035	61.5	.035		
11	50.0	.015	63.0	.025		
12	46.0	.03	64.0	.035		
13	44.0	.02	62.0	.03		
14	44.0	.03	59.0	.045		
15	42.0	.025	61.0	.035		
16	41.0	.02	60.0	.03		
17	56.0	.05	70.0	.055		
18	57.0	.06	67.0	.06		
Average	43.64	.027	61.92	.035	68.20	.10

* A third separation was made in only the first five trials.

The data presented in Table 2 indicate that as the amount of salt added to high-fat cream was increased from 0 to 10 percent concentration in the serum, there was a pronounced decrease in the amount of acid developed during the seven days storage without refrigeration, while there was little difference in extent of development of acid in cream samples with 10, 12 and 14 percent added salt. It was also evident that in the first three trials, in which cheese milk was used as a source of the cream, there was more extensive acid development than in trials 4 and 5 in which Grade A milk was the source of the cream. The results indicate that a concentration of 10 percent salt in the non-fat portion of the cream prevented extensive acid development. Since acid development is due to bacterial growth, the results indicate that salt concentrations of 10 percent or higher in the non-fat portion of the cream practically stopped this type of growth.

Flavor Deterioration

Flavor deterioration in the cream during storage was determined by churning the cream samples in a malt mixer and then scoring the butter after chilling. This method was used because the salt concentrations in many of the samples of cream were too high to permit direct scoring of the cream. Nearly all the salt was removed in the buttermilk and wash water. Several samples of the butter made from the salted cream were tested for salt content and were found to contain only about 0.6 percent to 0.8 percent salt. No sample tested contained as much as 1 percent salt. No additional salt was added after churning.

The influence of salt on flavor scores of butter as a measure of the rate and extent of deterioration of flavor in cream stored at room temperature (about 80 degrees F.) for three, five and seven days is shown in Table 3 and Figure 1. The scores on the butter made from

Table 2.—The Influence of Added Salt on the Development of Acid in High-Fat Cream During Seven Days Storage at Room Temperature (80 Degrees F.).

(Increase in percent titratable acidity over initial acidity)

Trial No.	Fat Test	Initial acidity	Salt concentration in the non-fat portion of the cream (percent):						
			0	4	6	8	10	12	14
1	62	.07	.38	.245	.175	.09	.035	.035	.02
2	59	.08	.365	.34	.215	.13	.06	.05	.02
3	61	.085	.675	.29	.18	.105	.08	.045	.04
4	60	.07	.235	.18	.085	.065	.05	.025	.035
5	58	.08	.215	.19	.06	.055	.03	.01	.01
Average	60	.077	.374	.249	.143	.089	.051	.033	.025

the fresh, unsalted cream before storage ranged from 37 to 38 and averaged 37.6. These scores were used as the standard for comparison with the scores on the butter made from the unsalted and salted cream after the various periods of storage.

The unsalted cream deteriorated very rapidly during storage at room temperature and developed highly undesirable off-flavors. The principal off-flavors noted were cheesy, malty, old cream, and coarse.

Although the cream with 4 percent salt in the non-fat portion showed considerable deterioration, the rate and extent of spoilage was considerably less than in the unsalted cream. The most common criticisms were coarse, stale, malty, and old cream.

The cream with 8 percent salt in the non-fat portion had somewhat better keeping quality than that with 6 percent salt. The only

TABLE 3.—THE INFLUENCE OF SALT ON THE FLAVOR SCORE* OF BUTTER CHURNED FROM CREAM HELD AT ROOM TEMPERATURE (ABOUT 80 DEGREES F.)

Trial No.	Score fresh	Salt concentrations in the non-fat portion of the cream (percent): 0	4	6	8	10	12	14
	Flavor Scores of Butter from Cream Held for Three Days							
1	37.5	35	36	37.5	37.5	37	37	37
2	37.5	36	36.5	37	37.5	38	37.5	37 +
3	37	36	36.5	36 +	37 −	37 +	37	37 +
4	38	37	37	37.5	38	38	38	38 −
5	38	35	36.5	37.5	37.5	38 +	38	38.5
Average	37.6	35.8	36.5	37.1	37.5	37.6	37.5	37.5
	Flavor Scores of Butter from Cream Held for Five Days							
1	37.5	35	36.5	37	37	37	37−	36
2	37.5	35	36	36	36.5	37+	37+	37
3	37	36−	35.5	36	36	37	37	37 −
4	38	34−	36	37	38−	38	38−	37.5
5	38	33	35	37	37.5	38	37	37.5
Average	37.6	34.6	35.8	36.6	37.0	37.4	37.2	37.0
	Flavor Scores of Butter from Cream Held for Seven Days							
1	37.5	34	35.5	36−	36.5	37	36−	36.5
2	37.5	33	35−	36	36+	37	37	37
3	37	34	37	36	34	37	37+	36.5
4	38	32	34	37	37.5	38	37.5	37
5	38	35	35.5	37+	37	38	38−	37.5
Average	37.6	33.6	35.4	36.4	36.2	37.4	37.1	36.9

* Flavor scores comparable to U. S. standards for grades of creamery butter. Grade AA, 38; Grade A, 37; Grade B, 35-36; Grade C, 34.

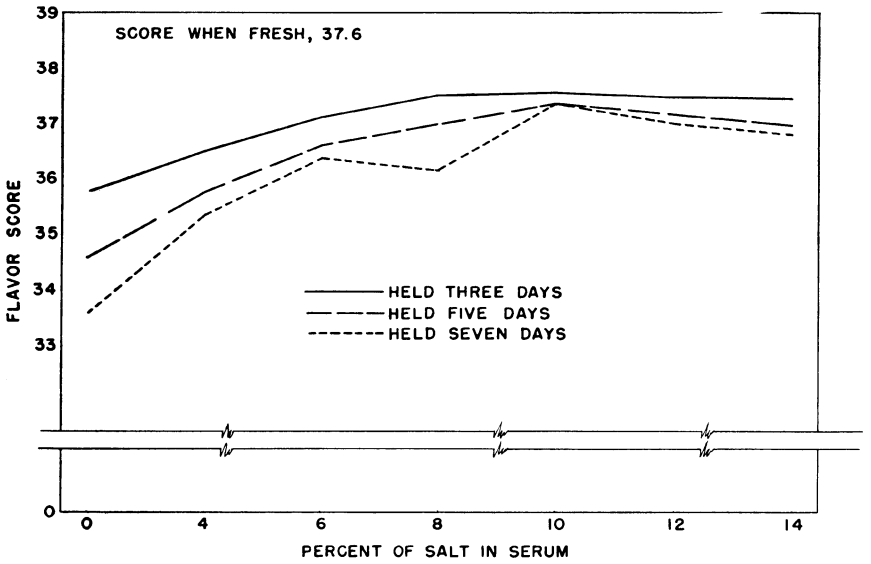

Figure 1.—Relation of holding period and percentage of salt in serum to flavor scores of butter made from salted cream. Data from Table 3. (The irregularity of the 7-day curve at the 8 percent level of salt is discussed on page below.)

criticisms that developed were coarse and storage, and three of the samples showed no defects after three days of storage. The low average score after seven days storage is due to considerable decomposition in one trial (trial 3), presumably caused by surface growth molds.

The cream with concentrations of 10, 12, and 14 percent salt in the non-fat portion showed no evidence of bacterial deterioration. After storage for seven days, the butter from the cream with 10 percent of added salt was not unfavorably criticized in two trials, was slightly coarse in another, and had a slight storage or stale flavor in the remaining two trials. The predominant flavor in the butter churned from the cream with 12 percent and with 14 percent salt added was a stale or storage flavor. The character of this stale or storage flavor suggested chemical rather than bacteriological deterioration.

It appears from the results that a concentration of 10 percent or more of salt in the non-fat portion of cream will prevent bacterial deterioration during seven days storage without refrigeration, although with 12 percent and 14 percent salt added there is apparently some chemical deterioration. Lesser amounts of salt tend to retard bacterial deterioration, but do not prevent it.

Determination of Fat in Salted Cream

Since several investigators have reported that the conventional Babcock method is impractical for use on salted cream, an effort was made to find a satisfactory method. Several modifications of the Babcock method were used with salted cream to determine their applicability.

One modification (3) which was tried involved adding the sulfuric acid in several portions, with an interval of waiting between each addition. This method eliminated inaccuracies due to foaming, but it was more time consuming than the conventional Babcock test and did not reduce the amount of HCl gas produced. Furthermore, a curd-like deposit was often formed at the base of the fat column, making accurate readings impossible. The Nebraska method (4), using sulfuric acid for one of its reagents, produced a foaming action and HCl gas. The glacial acetic-sulfuric acid method (6) was unsatisfactory for the same reason. The California method (7) was unsatisfactory because the red reader diffused throughout the fat column and made accurate readings impossible.

Several other tests appeared to give promising results and were selected for further study. These tests were: the old Minnesota (10), the improved Minnesota,* the Illinois (9), and the Pennsylvania (12) methods. The results obtained by these methods were compared with the results of the Mojonnier method and the calculated Babcock test on the same lot of cream.

The calculated Babcock fat test was determined as follows: The Babcock test was run on the cream and the weight of the fat in the sample was calculated. Salt was then added to the cream at the rate of 10 percent of the weight of the serum. The calculated Babcock test was computed as follows:

$$\text{Calculated Babcock test} = \frac{\text{Weight of fat in the cream}}{\text{Weight of cream} + \text{Weight of salt}} \times 100$$

The variations in the fat tests of one lot of salted cream using the old Minnesota, the improved Minnesota, the Illinois and the Pennsylvania methods, as compared with the fat tests obtained by the calculated Babcock and Mojonnier methods, are shown in Table 4.

The average of seven Babcock tests on the cream used in this experiment was 45.79 percent. The calculated Babcock tests after salt-

* The improved Minnesota method involves the use of "735 Minnesota Babcock reagent," manufactured and distributed by the Kimble Glass Division of Owens Illinois Glass Co., Vineland, New Jersey.

TABLE 4.—VARIATIONS IN BUTTERFAT CONTENT OF THE SAME LOT OF SALTED CREAM WHEN TESTED BY DIFFERENT METHODS.

(Butterfat; percent)

No. of samples	Method	Range	Average	Average variation from: Calculated Babcock	Average variation from: Mojonnier test
2	Mojonnier	------	43.15	−0.29	----
7	Calculated Babcock	43.2-43.7	43.44	-----	+0.29
24	Old Minnesota	45.0-46.5	45.88	+2.44	+2.73
24	Improved Minnesota	43.0-44.0	43.26	−0.18	+0.11
16	Illinois	45.5-47.0	46.13	+2.69	+2.98
16	Pennsylvania	44.2-45.5	44.71	+1.27	+1.56

ing averaged 43.44 percent, which was 0.29 percent more than the average of duplicate Mojonnier tests.

In tests by the old Minnesota method, there was no boiling action and the fat columns were clear, uniform, distinct, and easy to read. However, the fat tests were too high.

Eleven of 24 samples tested by the improved Minnesota method gave the same fat percentage as the calculated Babcock test. There was no boiling, and the fat columns were clear, uniform, distinct, and easy to read.

With the Illinois method, there was no boiling and the fat columns were fairly clear and uniform, but there was a slight cloudiness at the base of the fat column which made accurate reading difficult.

In tests using the Pennsylvania method, the fat columns were cloudy and difficult to read.

Thus, of the four methods examined in this study, the improved Minnesota method was found to be the most satisfactory test for fat in salted cream. The fat columns were uniform, clear, distinct, and easy to read. The results varied the least from the calculated Babcock and the Mojonnier methods. Further, the Minnesota reagent, unlike sulfuric acid, is not harmful to the skin or clothing.

SUMMARY

High-fat cream (60 percent or higher) was obtained with an ordinary farm separator by double separation of the cream, with little loss in time and efficiency as compared to single separation.

Very little acid development and flavor deterioration occurred during seven days storage at about 80 degrees F. when enough salt was added to high-fat cream to give a concentration of 10 percent or more in the non-fat portion of the cream. The slight deterioration in flavor noted involved the development of stale flavors, presumably due to chemical action. Lesser amounts of salt inhibited, but did not prevent, acid production and flavor deterioration.

Salted cream can be tested accurately with the improved Minnesota modification of the Babcock test.

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