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The influence of various procedures on the flavor and keeping quality of butter

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THE INFLUENCE OF VARIOUS PROCEDURES ON THE FLAVOR AND KEEPING QUALITY OF BUTTER

by

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INTRODUCTION

The addition of selected cultures of bacteria to cream intended for buttermaking was introduced about the same time as the pasteurization of the cream. Before this the cream was commonly inoculated with sour milk or cream, or with buttermilk from a lot of fine butter, in an attempt to obtain the desired flavor in the butter.

The studies on selected cultures of bacteria for use in buttermaking soon indicated that, in many cases, ordinary cream souring did not give the desired flavor and aroma production. Some investigators recommended the use of pure cultures while others immediately recognized the necessity for a mixed culture, if the desired results were to be obtained.

The mixtures of organisms necessary in a desirable culture are now well known. Attempts have been made to relate certain of the compounds formed in such a butter culture to the desirable flavor of the culture. A high volatile acid content in a butter culture has been considered of importance for some time. More recently the acetylmethylcarbinol and diacetyl contents have been given a great deal of consideration. It has been shown that high volatile acid and high acetylmethylcarbinol and diacetyl contents are associated with a desirable flavor and aroma in a culture. This information is of value from the standpoint of the preparation of desirable cultures.

Various modifications of the milk used in making butter culture have resulted in increased volatile acidity, acetylmethylcarbinol and diacetyl production by the butter culture organisms. Certain growing conditions and special strains of organisms have been found more effective than others. However, the question as to whether or not the desirable characteristics of a butter culture are transferred to butter by the simple addition of the culture to cream, or whether certain methods are necessary to bring the desired results has received relatively little attention.

STATEMENT OF THE PROBLEM

The work herein reported was undertaken for the purpose of obtaining additional information on the influence of certain characteristics of butter cultures and the manner in which the cultures are used on the flavor and keeping quality of the resulting butter. It is divided in four parts as follows:

Part 1. The influence of various methods of using butter culture on the flavor and keeping quality of butter.

Part 2. The influence of the type of butter culture on the flavor and keeping quality of butter.

Part 3. The influence of the addition of acetylmethylcarbinol or diacetyl to butter on its flavor and keeping quality.

Part 4. The manufacture of high scoring butter.

HISTORICAL

Early Methods of Cream Ripening

When attempts were first made to influence the ripening of cream intended for butter making, they consisted of adding, to the cream, buttermilk from a churning of good butter, or clean flavored sour milk or cream. Conn (6), as early as 1889, questioned whether or not cream ripening was merely a matter of souring. In 1896, he (8) pointed out that it was possible to have souring without the desired aroma production.

Storch (45) isolated pure cultures of bacteria from cream, butter and buttermilk in an effort to find organisms that would give the desired high aroma to butter. In Germany, Weigmann (49) found that the use of organisms giving the desired aroma to butter resulted in poor keeping quality, while the use of organisms giving little aroma resulted in good keeping quality. Hence he suggested a mixed culture in order to get a high aroma and also good keeping quality.

The Influence of the Various Methods of Using Butter Culture on the Flavor and Keeping Quality of Butter

Considerable work has been done on the influence of the method of using butter culture on the flavor and keeping quality of butter.

As early as 1889, Conn (4) recommended that milk intended for butter making be kept cool before separation and that the cream be held warm so as to get a desirable fermentation. Somewhat later, he (7) recommended the use of a pure culture which he had designated B41. The organism was isolated from a sample of so-called "preserved milk" from Uruguay which had been sent to the Columbian exposition in 1893. This milk had developed a very bitter taste. Conn stated that the use of this culture improved the flavor of Connecticut butter 20 per cent, according to estimates by experts. Conn (8) also recommended the inoculation of cream with a large amount of a desirable bacterial culture to prevent the growth of undesirable organisms. Weigmann (5), in some early work, stated that adding pure cultures to cream could be used as a means of preventing the development of a fishy flavor in butter.

Farrington and Russell (15) reported that butter made using Conn's culture B41, did not score as high when fresh or after storage as butter from normal (separated at the plant) or gathered cream held for 1 day at 70° F. or longer at 60° F. In four trials, Dean (9) found that ripened cream butter was superior to sweet cream butter after 3 or 4 weeks. Somewhat later, he (10) reported that the addition of culture to cream was more satisfactory than the practice of ripening the cream. He found that the addition of 20 to 30 per cent culture to cream gave butter which was superior to sweet cream butter. He also stated that the addition of as much as 27.5 per cent culture gave butter

of better keeping quality than the practice of ripening the cream.

According to Patrick, Leighton and Heileman (32), cream ripened for 17 to 21 hours at 60° F. was inferior to sweet cream butter in keeping quality when stored at 50° F. They also stated that during this storage period the sweet cream butter, in a measure, gained the flavor characteristics of the ripened cream product.

Eckles (14) made a study of one of the early outbreaks of putrid butter. He stated that it was primarily due to insanitary conditions on the farm. It was overcome by the introduction of more sanitary methods of handling the milk on the farm and the use of butter culture in the butter plant.

Shutt and Charron (41) decided sweet cream butter was decidedly superior to ripened cream butter. Sayer, Rahn and Farrand (39), in a study of butter made in a number of Michigan plants, reported that the use of butter culture always gave improvement in score when the butter was scored fresh.

Rogers (37) found that butter from pasteurized cream with enough culture added to give a cream acidity of 0.219 per cent did not become fishy during a 9 month storage period at 10° F. while butter from cream ripened to 0.523 per cent acid became fishy when held under these conditions. He stated that although this work indicated a direct relationship between the acidity of the cream at the time of churning and the development of fishiness, high acid cream did not always result in this defect. Hence he concluded that other factors, such as overworking the butter, may be important in the development of

fishiness. He also noted that butter from cream received from certain farms had a tendency to develop this defect.

Rogers and Gray (38) compared butter made from sweet cream, from sweet cream to which culture was added, from cream ripened to a medium degree of acidity and from cream ripened to a high degree of acidity; two series of churnings were made. In the first series the butter from the sweet cream scored highest, the butter from the sweet cream with culture added second, the butter from the medium ripened cream third, and the butter from the highly ripened cream fourth when examined after 20 days at 32° F. The same relationship existed between the scores after 6 months at 0° F. The ripened cream butter was distinctly inferior, both when fresh and after storage. In the second series the butter from sweet cream to which culture had been added was highest in score, the butter from sweet cream was second, the butter from the cream ripened to a medium degree of acidity was third and the butter from the highly ripened cream was fourth when examined after 20 days at 32° F. The same relationship existed after 6 months at 0° F. except the sweet cream butter ranked higher than the butter from sweet cream to which culture had been added.

Rogers, Thompson and Keithley (39) found that, when scored fresh butter made from cream pasteurized and then ripened was better than butter made from sweet pasteurized cream. They also stated that the ripened cream butter did not keep as well as the butter from sweet cream when stored at a temperature of 20° F.

According to Dyer (13) the production of an off flavor in cold storage butter was attributable to a slow oxidation of the non-fatty substances occuring in buttermilk, and the extent of this change was directly proportional to the quantity of acid present in the cream from which the butter was made. Guthrie (19) concluded that a high acidity in cream was the cause of metallic flavored butter. Hunziker and Hosman (23) found that the development of some acid in the cream slowed down the development of tallowiness in butter. According to Supplee (46), fishiness is a result of the change of lecithin to trimethylamine and he considered that acid fosters this change. Ibsen (24) found that to combat cheesy flavor in Danish butter during August and September the cream should be ripened to a high degree of acidity. Fryerhofer (17) stated that the development of a high acidity in cream was responsible for fishy, oily, and metallic flavors in butter.

Mortensen (30) made a comparison of butter from sweet cream and butter from ripened cream. Two ripening procedures were used. In the one case the cream was cooled to 40° F. after pasteurization, then warmed to 60° F. and 10 to 20 per cent butter culture added. In the other case the pasteurized cream was cooled to 60° to 70° F. and 10 to 20 per cent culture added. He reported that, when scored fresh, the butter from the ripened cream was higher in score, after 2 months the scores were about equal, while after 9 months the butter from sweet cream was superior.

According to Johnstone, (25) either the oxidation of lecithin in

the cream or its prevention in butter will overcome the development of a fishy flavor.

Grimes (18) in a study of butter deterioration, attributed the poor keeping quality of butter to the quality of cream rather than to the acid or organisms added through the use of butter culture. According to Sommer and Smit (42), fishiness was caused by high acidity, high salt, overworking the butter and the presence of copper and iron salts. They stated that the acid helped hydrolyze lecithin and also dissolved copper and iron which in turn catalized the oxidation of lecithin. Spitzer, Parfitt, Manhart and Epple (44) reported that butter with a pH of five to six was most desirable from the standpoint of keeping quality.

Reed (35) compared butter from sweet cream, butter from cream ripened to 030 to 0.45 per cent and, butter from cream to which 0.5 per cent culture had been added and butter made by the addition of the culture directly to the butter. He reported that all the butter made with culture was superior to the butter from sweet cream when scored fresh and also after 1 to 3 months at -10° to 10° F. He also stated that after a 3 month storage period at -10° to 10° F. some of the butter made with culture was as much as two points higher in score than the sweet cream butter.

Lucas, Ball, Vincent and Trout (27) compared butter made with the following methods:

1. Butter churned from sweet cream.

2. Butter made by the direct addition of culture to the butter at the rate of 3 per cent of the weight of the salt added.

3. Butter churned from cream to which 3 per cent culture was added just before churning.

4. Butter churned from cream ripened to 0.30 to 0.35 per cent acid.

5. Butter churned from cream ripened to 0.45 to 0.42 per cent acid.

When scored, the butter ranked as follows:

Treatment	Ranking when scored fresh	Ranking after 30 days at 0° F.	Ranking after 3 months at 0° F.
1	5th	4th	3rd
2	3rd	2nd	2nd
3	2nd	1st	1st
4	1st	3rd	4th
5	4th	5th	5th

Derby and Hammer (11) reported that the use of butter culture in cream helped prevent the development of surface taint in butter.

During a study of the use of butter culture Sparks (43) made butter with the following methods:

1. Butter churned from sweet cream.

2. Butter churned from cream to which 8 per cent butter culture was added at 70° F. ripened to 0.27 to 0.28 per cent acid, cooled to 40° F. and held overnight.

The average scores on the butter were as follows:

Treatment	Number of churnings	Average score of fresh butter	Average score after 6 months at 0° to 10° F.
1	13	92.3	91.9
2	25	93.3	92.3

Sixteen churnings were made with each of the following treatments:

1. Butter churned from sweet cream.
2. Butter churned from cream to which 3 per cent culture was added at the time of churning.
3. Butter churned from cream to which 8 per cent culture was added at 40° F. and held overnight.
4. Butter from cream to which 3 per cent culture was added at 70° F. ripened to 0.27 to 0.28 per cent acid, cooled to 40° F. and held overnight.

The following summary gives the average scores on the butter:

Treatment	Average score of fresh butter	Average score after 1 month at 45° F.
1	92.41	92.53
2	92.73	92.55
3	93.24	93.18
4	93.29	92.99

According to Bouska (4), much of the difficulty with cheesy and

surface taint butter in Canada is due to the practice of not using butter culture.

The Influence of the Type of Butter Culture on the Flavor and Keeping Quality of Butter

Efforts have been made to improve butter cultures by various modifications of the milk used in making the cultures but not many of these cultures have actually been employed in the manufacture of butter. According to Hammer (20), the addition of 0.1 to 0.2 per cent of either citric or lactic acid to milk for butter culture resulted in an improvement. Baker and Hammer (2) added lactose, milk ash, and butterfat to milk for butter cultures without any notable improvement in the quality. Orla-Jensen, Orla-Jensen and Spur (31) stated that the aroma bacteria are able to ferment citric acid with the production of carbon dioxide. They reported that the organisms lose this characteristic after being grown for a time in pure culture. Therefore, they considered the addition of citric acid to milk for butter culture as of minor importance since it did not produce consistent results. Templeton and Sommer (47) found that the addition of citric acid to milk for butter culture increased the volatile acid production approximately 50 per cent and the total acidity not over 10 per cent.

Michaelian and Hammer (28) showed that lactic acid was not essential for volatile acid production by the citric acid fermenting organisms Streptococcus citrovorus and Streptococcus paracitrovorus since a high

production was brought about by acidifying milk cultures with other acids. Working along this same general line Raffay (34), reported that the addition of 0.1 to 0.4 per cent citric acid to milk containing butter culture organisms gave large increases in aroma production. Templeton and Sommer (48) stated that the addition of citric acid to milk for butter culture gave butter of a noticeably higher score. Michaelian and Hammer (29) found that the addition of citric acid to milk for butter culture resulted in a large production of acetylmethylcarbinol and diacetyl.

The Influence of the Addition of Certain Chemicals to Cream and Butter on the Flavor and Keeping Quality of Butter

As early as 1894, de Schweinitz (12) suggested that the desirable flavor and aroma of butter are due to chemicals produced by bacteria. Consequently he recommended, that these chemicals be produced and added to the butter rather than adding a mixture of bacteria. The addition of citric acid to cream, according to Ritter and Strüssi (36), may result in the production of excessive flavor and poor keeping quality in the butter, hence such a practice was not recommended. Barnicort (3) added 4 parts per million of diacetyl directly to butter churned from cream with or without culture added. He reported that, when large quantities of diacetyl were present, the losses during storage of the butter were great, both in butter from cream with and without culture added. In the case of butter from cream to which culture was added, the diacetyl

was not lost but merely reduced to its precursor, acetylmethylcarbinol. Templeton and Sommer (48) found that the addition of 0.2 per cent citric acid, or its equivalent as sodium citrate, to cream along with butter culture was sufficient to increase the score of the resulting butter.

EQUIPMENT, MATERIALS AND METHODS

Equipment Used in the Manufacture of the Butter

A number of cream vats were employed in the handling of the cream. The Cherry-Burrell Company vats were as follows: a 300 gallon horizontal twin coil vat, a 100 gallon horizontal coil vat, and two 70 gallon horizontal coil vats. The following Creamery Package Company vats were also used: a 300 gallon horizontal coil vat, a 200 gallon horizontal coil vat, and a 50 gallon horizontal coil vat.

Two vertical, solid agitator, jacket type butter culture vats were used; the one was a Creamery Package Company glass lined vat and the other a Cherry-Burrell Company stainless steel vat. In some instances the culture was made in 10 gallon milk cans held in a tank of water.

The butter was made in churns varying in capacity from 60 to 600 pounds of butter. The Cherry-Burrell Company churns used were as follows: a 600 pound capacity churn No. 28; two 60 pound capacity Model 2 B churns; and one 40 pound capacity Model 1 B churn. A Creamery Package Company Victor churn of 600 pounds capacity was also employed.

Materials Used

All of the cream was gathered cream delivered to two stations and to the butter department operated by the Iowa State College. The milk for butter culture was delivered to the milk department operated by the Iowa State College from eight farms in the vicinity.

Preparation of the Butter Culture

The milk used for butter culture was received at about 8:00 A.M. and was held in the cooler until noon. In some cases an effort was made to select milk for butter culture on the basis of its flavor and sometimes the methylene blue test was made a basis for the selection. In a few instances mixed milk from all the patrons was used. The milk was pasteurized at 190° F. for 1 hour; direct steam was used in the Creamery Package Company vat and hot water in the Cherry-Burrell Company vat. The pasteurized milk was cooled to 71° F. and inoculated with about 2 per cent mother culture. The mother culture was added to the milk slowly, with the agitators in motion, and the milk was then stirred vigorously with a sterile stirring rod. The temperature of the butter culture room was thermostatically controlled at 71° F. during the cool months while in the warm months no means were available for controlling the temperature of the room.

The butter culture was usually ready to be cooled in about 16

hours. It was cooled as low as possible in the vats, usually to 58° F., and then placed in cans in a cooler and stirred from time to time until the temperature reached about 40° F.

Method of Manufacture of the Butter

The cream used for the manufacture of the butter was usually pasteurized at 145° F. for 30 minutes. In all cases the steam jet system of forced circulation was employed. The cream was usually cooled directly to the holding temperature of 38° F. Water at a temperature of about 52° F. was used to cool the cream to 60° F. In the large vats the cream was then cooled to 38° F., using brine at about 20° F., while in the small vats ice water was circulated by the self circulating method. The general practice of holding the cream about 16 hours (overnight) at a low temperature before churning was followed. When held in the large vats the temperature of the cream increased about 4° F. during the night. The small vats were found unsatisfactory for holding the cream so when the cream was treated in the small vats it was cooled and drawn into carefully sterilized 10 gallon cans which were placed in a cooler. The room used for this purpose had a temperature of about 38° F.

Before using the churns they were filled one-third full of cold water and rotated about 10 minutes. During this time the cream was adjusted to a temperature that would give a churning time of about 50 to 60 minutes. To adjust the churning temperature the coils were

filled with water and the steam valve merely cracked so the adjustment took place slowly. In the case of the large churnings a centrifugal cream pump was used to transfer the cream from the vats to the churns, while with the small churnings cans were employed for transferring.

A high grade vegetable color was used in varying amounts during the season when color addition was necessary. This was added directly to the cream in the churn.

The cream was churned to granules about the size of a pea and the buttermilk drawn. The granules were then rinsed with water 4° F. colder than the buttermilk during the warm months and 2° F. colder during the cold months. After the water ran clear from the buttermilk vent, wash water equal in volume to the buttermilk was added and the churn revolved four times in high gear. Then the butter was drained nearly dry through the buttermilk vent, worked a few revolutions and a first moisture test made. While making the first moisture test all the loose moisture was drained through a loosely fastened door. On the basis of the moisture test, water and salt were added to give about 1.5 per cent salt and 16 per cent moisture in the finished butter. The salt was added in a trench and enough of the required water was added to the trench to moisten the salt. The trench was then carefully closed and the remainder of the water added. The butter was worked until droplets of the free moisture were visible only on the churn door and no moisture could be squeezed out of the butter with paddles.

After using a churn it was cleaned as follows: a luke warm water

was added and the churn revolved a few times and drained. Then the churn was filled one-third full of water at 150° to 160° F., to which was added one-half pound of lime, and revolved for one-half hour. The water was then drained and the churn filled one-half full of water at 190° to 195° F. and revolved again for one-half hour. The churn was then drained and allowed to dry. Periodically the churns were treated with a hypochlorite solution.

Scoring the Butter

The samples of butter for the fresh scoring and the scoring after a few weeks at 28° F. were put in earthenware jars of about 2 pounds capacity. The samples for cold storage were put in 10 or 20 pound butter tubs and stored at about 0° F. The cold storage samples were tempered 1 to 2 days at 58° F. before they were scored.

The butter was scored by O. A. Storvick of the Gude Brothers Kieffer Company, H. D. Reynolds of the Fitch Cornell Company, R. O. Storvick of the Iowa State Brand Creameries, Inc., Roy Scoles of the State Department of Agriculture, A. W. Rudnick and Hubert Meir of the Iowa State College Extension Service, and M. Mortensen and B. W. Hammer of the Iowa State College Dairy Industry Department.

Statistical Treatment

The scores on the butter were treated statistically with the method described by Brandt (5). This is a procedure devised to test the significance of the results in a unique sample when differences are recorded as plus, minus or zero or quantative data are lacking. In the results obtained quantative data are available but since, in many cases, there was considerable variation in the scores given by the different judges, it was considered best to give the results the conservative treatment to be described. The accompanying alignment chart is based on the binominal $(P - Q)^n$ and the familiar test for the significance of a mean difference, the ratio of the mean difference to its standard deviation.

In using the approximate method, the differences are taken so the plus ones shall be in excess. The variables have been designated as follows:

P_o = observed proportion of plus differences.

P = expected proportion of plus differences.

$Q = 1 - P_o$

N = number of differences observed.

N_1 = number of differences for highly significant (1 per cent) points.

N_5 = number of differences for significant (5 per cent) points.

$\sigma = \sqrt{NPQ}$

Of these only P_o must be calculated. The formula is

$$P_o = \frac{\text{number of plus differences plus half the number of zeros}}{\text{total number of differences}}$$

If the two treatments are expected to have the same result, $P = Q = .5$. Under these conditions

$$\sigma = \sqrt{N\,(.5)\,(.5)}$$

$$= .5\sqrt{N}$$

The difference between the observed number of successes and the expected number is

$$NP_o = N\,(.5) - N\,(P_o - .5).$$

The ratio of the difference to its standard deviation is

$$\frac{N\,(P_o - .5)}{.5\sqrt{N}} = X$$

which reduces to

$$\sqrt{N}\,(P_o - .5) = .5X$$

In Table I of Fisher (16) the value of X for the highly significant (1 per cent) point is 2.576, and for the significant (5 per cent) point it is 1.960. These values substituted in the above equation give for the 1 per cent point

$$\sqrt{N_1}\,(P_o - .5) = 1.288$$

or taking logarithms of both sides,

$$.5 \text{ Log } N_1 - \text{Log } (P_o - .5) = 0.1099 \qquad (1)$$

and for the 5 per cent point

$$\sqrt{N_5}\,(P_o - .5) = 0.980$$

$$.5 \text{ Log } N_5 - \text{Log } (P_o - .5) = -0.0088. \qquad (2)$$

The accompanying chart is then based on equation (1) and (2) logarithms of (P_o - .5) for values of P_o from 0.55 - 1.00 are plotted on the first line but the values of P_o instead of (P_o - .5)are shown. The logarithms of the square roots of N_1 and N_5 are plotted on the second and third lines respectively, recording the values of N_1 and N_5 instead of their square roots. If a straight edge is placed on any value of P_o at a right angle to the three parallel lines the corresponding value of N_1 and N_5 can be read at the intersection with the second and third lines.

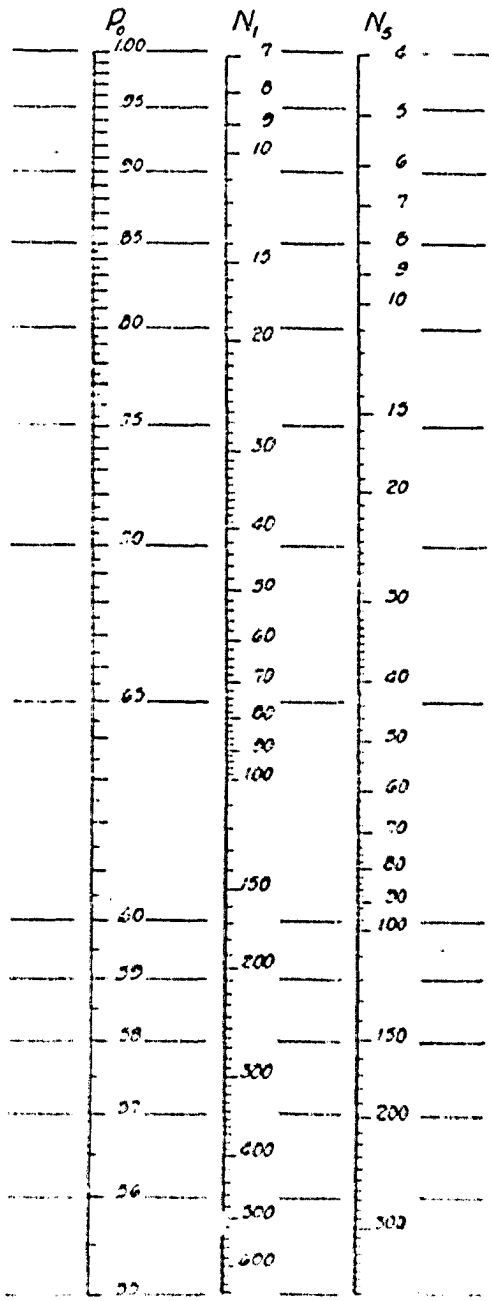
If N is equal to N_1 there is but one chance in a hundred that as great a proportion of success as that observed could be obtained on the basis of chance alone; the difference then would be highly significant. If N is equal to N_5 there are not more than five chances in a hundred that as great a proportion of successes as that observed could have been secured on the basis of chance alone, or the difference is significant.

Methods of Analysis

Acidity Determination. The acidities were determined by titrating 10 gm. samples with n/10 sodium hydroxide, using phenophthalein as the indicator.

Acetylmethylcarbinol plus Diacetyl Determination. The reagents used for the acetylmethylcarbinol plus diacetyl determination were as follows:

NUMBER OF OBSERVATIONS NECESSARY FOR A SIGNIFICANT (N_5) OR HIGHLY SIGNIFICANT (N_1) MEAN DIFFERENCE FOR VARIOUS VALUES OF P_0.



Ferric chloride solution; 40 gm. to 100 ml. with distilled water. Hydroxylamine hydrochloride solution; 20 gm. to 100 ml. with distilled water. Nickel chloride solution; 10 gm. to 100 ml. with distilled water. After adding 40 ml. of ferric chloride solution to oxidize the acetylmethylcarbinol to diacetyl, a 200 gm. portion of the material was distilled with steam generated from distilled water. The distillate was collected in a mixture of hydroxylamine hydrochloride and sodium acetate solutions by means of an adapter connected to the end of the condenser. Then the nickel chloride solution was added. The mixture of hydroxylamine hydrochloride (20 per cent solution) and sodium acetate (20 per cent solution) consisted of 1 part hydroxylamine hydrochloride to 2 parts sodium acetate. The quantity of this reagent used was varied with the amount of diacetyl expected. The distillate, with the reagent added, was allowed to stand at least 4 days to permit complete crystallization of the nickel dimethylglyoximate. This nickel salt was then filtered into a weighed crucible and washed with distilled water. After drying to constant weigh in an oven held at 221° to 230° F. (105° to 110° C.) and the results were recorded as the milligrams of nickel salt equivalent to acetylmethylcarbinol plus diacetyl per 200 gm. of material.

EXPERIMENTAL

The Influence of the Method of Using Butter Culture on the Flavor and Keeping Quality of Butter

The data obtained in the studies on the influence of the methods of using butter culture on the flavor and keeping quality of butter are presented in tables 1 to 5 inclusive.

Table 1 gives the results of 28 trials in which the addition of butter culture to the cream 16 hours before churning was compared to the addition at the time of churning. The cream used was gathered cream varying in acidity from 0.14 to 0.27 per cent; however, in all but three trials the acidities were below 0.20 per cent.

The cream was pasteurized and cooled to 38° F. in the large vats. Two 150 pound lots were removed and placed in carefully sterilized cans. Eight per cent of butter culture was added to one lot immediately. Both lots were held in a cooler (37° to 41° F.) until the following morning. Eight per cent of the same butter culture, which had been held cold overnight, was then added to the other lot and both lots were churned.

The acidities of the cream at churning varied from 0.21 to 0.34 per cent, and the acidities of the cream serum from 0.29 to 0.56 per cent. However, most of the cream acidities were below 0.26 per cent and most of the serum acidities were below 0.36 per cent. In eight of the trials

Table I.

Influence of the Method of Using Butter Culture on the Flavor and Keeping Quality of Sweet Cream Butter

Comparison of the additi of butter culture 16 hours before churning and at the time of churning

Trial	Original acidity of cream in %	Time of adding butter culture	Holding temperature of cream	Acidity at churning in %: Cream	Acidity at churning in %: Cream serum	Mg. Ni salt = to ABC - AC_2 per 200 gm. cream at churning	Fresh butter held at 28° F.: Age in days	Fresh butter held at 28° F.: Score	Storage Butter held at 0° F.: Age in days	Storage Butter held at 0° F.: Score
1	0.22	16 hrs. before churning	38°	0.28	0.38		45 da	93	210 da	91½
		At churning		.28	.38			92		90½
2	.18	16 hrs. before churning	39°	.26	.36		42	92	207	91
		At churning		.26	.36			91		91
3	.18	16 hrs. before churning	39°	.28	.38		39	92	204	90½
		At churning		.28	.38			92		91
4	.18	16 hrs. before churning	38°	.26	.36		36	92½	201	90½
		At churning		.25	.35			92		91
5	.16	16 hrs. before churning	37°	.22	.30		33	91½	198	90
		At churning		.21	.29			91		89½
6	.18	16 hrs. before churning	38°	.22	.30		30	91½	195	90
		At churning		.22	.30			91		89
7	.18	16 hrs. before churning	38°	.26	.36		27	91	192	90
		At churning		.24	.34			91		89
8	.18	16 hrs. before churning	38°	.24	.32		24	91	189	91
		At churning								

4	.18	16 hrs. before churning	38°	.26	.36		92½	201	90½
		At churning		.25	.35	36	92		91
5	.16	16 hrs. before churning	37°	.22	.30		91½	198	90
		At churning		.21	.29	33	91		89½
6	.18	16 hrs. before churning	38°	.22	.30		91½	195	90
		At churning		.22	.30	30	91		89
7	.18	16 hrs. before churning	38°	.26	.36		91	192	90
		At churning		.24	.34	27	91		89
8	.18	16 hrs. before churning	38°	.24	.32		91	189	91
		At churning		.23	.32	24	91		91
9	.16	16 hrs. before churning	37°	.21	.29		90	186	89
		At churning		.21	.29	21	91		89
10	.17	16 hrs. before churning	39°	.24	.34		91½	183	90½
		At churning		.22	.30	18	91		89
11	.16	16 hrs. before churning	38°	.21	.29		92	180	89
		At churning		.21	.29	15	91½		88
12	.14	16 hrs. before churning	38°	.21	.29		92	177	91
		At churning		.21	.29	12	91½		92
13	.16	16 hrs. before churning	40°	.22	.30		92	177	91
		At churning		.22	.30	12	91½		90
14	.16	16 hrs. before churning	39°	.22	.30		92	174	91
		At churning		.22	.30	9	91½		90

Table I. (Continued)

Influence of the Method of Using Butter Culture on the Flavor and Keeping Quality of Sweet Cream Butter

Comparison of the addition of butter culture 16 hours before churning and at the time of churning

Trial	Original acidity of cream in %	Time of adding butter culture	Holding temperature of cream	Acidity at churning in %		Mg.Ni salt = to AlC - AC_2 per 200 gm. cream at churning	Fresh butter held at 28° F.		Storage butter held at 0° F.	
				Cream	Cream serum		Age in days	Score	Age in days	Score
15	.14	16 hrs. before churning	39°	0.21	0.30		9 da	92	174 da	90½
		At churning		.21	.30			91		90
16	.16	16 hrs. before churning	38°	.24	.32		6	91½	168	90
		At churning		.24	.32			91½		89½
17	.18	16 hrs. before churning	37°	.22	.30		6	91½	168	90
		At churning		.22	.30			91		89
18	.17	16 hrs. before churning	38°	.25	.35	trace	3	93	210	92
		At churning		.25	.35	none		92½		91½
19	.16	16 hrs. before churning	37°	.25	.35	.0054	6	92	207	92
		At churning		.26	.33	.0037		91½		91
20	.16	16 hrs. before churning	38°	.26	.35	.0031	3	91½	204	91
		At churning		.26	.35	.0033		92		91
21	.15	16 hrs. before churning	39°	.24	.35	.0101	9	92	201	91
		At churning		.23	.34	.0017		91½		90½
22	.17	16 hrs. before churning	40°	.26	.36	.0020	6	92	198	92½
		At churning		.26	.36	.0009		91½		92

18	.17	At churning	38°	.25	.35	none	3	92½	210	91½
19	.16	16 hrs. before churning	37°	.25	.35	.0054	6	92	207	92
		At churning		.26	.33	.0037		91½		91
20	.16	16 hrs. before churning	38°	.26	.35	.0031	3	91½	204	91
		At churning		.26	.35	.0033		92		91
21	.15	16 hrs. before churning	39°	.24	.35	.0101	9	92	201	91
		At churning		.23	.34	.0017		91½		90½
22	.17	16 hrs. before churning	40°	.26	.36	.0020	6	92	198	92½
		At churning		.26	.36	.0009		91½		92
23	.27	16 hrs. before churning	41°	.34	.56	.0221	3	91½	195	92
		At churning		.34	.56	.0215		91		92
24	.16	16 hrs. before churning	39°	.24	.31	trace	12	92½	192	89½
		At churning		.23	.30	none		92		89
25	.16	16 hrs. before churning	39°	.24	.35	.0016	9	91	189	90
		At churning		.24	.35	.0016		92½		91
26	.22	16 hrs. before churning	40°	.26	.35	.0045	6	92½	186	91
		At churning		.26	.35	.0026		92		90½
27	.16	16 hrs. before churning	41°	.25	.34	.0036	3	92	183	91
		At churning		.25	.34	.0008		91½		92½
28	.16	16 hrs. before churning	40°	.24	.33	.0014	9	92½	180	91
		At churning		.24	.33	.0006		92		90½

the acidities of the cream at churning were slightly higher when the butter culture was added 16 hours before churning than when it was added at churning, although in all cases the differences were within the limits of error of the acidity test. In the other 20 trials the acidities were the same.

Acetylmethylcarbinol plus diacetyl determinations were made on the cream just before churning in eleven of the trials. In nine instances the acetylmethylcarbinol plus diacetyl content was higher when butter culture was added 16 hours before churning, in one trial it was higher when the culture was added at churning, and in one trial the values were equal.

The first scores on the butter were obtained between the third and forty-fifth day after manufacture, although the butter was usually scored within 12 days; this butter was held at about 28° F. The butter was also scored after 168 to 210 days in cold storage at about 0° F. The scores on the fresh butter ranged from 91 to 93 and on the cold storage butter from 88 to 92. The differences in scores of the butter, as a result of the two treatments, were not great but were quite consistent. The relationships of the scores are shown in the following summary.

	Fresh butter	Storage butter
Number of high scores when culture was added 16 hours before churning	21	18
Number of high scores when culture was added at churning	3	5
Number of tie scores	4	5
Total	28	28

The addition of culture 16 hours before churning gave a greater number of high scores than its addition at churning when the butter was scored fresh and also when scored after cold storage. When treated statistically a value of 14 was determined for N_1 in the case of the fresh butter. Since N or 28 is greater than N_1 or 14 the difference in the number of high scores is highly significant. A value of 19 was was determined for N_5 in the case of the cold storage butter. Since N or 28 is greater than N_5 or 19 this difference in the number of high scores is significant.

Table 2 presents the data obtained when adding butter culture various lengths of time before churning, as compared to the use of no culture. The cream employed was all sweet gathered cream varying from 0.16 to 0.18 per cent in acidity.

The cream was pasteurized and cooled to 38° F. in the large vats. Then from three to four lots of 150 pounds each were removed and placed in carefully sterilized cans. The following treatments were used with the cream:

Table II

Influence of the Method of Using Butter Culture on the Flavor and Keeping Quality of Sweet Cream Butter

Comparison of addition of butter culture at various lengths of time before churning on the AlC content of the cream and flavor and keeping quality of the butter

Trial	Original acidity of cream in %	Time of adding butter culture	Holding temperature of cream	Acidity at churning in %		Mg.Ni salt = to AlC – AC_2 per 200 gm. cream at churning	Fresh butter held at 28° F.		Storage butter held at 0° F.	
				Cream	Cream serum		Age in days	Score	Age in days	Score
1	0.16	112 hrs. before churning	39°	0.27	0.38	0.0008	6 da	93½	177 da	91½
		88 hrs. before churning		.26	.36	.0035		93		92
		40 hrs. before churning		.24	.34	.0053		93½		91½
		16 hrs. before churning		.24	.34	.0038		93		92
2	.16	112 hrs. before churning	39°	.26	.37	.0019	3	93	174	91½
		88 hrs. before churning		.26	.37	.0031		93½		91½
		40 hrs. before churning		.25	.36	.0014		93		92
		16 hrs. before churning		.25	.36	.0033		93½		90½
3	.18	88 hrs. before churning	37°	.24	.34	.0021	9	93	171	93
		64 hrs. before churning		.24	.34	.0020		93		93
		40 hrs. before churning		.23	.33	.0018		93		93
		At churning		.23	.33	.0013		93		93
4	.17	6 hrs. before churning	36°	.25	.34	.0029	6	93½		
		3 hrs. before churning		.25	.34	.0056		93½		
		At churning		.24	.33	.0021		93		

		6 hrs. before churning		.25	.34	.0029		93½		
4	.17	3 hrs. before churning	36°	.25	.34	.0056	6	93½		
		At churning		.24	.33	.0021		93		
		No starter		.18	.25	.0000		92½		
		16 hrs. before churning		.25	.34	.0036		93½		
		6 hrs. before churning		.25	.34	.0026		93		
5	.17	3 hrs. before churning	36°	.25	.34	.0019	3	93½		
		At churning		.24	.33	.0026		93		
		No startor		.17	.24	.0000		93		
		16 hrs. before churning		.25	.34	.0064		93½		
		6 hrs. before churning		.25	.34	.0021		93½		
6	.16	3 hrs. before churning	37°	.25	.34	.0019	9	93½		
		At churning		.23	.32	.0031		93½		
		No startor		.17	.23	.0000		93		
		16 hrs. before churning		.27	.36	.0028		93½		92½
		6 hrs. before churning		.27	.36	.0024		93½		93
7	.17	3 hrs. before churning	37°	.27	.36	.0019	6	93½	162	93
		At churning		.26	.35	.0006		93		93
		No starter		.17	.25	.0000		92½		93
		16 hrs. before churning		.26	.35	.0031		93½		93
8	.16	At churning	38°	.25	.34	.0013	3	93	159	93
		No starter		.17	.24	.0000		92½		92½

1. Pasteurized cream was held overnight at 36° to 39° F. and churned without adding butter culture.
2. Pasteurized cream was held overnight at 36° to 39° F., 8 per cent culture was then added, and some lots were churned immediately, some after 3 hours, and some after 6 hours.
3. Pasteurized cream to which 8 per cent culture was added immediately after cooling was held at 36° to 39° F. and churned after 16, 40, 64, 88 or 112 hours.

The acidities of the cream at churning varied from 0.17 per cent (without culture added) to 0.27 per cent (with culture added). The serum acidity of the cream varied from 0.24 per cent (without culture added) to 0.38 per cent (with culture added). The increase in acidity, even with the relatively long holding periods after the culture was added, were very slight and usually within the limits of error of the acidity test.

Acetylmethylcarbinol plus diacetyl determinations were made on each lot of cream just before churning. None of the samples without butter culture contained any acetylmethylcarbinol plus diacetyl. Immediately after mixing the cream and butter culture, acetylmethylcarbinol plus diacetyl was regularly present. After a 3 hour holding period the acetylmethylcarbinol plus diacetyl content was increased in two trials and decreased in two, and after 6 hours there was an increase in three trials and a decrease in one trial. In all four trials where cream containing butter culture was held 16 hours before churning, the

acetylmethylcarbinol plus diacetyl content was higher than when held for shorter periods. Holding periods of longer than 16 hours were compared in three of the trials. In one trial the acetylmethylcarbinol plus diacetyl content of the cream was higher after a 40 hour holding period than immediately after adding the culture. In one trial the acetylmethylcarbinol plus diacetyl was increased after a 40 hour holding period, as compared to a 16 hour period, while in another trial a decrease had taken place. A 64 hour holding period resulted in a higher acetylmethylcarbinol plus diacetyl content than a 40 hour holding period in one trial. Cream held for 88 hours showed a slightly higher acetylmethylcarbinol plus content than cream held 64 hours in one trial and the same was true in another trial where an 88 hour period was compared to a 40 hour period, while in a third trial a definite decrease took place between 40 and 88 hours. Holding periods of 112 hours were used in two trials and in both cases a decrease in acetylmethylcarbinol plus diacetyl had taken place when compared to the content after an 88 hour holding period.

The scores on the fresh butter were obtained between the third and ninth day. The butter was again scored after 159 to 177 days at about 0° F. The scores on the fresh butter ranged from 92 to 93½ and on the cold storage butter from 90½ to 93. The butter made using culture was higher in score than the butter made without culture in all but one trial and in this case the scores were the same.

The practice of holding cream 3 to 6 hours after adding the butter culture before churning gave slightly more high scores than when cream was churned immediately after adding culture. A holding period of 16 hours after adding the culture gave higher scoring butter in three out of four trials than the use of shorter holding periods and it was also higher in score than the butter churned immediately after adding culture in four out of four trials. In general this agrees with the results in table 1, where a holding period of 16 hours after adding culture gave butter superior to that made from cream churned immediately after adding culture. Holding periods of over 16 hours did not result in increases in the score of the butter.

The scores on the cold storage butter were in general slightly lower than on the fresh butter. In certain trials all the lots of butter seemed to deteriorate more than in others while in some cases there was no change in score. There was evidently no difference in keeping quality as a result of the different treatments. The scores were not treated statistically because of the few trials made with each of the various treatments.

The results of 13 trials in which the addition of butter culture to the cream 16 hours before churning was compared to its addition at the time of churning are given in table 3. In these trials only sour gathered cream was used. The original acidities of the cream varied from 0.43 to 0.65 per cent.

Table III

Influence of the Method of Using Butter Culture on the Flavor and Keeping Quality of Sour Cream Butter

Comparison of the addition of butter culture 16 hours before churning and at the time of churning

Trial	Original acidity of cream in %	Time of adding butter culture	Holding temperature of cream °F.	Acidity at churning in %		Fresh butter held at 28° F.		Storage butter held at 0° F.	
				Cream	Cream serum	Age in days	Score	Age in days	Score
1	0.55	16 hrs. before churning	38°	0.27	0.38	6 da	92½	210 da	91
		At churning		.27	.38		92		90½
2	.60	16 hrs. before churning	38°	.32	.43	8	91	208	91
		At churning		.32	.44		92		90½
3	.60	16 hrs. before churning	39°	.27	.37	6	91	205	91
		At churning		.28	.39		90		90½
4	.62	16 hrs. before churning	40°	.20	.29	6	90½	201	90½
		At churning		.18	.26		89½		89½
5	.65	16 hrs. before churning	39°	.26	.36	8	91½	198	90
		At churning		.25	.36		91		89
6	.65	16 hrs. before churning	39°	.21	.29	10	89½	195	88
		At churning		.21	.29		89		89
7	.58	16 hrs. before churning	40°	.21	.29	6	91	192	90½
		At churning		.21	.29		90½		89½
8	.53	16 hrs. before churning	39°	.21	.29	6	89½	184	89½

		At churning		.28	.39		90		90½
4	.62	16 hrs.before churning	40°	.20	.29	6	90½	201	90½
		At churning		.18	.26		89½		89½
5	.65	16 hrs.before churning	39°	.26	.36	8	91½	198	90
		At churning		.25	.36		91		89
6	.65	16 hrs.before churning	39°	.21	.29	10	89½	195	88
		At churning		.21	.29		89		89
7	.58	16 hrs.before churning	40°	.21	.29	6	91	192	90½
		At churning		.21	.29		90½		89½
8	.53	16 hrs.before churning	39°	.21	.29	6	89½	184	89½
		At churning		.21	.29		88½		88½
9	.47	16 hrs.before churning	37°	.25	.34	8	91	181	90
		At churning		.25	.34		90		89
10	.43	16 hrs.before churning	37°	.26	.36	10	91	177	90
		At churning		.26	.36		91		91
11	.46	16 hrs.before churning	36°	.25	.36	8	90	174	89
		At churning		.25	.32		89		88
12	.57	16 hrs.before churning	36°	.21	.29	8	90	171	90½
		At churning		.21	.29		90		90
13	.65	16 hrs.before churning	37°	.21	.29	8	89½	168	88
		At churning		.21	.29		89		89

The cream was neutralized to as near 0.20 per cent acidity as possible before pasteurization. One-half of the excess acid was reduced with magnesium oxide and the other one-half with sodium bicarbonate. The calculated amount of each neutralizer was made up to a 15 per cent suspension or solution and added to the cream at least 20 minutes before heating.

The cream was pasteurized in the large vats at 150° F. for 30 minutes, instead of the usual exposure, then cooled to 38° F. Two 150 pound portions were removed and treated in exactly the same manner with respect to the use of culture as the cream employed in obtaining the data given in table 1. The cream was held overnight at 36° to 40° F. and churned the next morning.

The acidities of the cream at churning ranged from 0.21 to 0.32 per cent and the acidities of the cream serum from 0.29 to 0.44 per cent. These large variations in acidity were probably due to the inaccuracies in the neutralization of relatively small lots of cream with the highly insoluble magnesium oxide neutralizer. In two trials the acidities of the cream at churning were slightly higher when culture was added 16 hours before churning than when it was added at churning, in 10 trials the acidities were the same and in one trial the cream to which culture was added at churning was higher in acidity. In every case the difference in acidity was within the limits of error of the acidity test.

The scores on the fresh butter were obtained between the sixth and

tenth day after manufacture. The butter was again scored after 168 to 210 days at about 0° F. The fresh butter ranged from 88½ to 92⅔ in score and the cold storage butter from 88 to 91.

The following summary shows the relationships of the scores.

	Fresh butter	Storage butter
Number of high scores when culture was added 16 hours before churning	10	11
Number of high scores when culture was added at churning	1	2
Number of tie scores	2	0
Total	13	13

The addition of culture 16 hours before churning gave a greater number of high scores than its addition at churning when the butter was scored fresh and also after cold storage. The results were treated statistically and a value of 9 was obtained for N_5 in the case of the fresh butter. Since N or 13 is greater than N_5 or 9 these results are significant. A value of 9 was obtained for N_5 in the case of the cold storage butter. N or 13 being greater than N_5 the results are significant.

The comparative effects of adding 8 per cent or 10 per cent of culture to cream after cooling, or of adding 8 per cent culture at 70° F. and ripening 1 hour before cooling, on the resulting butter are presented in table 4. In these ten trials sweet gathered cream, varying in acidity from 0.11 to 0.17 per cent, was used.

The cream was pasteurized and cooled to 70° F. in the large vats. One 150 pound lot was then removed and placed in a small 70 gallon vat

Table IV.

Influence of the Method of Using Butter Culture on the Flavor a

Comparison of the addition of (A) 8 per cent butter culture added
added at 70° F. cooled at once and (C) 8 per cent added at 7

Trial	Original acidity of cream in %	Method of using the butter culture	Acidity after adding butter culture in %	Holding temperature of cream °F.	Acidity at churning in %		Mg. ni salt - to AMC - AC_2 after adding b.c. per 200 gm. cream	Mg. ni salt to AMC - A after ripe ing per 20 gm. crea
					Cream	Cream serum		
		8% b.c. not ripened	0.21		0.22	0.30	0.0031	
1	0.16	10% b.c. not ripened	.22	43°	.26	.36	.0050	9 da
		8% b.c. ripened 1 hr.	.22		.24	.33	.0045	.0061
		8% b.c. not ripened	.18		.22	.30	.0072	
2	.14	10% b.c. not ripened	.20	38	.23	.31	.0085	
		8% b.c. ripened 1 hr.	.19		.24	.33	.0066	.0085
		8% b.c. not ripened	.19		.19	.27	.0059	
3	.14	10% b.c. not ripened	.20	35	.21	.29	.0042	
		8% b.c. ripened 1 hr.	.19		.20	.27	.0040	.0072
		8% b.c. not ripened	.19		.20	.27	.0044	
4	.13	10% b.c. not ripened	.20	37	.22	.31	.0065	
		8% b.c. ripened 1 hr.	.18		.23	.31	.0052	.0076
		8% b.c. not ripened	.18		.22	.30	.0058	
5	.13	10% b.c. not ripened	.21	38	.22	.31	.0085	
		8% b.c. ripened 1 hr.	.17		.21	.29	.0046	.0065
		8% b.c. not ripened	.24		.23	.32	.0058	
6	.17	10% b.c. not ripened	.24	36	.25	.34	.0070	
		8% b.c. ripened 1 hr.	.24		.23	.32	.0060	.0084
		8% b.c. not ripened	.17		.20	.27	trace	
7	.11	10% b.c. not ripened	.19	39	.20	.28	trace	
		8% b.c. ripened 1 hr.	.17		.21	.29	trace	.0032
		8% b.c. not ripened	.19		.23	.31	.0049	
8	.13	10% b.c. not ripened	.20	43	.23	.31	.0058	
		8% b.c.						

le IV.

on the Flavor and Keeping Quality of Sweet Cream Butter

er culture added at 70° F. cooled at once (B) 10 per cent
cent added at 70° F. ripened 1 hour and cooled

lt - AC_2 ing eam	Mg. ni salt - to AMC - AC_2 after ripening per 200 gm. cream	Mg. ni salt - to AMC - AC_2 at churning per 200 gm. cream	Fresh butter held at 28° F. Age in days	Score	Butter held for a few weeks at 28°F. Age in days	Score	Storage butter held at 0° F. Age in days	Score
		0.0068		93½		92½		93
	9 da	.0094	9 da	93½	27 da	92½	174 da	92½
	.0061	.0146		93½		93½		92½
		.0111		92		92		92½
		.0133	6	92	24	92½	171	93½
	.0085	.0209		92½		92½		93
		.0061		93		93		93
		.0059	3	93	16	93	163	93½
	.0072	.0075		92½		93		93½
		.0076		93		93		92
		.0093	9	93	24	93	163	92½
	.0076	.0162		93		93		92½
		.0103		93		92½		93
		.0124	6	93	21	92½	160	93½
	.0065	.0125		93½		92½		93½
		.0058		92		92½		93
		.0078	3	92½	18	92½	157	93
	.0084	.0102		92½		93		93
		.0035		92½		92½		93
		.0031	9	93	27	93	154	93½
	.0032	.0074		93		93		93½
		.0097		94		93½		93
		.0129	6	94½	24	93½	151	93
	.0076	.0168		94½		93½		93

	In %	Culture	In %	Fe	Cream	Serum	1200 gm. Cream	gm. C
		8% b.c.						
		not ripened	0.21		0.22	0.30	0.0031	
		10% b.c.						
1	0.16	not ripened	.22	43°	.26	.36	.0050	9
		8% b.c.						
		ripened 1 hr.	.22		.24	.33	.0045	.00
		8% b.c.						
		not ripened	.18		.22	.30	.0072	
		10% b.c.						
2	.14	not ripened	.20	38	.23	.31	.0085	
		8% b.c.						
		ripened 1 hr.	.19		.24	.33	.0066	.00
		8% b.c.						
		not ripened	.19		.19	.27	.0039	
		10% b.c.						
3	.14	not ripened	.20	35	.21	.29	.0042	
		8% b.c.						
		ripened 1 hr.	.19		.20	.27	.0040	.00
		8% b.c.						
		not ripened	.19		.20	.27	.0044	
		10% b.c.						
4	.13	not ripened	.20	37	.22	.31	.0065	
		8% b.c.						
		ripened 1 hr.	.18		.23	.31	.0052	.0
		8% b.c.						
		not ripened	.18		.22	.30	.0058	
		10% b.c.						
5	.13	not ripened	.21	38	.22	.31	.0065	
		8% b.c.						
		ripened 1 hr.	.17		.21	.29	.0046	.0
		8% b.c.						
		not ripened	.24		.23	.32	.0058	
		10% b.c.						
6	.17	not ripened	.24	36	.25	.34	.0070	
		8% b.c.						
		ripened 1 hr.	.24		.23	.32	.0060	.0
		8% b.c.						
		not ripened	.17		.20	.27	trace	
		10% b.c.						
7	.11	not ripened	.19	39	.20	.28	trace	
		8% b.c.						
		ripened 1 hr.	.17		.21	.29	trace	.0
		8% b.c.						
		not ripened	.19		.23	.31	.0049	
		10% b.c.						
8	.13	not ripened	.20	43	.23	.31	.0058	
		8% b.c.						
		ripened 1 hr.	.19		.24	.33	.0049	.0
		8% b.c.						
		not ripened	.21		.21	.29	.0047	
		10% b.c.						
9	.16	not ripened	.22	42	.22	.31	.0065	
		8% b.c.						
		ripened 1 hr.	.22		.22	.31	.0058	.0
		8% b.c.						
		not ripened	.19		.19	.26	.0046	
		10% b.c.						
10	.15	not ripened	.20	39	.20	.27	.0063	
		8% b.c.						
		ripened 1 hr.	.19		.19	.26	.0045	.0

51		0.0068		93½		92½		93
50	9 da	.0094	9 da	93½	27 da	92⅝	174 da	92¾
55	.0061	.0146		93⅝		93½		92½
72		.0111		92		92		92¾
55		.0133	6	92	24	92½	171	93½
66	.0085	.0209		92½		92¾		93½
99		.0061		93		93		93
92		.0059	3	93	16	93	163	93½
90	.0072	.0075		92½		93		93½
94		.0076		93		93		92
95		.0093	9	93	24	93	165	92½
92	.0076	.0162		93		93¼		92½
93		.0103		93		92⅝		93
95		.0124	6	93	21	92⅝	160	93½
96	.0065	.0125		93½		92⅝		93½
93		.0058		92		92¾		93
90		.0078	3	92½	18	92⅝	157	93
90	.0084	.0102		92½		93		93
99		.0035		92¾		92½		93½
99		.0031	9	93	27	93	154	93¾
90	.0032	.0074		93		93		93½
90		.0097		94		93¾		93
91		.0129	6	94¼	24	93¾	151	93
90	.0076	.0168		94½		93⅝		93
97		.0066		93		92½		92¾
91		.0067	3	93	27	92⅝	148	93
	.0071	.0087		93½		93½		93
91		.0077		92		92⅛		
			3	92	24	92⅜		
90	.0062	.0120		92		92⅝		

and 8 per cent butter culture added. After ripening for 1 hour the cream was cooled to 38° F., and placed in carefully sterilized cans. The cream remaining in the large vat was cooled to 38° F. and two lots of 150 pounds each were removed. Using the same batch of culture that was employed in ripening the cream, 8 per cent culture was added to one of these lots and 10 per cent to the other. All three lots were held in a cooler (35° to 43° F.) until the next morning, and churned.

The acidities of the cream immediately after adding the butter culture varied from 0.17 to 0.24 per cent. In nine trials the lots to which 10 per cent culture was added were slightly higher in acidity than the lots to which 8 per cent culture was added, and in one trial the acidities were equal. The acidities of the cream at the time of churning varied from 0.19 to 0.26 per cent and the serum acidities from 0.27 to 0.36 per cent. The cream to which 10 per cent culture was added was higher in acidity at churning than the cream to which 8 per cent culture was added after cooling in seven out of ten trials, while in three trials the acidities were the same. In seven of the ten trials the ripened cream was slightly higher in acidity at the time of churning than the cream to which 8 per cent culture was added after cooling, while in one trial the situation was reversed, and in two trials the acidities were the same. The cream to which 10 per cent culture was added was higher in acidity at churning than the ripened cream in five trials, in three trials the situation was reversed and in two trials the acidities were

equal.

Acetylmethylcarbinol plus diacetyl determinations were made on all the cream immediately after adding the butter culture, after ripening in the case of the one lot in each trial, and again at the time of churning. Immediately after adding the butter culture the lots to which 10 per cent culture was added were higher in acetylmethylcarbinol plus diacetyl than the lots to which 8 per cent culture was added in every trial except one. In this trial only a trace of acetylmethylcarbinol plus diacetyl was present in any of the lots. At the time of churning, the portions of cream to which 10 per cent culture was added were higher in acetylmethylcarbinol plus diacetyl, than the portions to which 8 per cent culture was added after cooling in seven of the ten trials, while in two trials the situation was reversed, and in one trial the determination on a sample was lost. The ripened lots of cream were higher in acetylmethylcarbinol plus diacetyl at churning than the lots to which 8 and 10 per cent culture was added after cooling in nine out of ten trials and in the other trial the sample was lost. All the lots in every trial increased in acetylmethylcarbinol plus diacetyl during the holding period which confirms the results presented in tables 1 and 2.

The scores on the fresh butter were obtained between the third and ninth day after manufacture. The butter was scored again after 16 to 27 days at about 28° F., and after 148 to 174 days at about 0° F. The scores on the fresh butter ranged from 92 to 94½, those on the butter

after holding at about 28° F. ranged from 92 to 93 3/4 and those on the cold storage butter ranged from 92 to 93 3/4. The relationships of these scores are shown in the following summaries.

Comparison of the use of 8 and 10 per cent culture added to the cream after cooling

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using 10 per cent culture added after washing	4	4	6
Number of high scores using 8 per cent culture added after cooling	0	0	1
Number of tie scores	6	6	2
Total	10	10	9

Comparison of the use of 10 per cent culture added to the cream after cooling with ripening of the cream

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores with ripened cream	6	8	1
Number of high scores using 10 per cent culture added after cooling	1	0	2
Number of tie scores	3	2	6
Total	10	10	9

Comparison of the use of 8 per cent culture added to the cream after cooling with ripening of the cream

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores with ripened cream	7	9	5
Number of high scores using 8 per cent culture added after cooling	1	0	1
Number of tie scores	2	1	3
Total	10	10	9

The addition of 8 and 10 per cent culture to cream after cooling was compared in the first summary. The use of 10 per cent culture gave more high scoring butter than the use of 8 per cent culture when the butter was scored fresh, also after holding at about 28° F. and again after cold storage. A value of 25 was determined for N_5 in case of the fresh butter, a value of 25 for the butter after holding at about 28° F. and a value of 14 for the butter after cold storage. Since 8 or 9 is less than any of these values for N_5 the difference in the number of high scores is in no case significant.

In the second summary the use of 10 per cent culture added to the cream after cooling was compared with ripening the cream. The ripened cream butter gave more high scores when scored fresh, also when scored after holding at about 28° F. while after cold storage the unripened cream butter gave the greater number of high scores. A value of 16 was determined for N_5 in case of the fresh butter. Since 8 or 10 is less than N_5 or 16 the difference in the number of high scores is not significant. A

A value of 7 was determined for N_5 in case of the butter after holding at 28° F. N or 10 is greater than N_5 or 7 and, accordingly, the difference in the number of high scores is significant. A value of over 400 was determined for N_5 in case of the cold storage butter. With N or 8 less than N_5 or 400, the difference in the number of high scores is not significant.

The use of 8 per cent culture added to cream after cooling was compared with ripening of the cream in the third summary. The ripened cream butter was more often high in score than the butter made from cream to which 8 per cent culture was added after cooling when scored fresh, also after holding at about 28° F. and again after cold storage. A value of 11 was determined for N_5 in case of the fresh butter. Since N or 10 is less than N_5 or 11 the difference in the number of high scores is not significant. A value of 9 was determined for N_1 in case of the butter held at about 28° F. N or 10 is greater than N_1 or 9 so that the difference in the number of high scores is highly significant. In case of the cold storage butter, a value of 44 was determined for N_5. Since N or 9 is less than N_5 or 44 the difference in the number of high scores is not significant.

Table 5 gives the results of seven trials in which butter was made using the following treatments: 8 per cent butter culture was added to cream after cooling and the cream then held at 28° to 36° F.; 8 per cent butter culture was added to cream after cooling and the cream then held at 42° to 51° F.; 8 per cent butter culture was added

Table V.

Influence of the Method of Using Butter Culture on the Flav

Comparison of (a) the addition of 8 per cent butter cult
per cent added at 70° F. ripened 1 hour u

Trial	Original acidity of cream in %	Method of using the butter culture	Acidity after adding butter culture in %	Holding temperature of cream °F.	Acidity at churning in % Cream	Acidity at churning in % Cream serum	Mg. ni salt to AlC - AC_2 after adding b.c. per 200 gm. cream	Mg. to Al after ing gm.
		8% b.c. not ripened	0.19	28° F.	0.20	0.27	0.0020	
1	0.13	8% b.c. not ripened	.19	48	.22	.30	.0026	
		8% b.c. ripened 1 hr.	.20	28	.20	.28	.0021	
		8% b.c. not ripened	.19	31	.19	.26	.0046	
2	.13	8% b.c. not ripened	.19	42	.19	.27	.0044	
		8% b.c. ripened 1 hr.	.19	31	.20	.27	.0044	
		8% b.c. not ripened	.18	31	.19	.26	.0007	
3	.13	8% b.c. not ripened	.18	43	.20	.27	.0006	
		8% b.c. ripened 1 hr.	.18	31	.19	.26	.0006	
		8% b.c. not ripened	.19	32	.20	.27	.0014	
4	.13	8% b.c. not ripened	.18	42	.20	.28	.0011	
		8% b.c. ripened 1 hr.	.18	32	.21	.29	.0009	
		8% b.c. not ripened	.20	36	.21	.29	.0005	
5	.15	8% b.c. not ripened	.20	48	.23	.31	.0004	
		8% b.c. ripened 1 hr.	.20	36	.21	.29	.0004	
		8% b.c. not ripened	.21	28	.22	.30	.0043	
6	.15	8% b.c. not ripened	.21	57	.29	.40	.0036	
		8% b.c. ripened 1 hr.	.21	28	.24	.33	.0044	
		8% b.c. not ripened	.18	34	.18	.25	.0033	
7	.14	8% b.c. not ripened	.18	50	.21	.28	.0025	
		8% b.c. ripened 1 hr.	.19	34	.22	.30	.0028	

)le V.

ıre on the Flavor and Keeping Quality of Sweet Cream Butter

ınt butter culture at 70° F. cooled at once, (b) 8
ipened 1 hour using various holding temperatures

ni salt - MC - AC_2 r adding per gm. cream	Mg. ni salt - MC - AC_2 after ripening per 200 gm. cream	Mg. ni salt - MC - AC_2 at churning per 200 gm. cream	Fresh butter held at 28°F. Age in days	Score	Butter held a few weeks at 28°F. Age in days	Score	Storage butter held at 0°F. Age in days	Score
0.0020		0.0035		93½		93		92½
.0026		.0050	7 da	93½	42 da	93	180 da	92½
.0021	0.0036	.0042		93½		93		92½
.0046		.0044		92½		92		91½
.0044		.0060	3	92½	38	92½	176	91
.0044	.0056	.0067		92½		92		91½
.0007		.0019		93		92½		92
.0006		.0033	9	93½	35	92½	173	92½
.0006	.0017	.0021		93		93		92½
.0014		.0034		93½		93		93½
.0011		.0032	2	93½	28	93	166	93½
.0009	.0022	.0051		93		93		93½
.0005		.0009		93		92½		93
.0004		.0035	9	93	25	92½	163	93
.0004	.0013	.0026		93		92½		93
.0043		.0058		93		93		93
.0036		.0126	6	93½	23	93½	160	93½
.0044	.0067	.0153		93½		93½		93½
.0033		.0037		93		92		93
.0026		.0087	3	93½	19	92½	156	93½
.0028	.0067	.0108		93½		92½		93½

to cream at 70° F., the cream ripened 1 hour and then cooled and held at 28° to 36° F. In these trials sweet cream varying from 0.13 to 0.15 per cent acidity was used.

The cream was pasteurized in the large vats and cooled to 70° F. One 150 pound lot was removed and placed in a 70 gallon vat and 8 per cent culture added. After ripening for 1 hour at 70° F. this cream was cooled to 32° F. and held at 28° to 36° F. overnight. The remainder of the cream in the large vat was cooled to 48° F. and another 150 pound lot was placed in carefully sterilized cans, and 8 per cent of the same culture was then added. This lot of cream was held overnight at 42° to 51° F. The rest of the cream in the large vat was cooled to 32° F. and a third 150 pound lot was removed and placed in cans. After adding 8 per cent of the same culture this lot of cream was held overnight at 28° to 36° F. The next morning all three lots of cream were churned.

The acidities of the cream immediately after adding the culture varied from 0.18 to 0.21 per cent. The differences in acidities between the lots in a trial immediately after adding the culture were very slight and all within the limits of error of the acidity test. The acidities of the cream at the time of churning varied from 0.19 to 0.29 per cent and the acidities of the cream serum from 0.26 to 0.40 per cent. The unripened cream held at 42° to 51° F. was higher in acidity than the unripened cream held at 28° to 36° F. in five trials and the acidities were equal in two trials. However, the differences in acidity were, in most cases, very slight and were often within the

limits of error of the acidity test. In four trials the unripened cream held at 42° to 51° F. was higher in acidity than the ripened cream held at 28° to 36° F., while in three trials the situation was reversed.

Acetylmethylcarbinol plus diacetyl determinations were made on the cream immediately after adding the butter culture, after ripening in case of the one lot in each trial, and again at the time of churning. Immediately after adding the culture the acetylmethylcarbinol plus diacetyl contents were so nearly the same with the lots in a trial that they were within the limits of error of the determination. At the time of churning the unripened cream held at 42° to 51° F. was higher in acetylmethylcarbinol plus diacetyl than the unripened cream held at 28° to 36° F. in six of the trials, while in one trial the situation was reversed. In four trials the ripened cream held at 28° to 36° F. was higher in acetylmethylcarbinol plus diacetyl than the unripened cream held at 42° to 51° F., while in three trials the situation was reversed. The ripened cream held at 28° to 36° F. was higher in acetylmethylcarbinol plus diacetyl than the unripened cream held at 28° to 36° F. in every trial. In every case there was an increase in acetylmethylcarbinol plus diacetyl during holding which confirms the results presented in tables 1, 2 and 4.

The butter was scored between the third and ninth day after manufacture, again after 19 to 42 days at about 28° F. and after cold storage for 156 to 180 days at about 0° F. The scores of the fresh butter varied

from 92½ to 93 3/4, those on the butter held at about 28° F. from 92 to 93⅓, and those on the cold storage butter from 91 to 93⅔. The relationships of these scores are shown in the following summaries.

Comparison of the use of unripened cream held at 42° to 51° F. and unripened cream held at 28° to 36° F.

	Fresh butter	Butter held at 28°F.	Storage butter
Number of high scores using holding temperatures of 42° to 51° F. on unripened cream	5	4	4
Number of high scores using holding temperatures of 28° to 36° F. on unripened cream	0	0	1
Number of tie scores	2	3	2
Total	7	7	7

Comparison of the use of unripened cream held at 42° to 51° F. and ripened cream held at 28° to 36° F.

	Fresh butter	Butter held at 28°F.	Storage butter
Number of high scores using holding temperatures of 28° to 36° F. on ripened cream	3	2	3
Number of high scores using holding temperatures of 42° to 51° F. on unripened cream	3	1	0
Number of tie scores	1	4	4
Total	7	7	7

Comparison of the use of unripened cream held at 28° to 36° F. and ripened cream held at 28° to 36° F.

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using ripened cream held at 28° to 36° F.	4	3	5
Number of high scores using unripened cream held at 28° to 36° F.	0	0	0
Number of tie scores	3	4	2
Total	7	7	7

In the first summary the use of holding temperatures of 28° to 36° F. and of 42° to 51° F. on cream to which 8 per cent culture was added after cooling, were compared. The butter from the cream held at 42° to 51° F. was more often high in score than the butter from the cream held at 28° to 36° F. when scored fresh, again after holding at about 28° F., and also after cold storage. A value of 8 was determined for N_5 in case of the fresh butter, a value of 13 for the butter after holding at about 28° F. and a value of 22 for the cold storage butter. N or 7 is less than any of the values for N_5, so the differences in the numbers of high scores are in no case significant.

Butter from unripened cream held at 42° to 51° F. was compared with butter from ripened cream held at 28° to 36° F. in the second summary. When scored fresh these two treatments resulted in an equal number of high scoring samples of butter. When scored after holding at about 28° F. and after cold storage the butter made from the ripened cream was more often high in score than the butter from the unripened cream. A value of

400 was determined for N_5 in case of the butter after holding at about 28° F., and a value of 22 for the cold storage butter. With N or 7 less than either of these values for N_5, the differences in the numbers of high scores are not significant.

In the third summary butter from unripened cream held at 28° to 36° F. was compared with butter from ripened cream held at 28° to 36° F. The butter from the ripened cream was more often high in score than butter from the unripened cream when scored fresh, again after holding at about 28° F., and also after cold storage. The value for N_5 was 13 in case of the fresh butter, 22 in case of the butter after holding at about 28° F. and 8 in case of the cold storage butter. Since N or 7 is less than any of these values, the differences in the numbers of high scores are in no case significant.

The Influence of the Type of Butter Culture on the Flavor and Keeping Quality of Butter

The data obtained in the study of the influence of the type of butter culture on the flavor and keeping quality of butter are presented in tables 6 to 10 inclusive.

Table 5 gives the results of 15 trials in which the use of regular butter culture, modified butter culture, and no culture were compared from the standpoint of their effect on the butter. The cream used was sweet gathered cream varying in acidity from 0.14 to 0.18 per cent. The modified culture was made from whole milk heated to 180° F. for 1 hour

Table VI

Influence of the Type of Butter Culture on the Flavor and Keeping Quality of Sweet Cream Butter

Comparison of (a) 8 percent regular butter culture added at 70°F. cooled at once (b) 8 percent modified butter culture added at 70°F. cooled at once and (c) no butter culture

Trial	Original acidity of cream in %	Kind of butter culture added	Acidity after adding butter culture in %	Holding temperature of cream °F.	Acidity at churning in %		Score of fresh butter held at 28°F.		Score of butter after a few weeks at 28°F.	
					Cream	Cream serum	Age in days	Score	Age in days	Score
		8% regular b.c.	0.22		0.23	0.31		93¼		92
1	0.17	8% modified b.c.	.22	38°	.23	.31	3 da	93½	27 da	91½
		No b. c.	.17		.18	.25		93		91½
		8% regular b.c.	.21		.22	.30		93		91½
2	.16	8% modified b.c.	.20	38	.22	.30	3	93	27	92
		No b. c.	.16		.17	.23		93		92
		8% regular b.c.	.21		.22	.30		93		91½
3	.16	8% modified b.c.	.21	37	.22	.30	9	93	36	92½
		No b.c.	.16		.16	.22		92 3/4		92¼
		8% regular b.c.	.20		.21	.30		93		91½
4	.14	8% modified b.c.	.20	37	.20	.27	6	93	33	92½
		No b. c.	.14		.15	.20		92 3/4		92¼
		8% regular b.c.	.21		.22	.30		93		92½
5	.15	8% modified b.c.	.22	37	.23	.31	3	93½	30	92½
		No b. c.	.15		.16	.22		92		92
		8% regular b.c.	.21		.22	.30		93		93
		8% modified								

		8% regular b.c.	.20		.21	.30		93			91 1/8
4	.14	8% modified b.c.	.20	37	.20	.27	6	93	33		92 1/2
		No b. c.	.14		.15	.20		92 3/4			92 1/2
		8% regular b.c.	.21		.22	.30		93			92 1/2
5	.15	8% modified b.c.	.22	37	.23	.31	3	93 1/2	30		92 1/2
		No b. c.	.15		.16	.22		92			92
		8% regular b.c.	.21		.22	.30		93			93
6	.14	8% modified b.c.	.20	41	.21	.29	9	93	36		92 3/4
		No b. c.	.14		.15	.20		92 1/2			92 1/2
		8% regular b.c.	.23		.23	.31		93			93
7	.17	8% modified b.c.	.22	36	.22	.30	6	93	33		92 3/4
		No b. c.	.17		.17	.23		92 1/2			92 1/2
		8% regular b.c.	.24		.25	.35		93			92 1/2
8	.18	8% modified b.c.	.25	37	.26	.36	3	93 1/2	30		93
		No b. c.	.18		.19	.26		93			92 3/4
		8% regular b.c.	.22		.22	.30		92 1/2			91 1/2
9	.16	8% modified b.c.	.21	36	.21	.29	9	93	27		92
		No b. c.	.16		.16	.22		92			91 1/2
		8% regular b.c.	.23		.23	.31		92			92 3/4
10	.16	8% modified b.c.	.23	35	.22	.30	6	93	24		93
		No b. c.	.16		.16	.22		91 1/2			92 1/2
		8% regular b.c.	.24		.24	.34		92 1/2			92 3/4
11	.17	8% modified b.c.	.23	35	.23	.31	3	93 1/2	21		93
		No b. c.	.17		.17	.23		92			92 1/2

		8% regular b.c.	.22		.22	.30		92½			91½
9	.16	8% modified b.c.	.21	36	.21	.29	9	93	27		92
		No b. c.	.16		.16	.22		92			91½
		8% regular b.c.	.23		.23	.31		92			92 3/4
10	.16	8% modified b.c.	.23	36	.22	.30	6	93	24		93
		No b. c.	.16		.16	.22		91½			92½
		8% regular b.c.	.24		.24	.34		92½			92 3/4
11	.17	8% modified b.c.	.23	36	.23	.31	3	93½	21		93
		No b. c.	.17		.17	.23		92			92½
		8% regular b.c.	.25		.25	.35		92½			92 3/4
12	.18	8% modified b.c.	.25	36	.25	.35	9	93½	24		93
		No b. c.	.18		.18	.25		92¼			92¼
		8% regular b.c.	.20		.20	.27		92 3/4			93
13	.14	8% modified b.c.	.21	36	.21	.29	6	93	21		93½
		No b. c.	.15		.15	.20		92½			93
		8% regular b.c.	.21		.21	.29		92 3/4			93½
14	.14	8% modified b.c.	.21	36	.21	.29	3	93	24		93 3/4
		No b. c.	.14		.14	.19		92½			93
		8% regular b.c.	.22		.22	.30		93			93
15	.14	8% modified b.c.	.21	36	.21	.30	6	93½	21		93½
		No b. c.	.14		.14	.19		92 3/4			92½

in a culture vat, cooled to 70° F. and inoculated with a pure culture of Streptococcus paracitrovorus in sterile milk. After growing the organism in the pasteurized milk for 24 hours, 0.3 per cent sulfuric acid and 0.15 per cent citric acid were added to the milk. After another 24 hours at 70° F. the culture was cooled to 40° F.

The cream was pasteurized and cooled to 38° F. in the large vats. Three 150 pound lots of cream were removed and placed in carefully sterilized cans. Eight per cent of regular culture was added to the one lot, 8 per cent of modified culture to another, and one lot was held without adding culture. All three lots were kept in a cooler at 35° to 41° F. until the next morning and then churned.

The acidities of the cream immediately after adding the culture varied from 0.14 (without culture) to 0.25 per cent(with culture). In six trials the acidity of the cream to which regular culture was added was higher than the acidity of the cream to which the modified culture was added, while in three trials the situation was reversed, and in six trials the acidities were equal. The lots containing regular and modified culture were higher in acidity in every trial than the lots without culture. At the time of churning the acidities of the cream ranged from 0.14 (without culture) to 0.26 per cent (with culture) and the serum acidities from 0.19 (without culture) to 0.36 per cent (with culture). At the time of churning the cream containing the regular culture was higher in acidity than the cream containing the modified culture in six trials, in three trials the situation was reversed and in six trials the acidities were the same. The lot containing regular

and modified culture were higher in acidity in every case than the lots containing no culture. In every case the differences in acidity, between the cream containing the regular culture and the modified culture, were within the limits of error of the acidity test, both immediately after adding the culture and at the time of churning.

The butter was scored between the third and ninth day after manufacture, and again after 21 to 36 days at about 28° F. The fresh scores ranged from 92 to 92½, those on the butter after holding at 28° F. from 91½ to 93 3/4. The relationship of these scores are shown in the following summaries.

Comparison of the use of regular and modified butter culture

	Fresh butter	Butter held at 28° F.
Number of high scores using modified butter culture	10	11
Number of high scores using regular butter culture	0	3
Number of tie scores	5	1
Total	15	15

Comparison of the use of regular butter culture and no culture

	Fresh butter	Butter held at 28° F.
Number of high scores using regular butter culture	13	9
Number of high scores using no culture	0	4
Number of tie scores	2	2
Total	15	15

Comparison of the use of modified butter culture and no culture

	Fresh butter	Butter held at 28° F.
Number of high scores using modified butter culture	14	13
Number of high scores using no culture	0	0
Number of tie scores	1	2
Total	15	15

In the first summary butter made with modified culture and regular culture was compared. The use of the modified culture resulted in more high scores than the use of regular culture, both when the butter was fresh and after holding at about 28° F. A value of 9 was determined for N_S in case of the fresh butter and a value of 14 in the case of the butter after a holding at about 28° F. N or 15 is greater than either of these values for N_S, so the differences in the numbers of high scores are significant.

The use of regular culture and no culture was compared in the second summary. The use of regular culture resulted in more high scoring butter than the use of no culture both when the butter was scored fresh, and when scored after holding at about 28° F. A value of 10 was determined for N_1 in case of the fresh butter. Since N or 15 is greater than N_1 or 10 the difference in the number of high scores is highly significant. A value of 35 was determined for N_5 after holding the butter at 28° F. Since N or 15 is less than N_5 or 35, the difference in the number of high scores is not significant.

The use of modified culture and no culture was compared in the third summary. The butter made with the modified culture was more often high in score than the butter made without culture when scored fresh and also after holding at 28° F. A value of 8 was determined for N_1 in case of the fresh butter and a value of 10 for N_1 in the case of the butter after holding at 28° F. N or 15 is greater than either of these values so the difference in the number of high scores is significant in both cases.

Additional data on the use of regular culture, modified culture, and no culture are presented in table 7. Eight trials were carried out, using sour gathered cream varying from 0.46 to 0.53 per cent in acidity.

The cream was neutralized to as near 0.20 per cent acidity as possible before pasteurization. One-half of the excess acid was neutralized with magnesium oxide, and the other one-half with sodium bicarbonate. The calculated amounts of neutralizer were made up to 15

Table VII

Influence of the Type of Butter Culture on the Flavor of Sour Cream Butter

Comparison of (a) 8 percent regular butter culture added at 70° cooled at once (b) 8 percent modified butter culture added at 70° cooled at once and (c) no butter culture

Trial	Original acidity of cream in %	Kind of butter culture added	Acidity after adding butter culture in %	Holding temperature of cream °F.	Acidity at churning in %		Score of fresh butter	
					Cream	Cream serum	Age in days	Score
1	0.49	8% regular b.c.	0.25	34°	0.25	0.35	7 da	91½
		8% modified b.c.	.24		.24	.36		92
2	.52	8% regular b.c.	.27	35°	.27	.37	7	90½
		8% modified b.c.	.24		.25	.35		91
		No b.c.	.20		.20	.27		90
3	.54	8% regular b.c.	.25	36°	.25	.35	4	90
		8% modified b.c.	.23		.24	.36		91½
		No b.c.	.20		.20	.27		91
4	.47	8% regular b.c.	.22	37°	.23	.31	4	89¾
		8% modified b.c.	.22		.23	.31		90
		No b.c.	.19		.20	.27		89½
5	.46	8% regular b.c.	.25	37°	.25	.35	4	91½
		8% modified b.c.	.25		.25	.35		92

2	.52	8% modified b.c.	.24	35°	.25	.35	7	91
		No b.c.	.20		.20	.27		90
3	.54	8% regular b.c.	.25	36°	.25	.35	4	90
		8% modified b.c.	.23		.24	.36		91½
		No b.c.	.20		.20	.27		91
4	.47	8% regular b.c.	.22	37°	.23	.31	4	89¾
		8% modified b.c.	.22		.23	.31		90
		No b.c.	.19		.20	.27		89½
5	.46	8% regular b.c.	.25	37°	.25	.35	4	91½
		8% modified b.c.	.25		.25	.35		92
		No b.c.	.20		.20	.27		91
6	.53	8% regular b.c.	.23	38°	.23	.31	7	90
		8% modified b.c.	.23		.23	.31		90
		No b.c.	.21		.21	.29		88
7	.52	8% regular b.c.	.24	38°	.24	.36	7	88¼
		8% modified b.c.	.23		.23	.31		88⅛
		No b.c.	.20		.20	.27		88
8	.53	8% regular b.c.	.25	37°	.25	.35	4	90
		8% modified b.c.	.26		.25	.35		90⅛
		No b.c.	.20		.20	.27		89½

per cent suspensions or solutions and were added to the cream at least 20 minutes before heating. The magnesium oxide was always added at least 10 minutes before adding the sodium bicarbonate. The cream was pasteurized in the large vats at 150° F. for 30 minutes, instead of the usual exposure, and then cooled to 38° F. Three 150 pound lots of cream were placed in carefully sterilized cans and treated with culture in exactly the same manner as the cream used in obtaining the data in table 6. All three lots were held in the cooler (34° to 38° F.) until the next morning and then churned.

The acidities of the cream immediately after adding culture varied from 0.19 (without culture) to 0.27 per cent (with culture). In four trials the acidity of the cream containing regular culture was higher than that of the cream containing modified culture, in one trial the situation was reversed, and in three trials the acidities were the same. The lots containing regular and modified culture were higher in acidity than the lots without culture in every trial.

At the time of churning the cream containing the regular culture was higher in acidity than the cream containing the modified culture in four trials, and the acidities were the same in four trials. The lots of cream containing regular and modified culture were higher in acidity in every trial than the cream without culture.

The butter was scored between the fourth and seventh day after manufacture. The scores on the butter ranged from 88 to 92. The following summaries show the relationships of the scores.

Comparison of the use of regular and modified butter culture

	Fresh butter
Number of high scores using modified butter culture	7
Number of high scores using regular butter culture	0
Number of tie scores	1
Total	8

Comparison of the use of regular butter culture and no culture

	Fresh butter
Number of high scores using regular butter culture	6
Number of high scores using no culture	1
Number of tie scores	0
Total	7

Comparison of the use of modified butter culture and no culture

	Fresh butter
Number of high scores using modified butter culture	7
Number of high scores using no culture	0
Number of tie scores	0
Total	7

In the first summary butter made with regular butter culture and modified culture was compared. The use of the modified culture resulted in more high scores than the use of regular culture. A value of 6 was determined for N_5. Since N or 8 is greater than N_5 or 6, the difference in the number of high scores is significant.

Butter made with regular culture was compared to butter made without culture, in the second summary. The butter made with regular culture was more often high in score than the butter made without culture. A value of 8 was determined for N_5. N or 7 was less than N_5 or 8 so the difference in the number of high scores is not significant.

In the third summary the use of modified culture and no culture was compared. The modified culture gave higher scoring butter in every trial. A value of 7 was determined for N_1. Since N or 7 is the same as N_1 or 7 the difference in the number of high scores is highly significant.

Table 8 presents the results obtained in nine trials comparing the use of regular culture, regular culture neutralized and no culture. Gathered sweet cream, varying from 0.15 to 0.17 per cent in acidity was used in these comparisons. The neutralized culture was reduced to as near 0.3 per cent acidity as possible, using sodium bicarbonate in the first four trials, and 5N sodium hydroxide in the last five. It was found that amounts in excess of those calculated were necessary to neutralize the acidities to the desired degree.

The cream was pasteurized in the large vats, cooled to 70° F. and

Table VIII

Influence of the Type of Butter Culture on the Flavor and Keeping Quality of Sweet Cream Butter

Comparison of (a) 8 percent modified butter culture added at 70°F. cooled at once (b) 8 percent modified butter culture and added at 70°F. cooled at once and (c) no butter culture

Trial	Original acidity of cream in %	Kind of butter culture added	Acidity after adding butter culture in %	Holding temperature of cream °F.	Acidity at churning in % Cream	Acidity at churning in % Cream serum	Fresh butter held at 28°F. Age in days	Fresh butter held at 28°F. Score	Butter held a few weeks at 28°F. Age in days	Butter held a few weeks at 28°F. Score	Storage butter held at 0°F. Age in days	Storage butter held at 0°F. Score
		8% regular b.c.	0.20		0.21	0.29		93		91½		92
1	0.15	8% regular b.c. neutralized	.20	38°	.20	.28	6 da	93	49 da	92½	180 da	92
		No b. c.	.15		.15	.20		93		91½		91
		8% regular b.c.	.22		.23	.32		93½		92		91 3/4
2	.17	8% regular b.c. neutralized	.19	38	.17	.23	3	93½	31	92 3/4	171	91
		No b. c.	.17		.17	.23		93		92½		91 3/4
		8% regular b.c.	.22		.22	.31		93		93		93½
3	.16	8% regular b.c. neutralized	.17	37	.18	.25	2	93	27	92 3/4	166	93
		No b. c.	.16		.16	.22		92 3/4		92½		93¼
		8% regular b.c.	.21		.20	.28		93½		90½		91½
4	.15	8% regular b.c. neutralized	.16	36	.15	.21	2	93	60	92½	163	93
		No b. c.	.15		.15	.20		93		91½		93
		8% regular b.c.	.21		.21	.28		93½		93½		92½
		8% regular										

		No b. c.	.16		.16	.22		92 3/4			92½			93½		
		8% regular b.c.	.21		.20	.28		93½			90½			91½		
4	.15	8% regular b.c. neutralized	.16	36	.15	.21	2	93	60	163	92½			93		
		No b. c.	.15		.15	.20		93			91½			93		
		8% regular b.c.	.21		.21	.28		93½			93½			92½		
5	.15	8% regular b.c. neutralized	.18	36	.18	.25	10	93½	56	159	92			92½		
		No b. c.	.15		.15	.21		93¼			92			92		
		8% regular b.c.						95			92			93		
6	.16	8% regular b.c. neutralized		38			7	93½	53	156	92			92½		
		No b. c.						93¼			92			92 3/4		
		8% regular b.c.						93			92			92 3/4		
7	.16	8% regular b.c. neutralized		38			4	93½	50	153	92½			92 3/4		
		No b. c.						92 3/4			91			92 3/4		
		8% regular b.c.						93½			92½			88		
8	.15	8% regular b.c. neutralized		38			6	93 3/4	46	145	93½			92½		
		No b. c.						92 3/4			93			91½		
		8% regular b.c.						93½			92½			92 3/4		
9	.15	8% regular b.c. neutralized		38			3	93½			93½			92½		
		No b. c.						93			93			93		

two 150 lots were removed and placed in 70 gallon vats. Eight per cent of regular culture was added to one lot and 8 per cent of the neutralized culture to the other. Both lots were then immediately cooled to 38° F. and placed in carefully sterilized cans. The remainder of the cream in the large vat was cooled to 38° F. and a third lot of 150 pounds was placed in cans. All three lots were held at 36° to 38° F. until the next morning and churned.

Acidity determinations were made on the cream in five trials. Immediately after adding the culture the acidities ranged from 0.15 (without culture) to 0.22 per cent (with culture). In four of the five trials the acidity of the cream containing the regular culture was higher than that of the cream to which neutralized culture was added, while in one trial the acidities were the same. The cream to which regular culture was added was higher in acidity than the cream without culture in every trial. The cream to which neutralized culture was added was higher in acidity than the cream without culture in every trial. At the time of churning the acidities of the cream varied from 0.15 (without culture) to 0.23 per cent (with culture) and the serum acidities from 0.20 (without culture) to 0.32 per cent (with culture). The cream containing regular culture was higher in acidity than the cream to which neutralized culture was added in all five trials. The cream to which neutralized culture was added was higher in acidity than the cream without culture in three trials and with two trials the acidities were the same. The lots to which regular culture

was added were higher in acidity than the lots without culture in all the trials.

The fresh butter was scored between the second and tenth day after manufacture. The butter was again scored after 27 to 60 days at about 28° F. and also after 138 to 180 days at about 0° F. On the fresh butter the scores ranged from 92 3/4 to 93 3/4, after holding at about 28° F. the scores varied from 90½ to 93½, and after cold storage the scores ranged from 88 to 93½. The following summary shows the relationships of the scores.

Comparison of the use of regular culture and regular culture neutralized

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using regular culture neutralized	3	6	2
Number of high scores using regular culture	2	1	4
Number of tie scores	4	2	3
Total	9	9	9

Comparison of the use of regular culture and no culture

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using regular culture	7	2	4
Number of high scores using no culture	1	4	3
Number of tie scores	1	3	2
Total	9	9	9

Comparison of the use of regular culture neutralized and no culture

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using regular culture neutralized	7	7	3
Number of high scores using no culture	0	0	4
Number of tie scores	2	2	2
Total	9	9	9

In the first summary the use of regular culture and regular culture neutralized was compared. The butter made with the regular culture neutralized gave slightly more high scores when fresh, after holding at about 28° F. and again after cold storage. A value of 400 was determined for N_9 in the case of the fresh butter, a value of 13 in the case of the butter after holding at about 28° F. and a value of over 400 in the case of the cold storage butter. Since N or 9 is less than any of these values the differences in the numbers of high scores

are not significant.

Butter made with regular culture and without culture was compared in the second summary. When scored fresh the butter made with culture was more often high in score than the butter without culture, while after holding at about 28° F. the butter made without culture was more often high in score. After cold storage there was an equal number of high scores. A value of 9 was determined for N_5 in case of the fresh butter. N or 9 is equal to N_5 or 9 so the difference in the number of high scores is significant. A value of 400 was determined for N_5 in case of the butter held at 28° F. and also for the butter after cold storage. Since N or 9 is less than N_5 or 400 the differences in the numbers of high scores are not significant.

The use of regular culture neutralized and no culture was compared in the third summary. The butter made with regular culture neutralized was more often high in score than the butter made without culture when scored fresh and also after holding at about 28° F. After cold storage the butter made without culture gave slightly more high scores than the butter made with regular culture neutralized. A value of 7 was determined for N_5 both in the case of the fresh butter and the butter after holding at 28° F. Since N or 9 is greater than N_5 or 7, the difference in the number of high scores is significant in each case. A value of over 400 was determined for N_5 in case of the cold storage butter. Since N or 9 is less than N_5 or over 400, the difference in the number of high scores is not significant.

The influence of using modified culture, modified culture neutralized and no culture on sweet cream butter is shown in table 9. Nine trials were made using gathered sweet cream varying in acidity from 0.15 to 0.17 per cent. The modified culture used has been described. An effort was made to reduce the neutralized culture to an acidity of 0.3 per cent. In the first four trials sodium bicarbonate was used for neutralizing and in the last five trials sodium hydroxide was employed. In every case it was found that quantities in excess of the amounts calculated were necessary to neutralize the acidity to the desired point.

The cream was pasteurized in the large vats and cooled to 70° F. Two 150 pound lots were removed and placed in small 70 gallon vats. Eight per cent of modified culture was added to one lot and 8 per cent of modified culture neutralized was added to the other; both lots were immediately cooled to 38° F. and placed in carefully sterilized cans. The cream remaining in the large vat was cooled to 38° F. and a 150 pound lot removed and placed in cans without adding any culture. All three lots were held overnight at 36° to 38° F. and churned the next morning.

Immediately after treatment with culture the acidities of the cream ranged from 0.15 (without culture) to 0.23 per cent (with culture). In every trial the cream to which the modified culture had been added was higher in acidity than the cream to which modified culture neutralized had been added, and both were higher in acidity than the cream without culture. At the time of churning the acidities of the cream ranged

Table IX.

Influence of the Type of Butter Culture on the Flavor and Keeping Quality of Sweet Cream Butter

Comparison of (a) 8 percent modified butter culture added at 70° F. cooled at once (b) 8 percent modified butter culture neutralized and added at 70° F. cooled at once and (c) no butter culture

Trial	Original acidity of cream in %	Kind of butter culture added	Acidity after adding butter culture in %	Holding temperature of cream °F.	Acidity at churning in %		Fresh butter held at 28° F.		Butter held a few weeks at 28° F.		Storage butter held at 0° F.	
					Cream	Cream serum	Age in days	Score	Age in days	Score	Age in days	Score
		8% modified b.c.	0.20		0.21	0.29		93½		93½		92½
1	0.15	8% modified b.c. neutralized	.19	38°	.19	.27	6 da	93½	49 da	93	180 da	92
		No b.c.	.15		.15	.20		93		91½		91
		8% modified b.c.	.23		.22	.31		93		93		92½
2	.17	8% modified b.c. neutralized	.18	38	.16	.22	3	93½	31	92½	171	91½
		No b.c.	.17		.17	.23		93		92½		91 3/4
		8% modified b.c.	.22		.22	.31		93½		93		93½
3	.16	8% modified b.c. neutralized	.17	37	.17	.24	2	93½	27	92½	166	93½
		No b.c.	.16		.16	.22		92 3/4		92½		93½
		8% modified b.c.	.20		.20	.28		93½		93		93½
4	.15	8% modified b.c. neutralized	.16	36	.17	.24	2	92½	60	90	163	92
		No b.c.	.15			.20		93		91½		93
		8% modified b.c.	.21		.18	.25		94		92 3/4		92 3/4
4	.15	8% modified b.c.		36			10		56		159	

3	.16	8% modified b.c. neutralized	.17	37	.17	.24	2	93½		27	92½		166	93½	
		No b.c.	.16		.16	.22		92 3/4			92½			93½	
4	.15	8% modified b.c.	.20	36	.20	.28	2	93½		60	93		163	93½	
		8% modified b.c. neutralized	.16		.17	.24		92½			90			92	
		No b.c.	.15			.20		93			91½			93	
4	.15	8% modified b.c.	.21	36	.18	.25	10	94		56	92 3/4		159	92 3/4	
		8% modified b.c. neutralized	.17		.16	.22		94			91½			92½	
		No b.c.	.15		.15	.20		93½			92			92	
6	.16	8% modified b.c.		38			7	93 3/4		53	92½		156	93¼	
		8% modified b.c. neutralized						93½			92½			92 3/4	
		No b.c.						93½			92			92 3/4	
7	.16	8% modified b.c.		38			4	93½		50	91½		153	92 3/4	
		8% modified b.c. neutralized						93½			92 3/4			93	
		No b.c.						92 3/4			91			92 3/4	
8	.15	8% modified b.c.		38			6	93½		46	92 3/4		145	92	
		8% modified b.c. neutralized						93			93½			92	
		No b.c.						92 3/4			93			91½	
9	.15	8% modified b.c.		38			3	93		39	93½		138	92½	
		8% modified b.c. neutralized						93½			93			92½	
		No b.c.						93			92½			93	

0.15 (without culture) to 0.22 per cent (with culture) and the serum acidities varied from 0.20 (without culture) to 0.31 per cent (with culture). In every case cream containing modified culture was higher in acidity than either the cream containing modified culture neutralized, or the cream churned without culture. The cream containing modified culture neutralized was higher in acidity than the cream churned without culture in all except one trial where the situation was reversed.

The butter was scored between the second and tenth day after manufacture, again after 27 to 60 days at about 28° F. and after 138 to 180 days at about 0° F. The scores on the fresh butter ranged from 92½ to 94, on the butter held at about 28° F. the scores varied from 90 to 93¼, while the range in score of the butter after cold storage was from 91 to 93½. The relationships of these scores are shown in the following summaries.

Comparison of the use of modified culture and modified culture neutralized

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using modified culture	3	7	6
Number of high scores using modified culture neutralized	3	2	1
Number of tie scores	3	0	2
Total	9	9	9

Comparison of the use of modified culture and no culture

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using modified culture	7	8	7
Number of high scores using no culture	0	1	1
Number of tie scores	2	0	1
Total	9	9	9

In the first summary the use of modified culture and modified neutralized was compared. The butter made with modified culture was more often high in score than the butter made with modified culture neutralized when scored after holding at 28° F. and when scored after cold storage, while when scored fresh the number of high scores were equal. A value of over 400 was determined for N_5 in case of the fresh butter, a value of 14 in case of the butter after holding at about 28°F. and a value of 14 for the cold storage butter. Since N or 9 is less than any of these values, the differences in the numbers of high scores are not significant.

Butter made with modified culture was compared with butter made without culture in the second summary. The butter made with modified culture was more often high in score when scored fresh, again after holding at about 28° F., and also after cold storage. A value of 8 was determined for N_5 in case of the fresh butter and for the butter after holding at about 28° F., while 9 was the value for the cold storage butter. Since N or 9 is as great or greater than any of these

values for N_5, the difference in the number of high scores is significant in each case.

In the third summary butter made with modified culture neutralized and without culture was compared. The butter made with modified culture neutralized was more often high in score than the butter made without culture when scored fresh, also when scored after holding at about 28° F. and when scored after cold storage. A value of 8 was determined for N_5 in case of the fresh butter. N or 9 being greater than N_5 or 8, the difference in the number of high scores is significant. A value of 20 was determined for N_5 in case of the butter after holding at about 28° F., and a value of over 400 for the butter after cold storage. Since N or 9 is less than these values, the difference in the number of high scores is not significant in either case.

Table 10 gives the results of 10 trials in which the use of regular culture was compared with the use of culture which was pasteurized after ripening. The cream used in these trials was gathered cream varying in acidity from 0.14 to 0.16 per cent. The pasteurized culture was made by heating regular culture to 145° F. for 30 minutes and filtering off the curd; the remaining serum was cooled to 40° F. and used in the cream.

The cream was pasteurized in the large vats and cooled to 70° F. Two lots of 150 pounds each were removed and placed in small 70 gallon vats. Eight per cent of regular culture was added to the one vat and 8 per cent of the pasteurized culture to the other. Both lots were then immediately cooled to 38° F., held in the cooler (36° to 38° F.) overnight

Table X

Influence of the Type of Butter Culture on the Flavor and Keeping Quality of Sweet Cream Butter

Comparison of (a) 8 per cent regular butter culture added at 70° F. cooled at once and (b) 8 per cent regular butter culture pasteurized added at 70° F. cooled at once

Trial	Original acidity of cream in %	Kind of butter culture added	Acidity after adding b.c. in %	Holding temperature of cream °F.	Acidity at churning in %		Fresh butter held at 28° F.		Butter held a few weeks at 28° F.		Storage butter held at 0° F.	
					Cream	Cream serum	Age in days	Score	Age in days	Score	Age in days	Score
1	0.16	8% regular b.c.	0.24	36°	0.24	0.34	2 da	93	60 da	93	180 da	92½
		8% regular b.c. pasteurized	.24		.24	.34		93		92½		91 3/4
2	.16	8% regular b.c.	.24	36°	.24	.34	3	93½	59	92½	179	92½
		8% regular b.c. pasteurized	.25		.25	.35		93		91		92
3	.16	8% regular b.c.	.25	36°	.25	.35	5	93½	57	92	177	92½
		8% regular b.c. pasteurized	.24		.24	.34		93		92		93
4	.15	8% regular b.c.	.27	37°	.23	.32	2	93½	53	93	175	93
		8% regular b.c. pasteurized	.23		.23	.32		93		92		92½
5	.15	8% regular b.c.	.23	36°	.23	.32	3	93½	47	93	167	92
		8% regular b.c. pasteurized	.23		.23	.32		93		92		91 3/4
6	.14	8% regular b.c.	.22	37°	.23	.32	2	93	32	93	152	91½
		8% regular b.c. pasteurized	.22		.23	.32		92½		92		91

Trial	Original acidity of cream in %	Kind of butter culture added	Acidity after adding b.c. in %	Holding temperature of cream °F.	Acidity at churning in %		Fresh butter held at 28° F.		Butter held a few weeks at 28° F.		Storage butter held at 0° F.	
					Cream	Cream serum	Age in days	Score	Age in days	Score	Age in days	Score
1	0.16	8% regular b.c.	0.24	36°	0.24	0.34	2 da	93	60 da	93	180 da	92½
		8% regular b.c. pasteurized	.24		.24	.34		93		92½		91 3/4
2	.16	8% regular b.c.	.24	36°	.24	.34	3	93½	59	92½	179	92½
		8% regular b.c. pasteurized	.25		.25	.35		93		91		92
3	.16	8% regular b.c.	.25	36°	.25	.35	5	93½	57	92	177	92½
		8% regular b.c. pasteurized	.24		.24	.34		93		92		93
4	.15	8% regular b.c.	.27	37°	.23	.32	2	93½	53	93	175	93
		8% regular b.c. pasteurized	.23		.23	.32		93		92		92½
5	.15	8% regular b.c.	.23	36°	.23	.32	3	93½	47	93	167	92
		8% regular b.c. pasteurized	.23		.23	.32		93		92		91 3/4
6	.14	8% regular b.c.	.22	37°	.23	.32	2	93	32	93	152	91½
		8% regular b.c. pasteurized	.22		.23	.32		92½		92		91
7	.15	8% regular b.c.	.23	38°	.24	.34	2	93	25	92½	145	92
		8% regular b.c. pasteurized	.25		.24	.34		92½		92½		92

and churned the next morning.

The acidities of the cream ranged from 0.22 to 0.25 per cent immediately after adding the cultures. At churning the cream acidities varied from 0.23 to 0.25 per cent and the serum acidities from 0.32 to 0.35 per cent. The acidities of the cream in each trial, within the limits of error of the acidity test, were the same immediately after adding the culture and again at the time of churning.

The butter was scored between the second and fifth day after manufacture. It was scored again after 25 to 60 days at about 28° F. and after 145 to 180 days in cold storage at about 0° F. The fresh scores varied from 92½ to 93½, after holding at about 28° F. the scores ranged from 91 to 93 and after cold storage the scores varied from 91 to 93. The following summary shows the relationships of the scores.

Comparison of the use of regular culture and pasteurized butter culture

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using regular culture	6	6	5
Number of high scores using pasteurized culture	0	0	1
Number of tie scores	1	1	1
Total	7	7	7

The summary shows that the butter made using regular culture was more often high in score than that made with the pasteurized culture. A value of 6 was determined for N_5 in the case of the fresh butter and also in the case of the butter held at about 28° F. Since N is 7, which is greater than N_5 or 6, the differences in the scores are significant. After cold storage a value of 12 was determined for N_5. N or 7 being less than N_5 or 12, the difference in score is not significant.

The Influence of the Addition of Diacetyl and Acetylmethylcarbinol to Butter on its Flavor and Keeping Quality

The data obtained on the influence of the addition of diacetyl and acetylmethylcarbinol to butter on the flavor and keeping quality are presented in tables 11 to 14 inclusive.

Table 11 gives the results of five trials comparing the use of regular butter culture, the addition of diacetyl directly to butter, and the use of no butter culture. The cream used in these trials was gathered cream varying in acidity from 0.16 to 0.20 per cent.

The cream was pasteurized in the large vats and cooled to 70° F. One lot of 150 pounds was placed in a small 70 gallon vat. Eight per cent of regular culture was then added and the cream immediately cooled to 38° F. The cream remaining in the large vat was cooled to 38° F. and two 150 pound lots were placed in carefully sterilized cans. All 3 lots were held in a cooler (36° to 38° F.) overnight and churned the

Table XI

Influence of Adding Acetylmethylcarbinol and Diacetyl on

Comparison of (A) 8 per cent butter culture added
added direct to the butter and

Trial	Original acidity of cream in %	Treatment of the cream and butter	Holding temperature of cream °F.	Acidity at churning in %		Mg. ni salt - to AMC - AC_2 in butter at once after churning per 200 gm. butte	
				Cream	Cream serum	Serum	Butterfat
		8% regular b.c.		0.24	0.33	0.0058	0.0014
1	0.16	.3 cc. diacetyl per 100# butter	36°	.16	.22	.0012	trace
		No.b.c.		.16	.22	.0015	none
		8% regular b.c.		.23	.31	.0033	none
2	.17	.3 cc. diacetyl per 100# butter	36	.17	.24	.0024	none
		No b.c.		.17	.24	.0025	none
		8% regular b.c.		.26	.36	.0048	none
3	.19	.3 cc. diacetyl per 100# butter	37	.19	.27	.0012	none
		No b.c.		.19	.27	.0013	none
		8% regular b.c.		.26	.26	.0035	none
4	.20	.3 cc. diacetyl per 100# butter	37	.19	.29	.0052	none
		No b.c.		.20	.28	.0051	none
		8% regular b.c.		.25	.25	.0053	none
5	.19	.3 cc. diacetyl per 100# butter	36	.19	.29	.0044	none
		No b.c.		.19	.29	.0030	none

XI

yl on the Flavor and Keeping Quality of Sweet Cream Butter

dded at 70° F. cooled at once (B) .3 co. of AC_2
and (C) no butter culture

AC_2	Mg. ni salt - to AMC - AC_2 7 days after churning per 200 gm. butter		Fresh butter held at 28° F.		Butter held a few days at 28° F.		Storage butter held at 0° F.	
butter fat	Serum	Butterfat	Age in days	Score	Age in days	Score	Age in days	Score
0014	0.0069	trace		93½		93		93½
ee	none	none	3 da	93½	40 da	93	221 da	93
e	none	none		92½		92		92½
e	..0035	none		93		91¾		92
e	.0016	none	2	93	38	92	214	93
e	.0016	none		92		91½		92
e	.0031	none		93½		92¾		93
e	none	none	4	93½	33	95	210	92
e	none	none		93		92½		91
e	.0049	none		93½		92½		91
e	.0055	trace	3	93½	33	92½		91½
e	.0041	trace		93½		92		91
e	.0066	none		93½		92½		91½
e	.0051	none	2	93½	26	92½	200	92
e	.0012	none		93		92		91½

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next morning. At the time of adding the salt, diacetyl was added to one of the lots churned without culture, at the rate of 0.3 cc. of a 10 per cent solution per 100 pounds of butterfat.

The acidities of the cream at the time of churning ranged from 0.16 (without culture) to 0.26 per cent (with culture) and the serum acidities from 0.19 (without culture) to 0.36 per cent (with culture). The lots of cream containing culture were higher in acidity than the lots without culture in every trial.

Acetylmethylcarbinol plus diacetyl determinations were made on the serum of the butter and on the pure butterfat, immediately after churning and again after 7 days. The serum of the butter made with culture was higher in acetylmethylcarbinol plus diacetyl than the serum of the butter made by the direct addition of diacetyl in four of the five trials. In the other trial the acetylmethylcarbinol plus diacetyl contents of the serums were very nearly equal in all three lots of butter. The pure butterfat contained acetylmethylcarbinol plus diacetyl in only two of the 15 lots and then the quantities were small. After 7 days the acetylmethylcarbinol plus diacetyl content of the serum of the butter made with culture had either remained the same or increased slightly. The acetylmethylcarbinol plus diacetyl content of the serum of the butter made by the direct addition of diacetyl had decreased in three trials and remained about the same in two trials; with the serum of the butter made without culture the values had decreased in all five trials. At this time there was not more than a trace of acetylmethyl-

carbinol plus diacetyl in the pure butterfat in any of the butter.

The butter was scored from 2 to 4 days after manufacture, again after 26 to 40 days at about 28° F. and after 200 to 221 days at about 0° F. The scores on the fresh butter ranged from 92 to 93½, the scores on the butter held at about 28° F. ranged from 91½ to 93 and the scores on the cold storage butter varied from 91 to 93½. The following summaries show the relationships of the scores.

Comparison of the use of butter culture and diacetyl

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using diacetyl	0	2	3
Number of high scores using butter culture	1	0	2
Number of tie scores	4	3	0
Total	5	5	5

Comparison of the use of butter culture and no culture

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using butter culture	5	5	2
Number of high scores using no culture	0	0	1
Number of tie scores	0	0	2
Total	5	5	5

Comparison of the use of diacetyl and no culture

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using diacetyl	5	5	5
Number of high scores using no culture	0	0	0
Number of tie scores	0	0	0
Total	5	5	5

In the first summary the use of regular culture and diacetyl was compared at each scoring. There was very little difference between the two treatments in the number of high scores. Values of over 400 were determined for N_5 in case of the fresh butter and the butter scored after holding at about 28° F., while a value of 35 was determined in the case of the cold storage butter. Since N or 5 is less than these values, the differences in the numbers of high scores are not significant.

Regular culture and no culture were compared in the second summary. The butter made using regular culture gave a greater number of high scores when scored fresh, after holding at about 28° F. and also after cold storage. Values of 4 were determined for N_5 in the case of the fresh butter and the butter held at about 28° F. N or 5 is greater than N_5 or 4, and accordingly, the differences in scores are significant. After storage a value of 350 was determined for N_5. Since N or 5 is less than N_5 or 350, the difference in the number of high scores is not significant.

Table XII

Influence of Adding Acetylmethylcarbinol and Diacetyl on the Flavor and Keeping Sweet Cream Butter

Comparison of (a) 8 percent butter culture added at 70° F. cooled at once (b) 4 cc. to 100# of the butter and (c) no butter culture

Trial	Original acidity of cream in %	Treatment of cream and butter	Holding tempera-ture of cream °F.	Acidity at churning in % Cream	Acidity at churning in % Cream serum	Fresh butter held at 28°F. Age in days	Fresh butter held at 28°F. Score	Butter held a few weeks at 28° F. Age in days	Butter held a few weeks at 28° F. Score	A
1	0.21	8% regular b.c.	36°	0.28	0.38	8 da	93¾	60 da	91	
		.4 cc. AMC per 100# butter		0.21	.30		92½		91½	
		No b.c.		.21	.30		92½		88	
2	.17	8% regular b.c.	36	.26	.35	2	93¼	52	91	
		.4 cc. AMC per 100# butter		.17	.24		93½		90	
		No b.c.		.17	.24		93		90	
3	.18	8% regular b.c.	37	.25	.34	12	93¼	66	89	
		.4 cc. AMC per 100# butter		.18	.25		93	66	89	
		No b.c.		.18	.25		93		88	
4	.19	8% regular b.c.	37	.25	.34	8	91¾	69	92	
		.4 cc. AMC per 100# butter		.19	.27		91¾		92	
		No b.c.		.19	.27		91½		91½	
5	.16	8% regular b.c.	37	.25	.34	13	92¾	66	92	
		.4 cc. AMC per 100# butter		.17	.24		92¼		92	
		No b.c.		.16	.22		93		91¾	

Table XII

.dding Acetylmethylcarbinol and Diacetyl on the Flavor and Keeping Quality of Sweet Cream Butter

8 percent butter culture added at 70° F. cooled at once (b) 4 cc. AMC added direct to 100# of the butter and (c) no butter culture

nt / m	Holding tempera-ture of cream °F.	Acidity at churning in %		Fresh butter held at 28°F.		Butter held a few weeks at 28° F.		Storage butter held at 0° F.	
		Cream	Cream serum	Age in days	Score	Age in days	Score	Age in days	Score
lar:									
		0.28	0.38		93¾		91		89½
MC									
#	36°			8 da		60 da		155 da:	
r		0.21	.30		92¾		91½		89½
c.		.21	.30		92½		88		90
lar:									
.		.26	.35		93¼		91		92½
MC									
#	36			2		52		147	
r		.17	.24		93½		90		92½
c.		.17	.24		93		90		92
lar:									
		.25	.34		93¼		89		91
MC									
#	37			12		66		154	
r		.18	.25		93	66	89		90
c.		.18	.25		93		88		90½
lar:									
		.25	.34		91¾		92		89½
MC									
#	37	.19	.27	8	91¾	69	92	143	90½
r									
c.		.19	.27		91½		91½		91¾
lar:									
		.25	.34		92¾		92		91½
MC									
#	37			13		66		140	
r		.17	.24		92¼		92		91¾
c.		.16	.22		93		91¾		92

In the third summary the use of diacetyl and no culture was compared. The butter made using diacetyl was more often high in score than the butter made without culture when scored fresh, when scored after holding at about 28° F. and also when scored after cold storage. A value of 4 was determined for N_5 in the case of the fresh butter, the butter held at about 28° F. and the butter after cold storage. Since N or 5 is greater than N_5 or 4, these differences in the numbers of high scores are all significant.

The results of five trials comparing the use of butter culture, the direct addition of acetylmethylcarbinol to butter, and the use of no culture are given in table 12. The cream used in the series of churnings was gathered cream varying in acidity from 0.16 to 0.21 per cent.

The cream was pasteurized in the large vats cooled to 70° F. and a 150 pound lot placed in a small 70 gallon vat. Eight per cent butter culture was added and the cream was cooled to 38° F. and placed in cans. The cream remaining in the large vat was cooled to 38° F. and two 150 pound lots were placed in cans. All 3 lots were held in a cooler (36° to 37° F.) overnight and churned the next morning. At the time of adding salt, 0.4 cc. of a 10 per cent solution of acetylmethylcarbinol per 100 pounds of fat was added to one of the lots churned without culture. The acetylmethylcarbinol was a commercial preparation and undoubtedly contained considerable diacetyl.

The acidities of the cream at churning varied from 0.16 (without

culture) to 0.28 per cent (with culture) and the acidities of the serum from 0.22 (without culture) to 0.38 per cent (with culture). The cream containing culture was higher in acidity than the cream without culture in every trial.

The butter was scored between the second and twelfth day after manufacture, after 52 to 69 days at about 28° F. and also after 140 to 155 days at about 0° F. The scores on the fresh butter varied from 91⅓ to 93 3/4, the scores on the butter held at about 28° F. ranged from 88 to 92 and on the cold storage butter the scores varied from 89½ to 92½. The relationships of the scores are shown in the following summaries.

Comparison of the use of butter culture and acetylmethylcarbinol

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using butter culture	5	1	1
Number of high scores using acetylmethylcarbinol	0	1	3
Number of tie scores	2	3	1
Total	5	5	5

Comparison of the use of butter culture and no culture

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using butter culture	4	5	2
Number of high scores using no culture	1	0	3
Number of tie scores	0	0	0
Total	5	5	5

Comparison of the use of acetylmethylcarbinol and no culture

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using acetylmethylcarbinol	3	4	1
Number of high scores using no culture	1	0	4
Number of tie scores	1	1	0
Total	5	5	5

In the first summary the use of butter culture and acetylmethylcarbinol was compared. The use of butter culture gave the greater number of high scores when the butter was scored fresh. After holding at about 28° F. the number of high scores were equal with the two treatments while after cold storage the butter made with acetylmethylcarbinol gave the greater number of high scores. A value of 11 was determined for N_5 in the case of the fresh butter, a value of 400 in the case of the butter after holding at about 28° F., and a value of 25 in the case of the butter

after cold storage. Since N or 5 is less than any of these values, the differences in the numbers of high scores are not significant.

In the second summary the use of butter culture and no culture was compared. The butter made with culture gave the greater number of high scores when scored fresh and after holding at about 28° F., while the butter without culture gave the greater number of high scores after cold storage. A value of 11 was determined for N_5 in case of the fresh butter and a value of over 400 in the case of the cold storage butter. Since N or 5 is less than either of the values, the differences in the numbers of high scores are not significant. A value of 4 was determined for N_5 in the case of the butter after holding at 28° F. N or 5 is greater than N_5 or 4 so the difference in the number of high scores is significant.

The use of acetylmethylcarbinol and no culture are compared in the third summary. The acetylmethylcarbinol gave the greater number of high scores when the butter was scored fresh and also when scored after holding at about 28° F., while after cold storage the butter without culture gave the greater number of high scores. A value of 25 was determined for N_5 in case of the fresh butter, a value of 7 after holding at about 28° F., and a value of 11 after cold storage. Since N or 5 is less than any of these values, the differences in the number of high scores are not significant.

Table 13 gives the results of 15 trials in which butter was made using the following treatments: (A) the addition of butter culture to

Table XIII

Influence of Adding Acetylmethylcarbinol and diacetyl on the Flavor and Keeping Quality of Sweet Cream Butter

Comparison of (a) 8 percent regular butter culture added at 70°F. cooled at once (b) .4 c.c. AMC added to 100 # butter and various cultures of S. lactis added to the cream and (c) no butter culture

Trial	Original acidity of cream in %	Treatment of the cream	Holding temperature of cream °F.	Acidity at churning in %		Fresh butter held at 28°F.		Butter held a few weeks at 28°F.		Storage butter held at 0°F.	
				Cream	Cream serum	Age in days	Score	Age in days	Score	Age in days	Score
1	0.18	8% regular b.c.	36°	0.25	0.34	4 da	95½	27 da	93	183 da	91½
		.4 cc. AMC added to 100# butter + S.L. 16		.19	.27		93½		92 3/4		91 3/4
		No b. c.		.18	.25		93		92		91½
2	.20	8% regular b.c.	37	.27	.37	3	92 3/4	28	92 3/4	175	91½
		.4 cc. AMC added to 100# butter + S.L. 16		.21	.30		92		92½		91½
		No b. c.		.21	.30		91 3/4		92½		91
3	.20	8% regular b.c.	36	.26	.36	2	92 3/4	23	93½	170	92 3/4
		.4 cc. AMC added to 100# butter + S.L. 16		.20	.28		93		93		91 3/4
		No b. c.		.20	.28		92½		92½		92
4	.20	8% regular b.c.	37	.27	.37	3	92½	37	89½	168	91½
		.4 cc. AMC added to 100# butter + S.L. 16		.20	.28		92½		91½		91½
		No b. c.		.20	.28		92		90		91
5	.19	8% regular b.c.	37	.25	.34	2	93	42	91½	163	92 3/4
		.4 cc. AMC added to 100# butter + S.L. 16		.19	.27		92 3/4		91½		93
		No b. c.		.19	.27		92½				

		No b. c.		.20	.28		92			90			91	
		8% regular b.c.		.25	.34		93			91½			92 3/4	
5	.19	.4 cc. AMC added to 100# butter + S.L. 16	37	.19	.27	2	92 3/4	42		91½	163		93	
		No b. c.		.19	.27		92½			91			92½	
		8% regular b.c.		.25	.34		92½			90½			92½	
6	.16	.4 cc. AMC added to 100# butter + S.L. 16	37	.17	.23	4	92½	66		91	161		92	
		No b. c.		.16	.22		92			90½			91 3/4	
		8% regular b.c.		.26	.36		93			90½			92	
7	.18	.4 cc. AMC added to 100# butter + S.L. 16	37	.18	.24	9	93	61		90½	156		91 3/4	
		No b. c.		.17	.23		92½			90			91½	
		8% regular b.c.		.25	.34		92			91½			91 3/4	
8	.17	.4 cc. AMC added to 100# butter + S.L. 16	37	.18	.24	7	92½	59		92	154		92	
		No b.c.		.17	.23		92 3/4			91½			91½	
		8% regular b.c.		.26	.36		91 3/4			90			91 3/4	
9	.18	.4 cc. AMC added to 100# butter + S.L. 16	37	.19	.27	11	92½	48		90	150		91½	
		No b. c.		.18	.24		92			90			92	
		8% regular b.c.		.27	.37		92½			91½			90	
10	.19	.4 cc. AMC added to 100# butter + S.L. 16	35	.20	.28	10	92	47		91½	149		91	
		No b. c.		.18	.24		92			91			92	
		8% regular b.c.		.26	.36		93½			92½			92½	
11	.17	.4 cc. AMC added to 100# butter +	36			9		76			146			

		No b. c.		.18	.24		92			90		92
		8% regular b.c.		.27	.37		92½			91½		90
10	.19	.4 cc. AMC added to 100# butter + S.L. 16	35	.20	.28	10	92	47		91½	149	91
		No b. c.		.18	.24		92			91		92
		8% regular b.c.		.26	.36		93½			92½		92½
11	.17	.4 cc. AMC added to 100# butter + S.L. 16	36	.18	.24	9	93½	76		92	146	92½
		No b. c.		.17	.23		93			92		92½
		8% regular b.c.		.24	.33		93½			91		89
12	.16	.4 cc. AMC added to 100# butter + S.L. 16	37	.17	.23	8	93½	74		91½	144	91
		No b. c.		.16	.22		93			91½		90½
		8% regular b.c.		.26	.36		93½			91½		92
13	.17	.4 cc. AMC added to 100# butter + S.L. 16	37	.18	.24	7	93½	68		91½	142	91½
		No b. c.		.17	.23		93			91		91
		8% regular b.c.		.25	.34		91 3/4			91½		91½
14	.18	.4 cc. AMC added to 100# butter + S.L. 16	38	.17	.23	6	91½	67		91½	140	90½
		No b. c.		.16	.22		91½			91		90½
		8% regular b.c.		.26	.36		93			92½		92
15	.18	.4 cc. AMC added to 100# butter + S.L. 16	38	.18	.24	12	92 3/4	65		92	139	91½
		No b. c.		.17	.23		92			92		91 3/4

the cream, (B) the addition of Streptococcus lactis to the cream and acetylmethylcarbinol to the resulting butter, and (C) the addition of no culture to the cream. The cream used in this series was sweet gathered cream varying in acidity from 0.16 to 0.20 per cent.

The cream was pasteurized in the large vats and cooled to 70° F. One lot of 150 pounds was then placed in a small vat and 8 per cent of butter culture added. It was then cooled to 38° F. and removed to cans. The remainder of the cream was cooled in the large vat to 38° F. and two 150 pound lots were put into cans. A pure culture of Streptococcus lactis, which had been grown in sterile milk was added to the one lot while no culture was added to the other. All three lots were held in the cooler (35° to 38° F.) overnight and churned the next morning. At the time of adding salt to the butter from the cream inoculated with S. lactis, 0.4 cc. of a 10 per cent solution of acetylmethylcarbinol per 100 pounds of butterfat was added directly to the butter.

The acidities of the cream at the time of churning varied from 0.16 (without culture) to 0.27 per cent (with culture), and the serum acidities ranged from 0.22 (without culture) to 0.37 per cent (with culture). The cream to which butter culture was added was consistently higher in acidity than the cream to which a culture of S. lactis was added and also higher than the cream churned without culture. The cream to which the culture of S. lactis was added was higher in acidity than that churned without culture in 11 trials, while the acidities were equal in 4 trials.

The butter was scored between the second and twelfth day after manufacture, again after 23 to 76 days at about 28° F., and after 138 to 183 days at about 0° F. The scores on the fresh butter varied from 91⅔ to 93½, the scores on the butter after holding at about 28° F. ranged from 89½ to 93⅓, while the scores after cold storage ranged from 90 to 93. The following summaries show the relationships of the scores.

Comparison of the use of butter culture with the use of a pure culture of *S. lactis* and the addition of acetylmethylcarbinol

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using butter culture	7	8	9
Number of high scores using *S. lactis* and acetylmethylcarbinol	3	4	6
Number of tie scores	5	3	0
Total	15	15	15

Comparison of the use of butter culture and no culture

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using butter culture	13	10	10
Number of high scores using no culture	2	2	3
Number of tie scores	0	3	2
Total	15	15	15

Comparison of the use of a culture of S. lactis and the addition of acetylmethylcarbinol with the use of no culture

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using S. lactis and acetylmethylcarbinol	13	10	9
Number of high scores using no culture	1	1	5
Number of tie scores	1	4	1
Total	15	15	15

In the first summary the use of butter culture was compared to the use of S. lactis and acetylmethylcarbinol. The butter made using butter culture gave a greater number of high scores when scored fresh, when scored after holding at about 28° F. and also when scored after cold storage. A value of 56 was determined for N_5 in case of the fresh butter, a value of 56 for the butter after holding at 28° F. and a value of 96 for the butter after cold storage. N or 15 is less than any of these values for N_5 so the difference in the number of high scores is in no case significant.

In the second summary butter made with and without butter culture was compared. The butter made with culture gave the greater number of high scores when scored fresh, when scored after holding at about 28° F. and also when scored after cold storage. A value of 13 was determined for N_1 in case of the fresh butter. Since N or 15 is greater than N_1 or 13 the difference in score is highly significant. A value of 14 was determined for N_5 in the case of the butter held at about 28° F. Since

N or 15 is greater than N_5 or 14, the difference in the number of high scores is significant. A value of 19 was determined for N_5 in case of the cold storage butter. N or 15 is less than N_5 or 19 and, accordingly, the difference in the number of high scores is not significant.

In the third summary the use of S. lactis and acetylmethylcarbinol was compared with the use of no culture. The butter made using S. lactis and acetylmethylcarbinol gave a greater number of high scores when scored fresh, when scored after holding at 28° F., and also when scored after cold storage. A value of 11 was determined for N_1 or 1 so, the difference in the number of high scores is highly significant. A value of 11 was determined for N_5 in case of the butter held at about 28° F. Since N or 15 is greater than N_5 or 11, the difference in the number of high scores is significant. In the case of the cold storage butter a value of 58 was determined for N_5. N or 15 is less than N_5 or 58, and, accordingly, the difference in the number of high scores is not significant.

Table 14 presents the results of 4 trials in which butter was made using the following treatments: (A) the addition of butter culture to cream, (B) the addition of Streptococcus paracitrovorus to the cream and acetylmethylcarbinol to the resulting butter, and (C) the addition of

Table XIV

Influence of Adding Acetylmethylcarbinol and Diacetyl on the Flavor and Keeping Quality of Sweet Cream Butter

Comparison of (a) 8% regular butter culture added at 70° F. cooled at once (b) .4 cc. of AMC added per 100# butter and a culture of S. paracitrovorus added to the cream and (c) no butter culture

Trial	Original acidity of cream in %	Treatment of cream and butter	Holding temperature of cream °F.	Acidity at churning in % Cream	Acidity at churning in % Cream serum	Fresh butter held at 28°F. Age in days	Fresh butter held at 28°F. Score	Butter held a few weeks at 28° F. Age in days	Butter held a few weeks at 28° F. Score	Storage butter held at 0° F. Age in days	Storage butter held at 0° F. Score
		8% regular b.c.		0.26	0.36		91½		92		90½
1	0.19	.4 cc. AMC per 100# butter - MU 29	37°	.20	.28	3 da:	91	26 da:	91¾	191 da:	90
		No b.c.		.19	.27		91½		91½		90½
		8% regular b.c.		.28	.38		91¾		92½		91½
2	.19	.4 cc. AMC per 100# butter - MU 29	38	.19	.27	2	92	28	92	189	91½
		No b.c.		.19	.27		91¾		91¾		91
		8% regular b.c.		.24	.33		92		91½		91½
3	.17	.4 cc. AMC per 100# butter - MU 29	37	.19	.27	5	91½	41	91½	162	91
		No b.c.		.17	.23		91¾		91		91½
		8% regular b.c.		.26	.36		92½		89½		89
4	.17	.4 cc. AMC per 100# butter - MU 29	36	.17	.23	3	92¼	65	90	160	89
		No b.c.		.17	.23						

100# butter and a culture of S. paracitrovorus added to the cream and (c) no butter culture

Trial	Original acidity of cream in %	Treatment of cream and butter	Holding temperature of cream °F.	Acidity at churning in %		Fresh butter held at 28°F.		Butter held a few weeks at 28° F.		Storage butter held at 0° F.	
				Cream	Cream serum	Age in days	Score	Age in days	Score	Age in days	Score
1	0.19	8% regular b.c.	37°	0.26	0.36	3 da	91½	26 da	92	191 da	90½
		.4 cc. AMC per 100# butter - MU 29		.20	.28		91		91¾		90
		No b.c.		.19	.27		91½		91½		90½
2	.19	8% regular b.c.	38	.28	.38	2	91¾	28	92¼	189	91½
		.4 cc. AMC per 100# butter - MU 29		.19	.27		92		92		91½
		No b.c.		.19	.27		91¾		91¾		91
3	.17	8% regular b.c.	37	.24	.33	5	92	41	91½	162	91½
		.4 cc. AMC per 100# butter - MU 29		.19	.27		91½		91½		91
		No b.c.		.17	.23		91¾		91		91½
4	.17	8% regular b.c.	36	.26	.36	3	92½	65	89½	160	89
		.4 cc. AMC per 100# butter - MU 29		.17	.23		92¼		90		89
		No b.c.		.17	.23		92		89½		91

no culture to the cream. The cream used was gathered sweet cream varying in acidity from 0.17 to 0.19 per cent.

The cream was pasteurized in the large vats and cooled to 70° F. A 150 pound lot of cream was removed and placed in a small 70 gallon vat. Eight per cent of butter culture was added to this cream and it was immediately cooled to 38° F. and placed in cans. The remainder of the cream in the large vat was cooled to 38° F. and two 150 pound lots were removed to cans. A pure culture of Streptococcus paracitrovorus that had been grown in sterile milk was added to one of these lots. No culture was added to the other lot.. All three lots were held overnight in a cooler (36° to 38° F.) and churned the next morning. At the time of adding salt, 0.4 cc. of a 10 per cent solution of acetylmethylcarbinol per 100 pounds of butterfat was added to the butter from the cream inoculated with S. paracitrovorus. The acetylmethylcarbinol undoubtedly contained diacetyl as it was a commercial preparation.

The acidities of the cream at churning ranged from 0.17 (without culture) to 0.26 per cent (with culture) and the serum acidities ranged from 0.23 (without culture) to 0.36 per cent (with culture). In every trial the lots to which butter culture was added were higher in acidity than the lots containing the culture of S. paracitrovorus and also higher than the lots without culture. The lots containing S. paracitrovorus and the lots without culture were very nearly the same in acidity and any differences were within the limits of error of the acidity test.

The butter was scored between the second and fifth day after manufacture, again after 26 to 65 days at about 28° F. and after 160 to 191 days at about 0° F. The scores on the fresh butter ranged from 91 to 92½, the scores after holding at about 28° F. ranged from 89½ to 92½, and the scores after cold storage ranged from 89 to 91½. The relationships of the scores are shown in the following summaries.

Comparison of the use of butter culture with the use of pure culture of S. paracitrovorus and the addition of acetylmethylcarbinol

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using butter culture	3	3	2
Number of high scores using S. paracitrovorus and acetylmethylcarbinol	1	1	0
Number of tie scores	0	0	2
Total	4	4	4

Comparison of the use of butter culture and no culture

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using butter culture	2	3	2
Number of high scores using no culture	0	0	1
Number of tie scores	2	1	1
Total	4	4	4

Comparison of the use of a culture of S. paracitrovorus and the addition of acetylmethylcarbinol with the use of no culture

	Fresh butter	Butter held at 28° F.	Storage butter
Number of high scores using S. paracitrovorus and acetylmethylcarbinol	2	4	1
Number of high scores using no culture	2	0	3
Number of tie scores	0	0	0
Total	4	4	4

In the first summary butter made using regular culture was compared to butter made with a culture of S. paracitrovorus and acetylmethylcarbinol. The butter made with butter culture gave the greater number of high scores when scored fresh, when scored after holding at about 28° F. and also after cold storage. A value of 16 was determined for N_5 in the case of each set of scores. Since N or 4 is less than N_5 or 16 the differences in the numbers of high scores are not significant.

In the second summary butter made with and without culture was compared. The butter made with culture gave more high scores when scored fresh and also after holding at about 28° F. or in cold storage. A value of 16 was determined for N_5 in the case of the fresh butter, a value of 7 in the case of the butter held at about 28° F. and a value of over 400 in the case of the cold storage butter. N or 4 is less than any of these values so that the differences in the numbers of high scores are not significant.

In the third summary butter made with S. paracitrovorus and acetylmethylcarbinol was compared to butter made using no culture. The butter made with S. paracitrovorus and acetylmethylcarbinol gave more high scores than the butter made without culture when scored after holding at about 28° F., when scored after cold storage the butter made without culture was most often high in score; while when scored fresh there were an equal number of high scores. A value of 4 was determined for N_5 in the case of the butter held at about 28° F. Since N or 4 is equal to N_5 or 4 the difference in the number of high scores is significant. After cold storage a value of 16 was determined for N_5. Since N or 4 is less than N_5 or 16 the difference in the number of high scores is not significant.

The Manufacture of High Scoring Butter

In some instances it is desirable to make butter higher in score than any of the established commercial grades. The treatments used in the manufacture of 45 churnings of butter entered in state and national butter contests during the years 1932 to 1935, inclusive, are presented in table 15. The cream used was always carefully selected on the basis of its flavor, and the acidities immediately after selection varied from 0.13 to 0.19 per cent. In all cases the cream was pasteurized at 145° F. for 30 minutes.

From the standpoint of the type of culture used, the method of use, and the neutralization of the cream before adding culture, various

Table XV

The Manufacture of High Scoring B

Trial	Original acidity of the cream in %	Treatment as to neutralization	Kind of butter culture	Amount of butter culture in %	Method of using the butter culture	Acid Cre
1	0.14	----	Regular	8	Not ripened held 6 hr.	0.
2	.15	----	Regular	8	Not ripened held 6 hr.	.
3	.15	----	Regular	9	Not ripened held 6 hr.	.
4	.14	----	Regular	7	Not ripened held 6 hr.	.
5	.13	----	Regular	8	Not ripened held 6 hr. Ripened 1 hr.	.
6	.15	----	Regular	7	Not ripened hold 12 hr.	.
7	.14	----	Modified	8	Not ripened hold 12 hr.	.
8	.18	----	Modified	7	Not ripened held 12 hr.	.
9	.17	----	Regular	7	Not ripened held 12 hr.	.
10	.16	----	Regular	7	Not ripened held 12 hr.	.
11	.18	----	Regular	7	Not ripened held 12 hr.	.
12	.16	----	Modified	8	Not ripened held 12 hr.	.
13	.14	----	Modified	8	Not ripened held 12 hr.	.
14	.14	----	Modified	8	Not ripened held 12 hr.	.
15	.18	----	Modified	8	Not ripened held 12 hr.	.
16	.18	----	Regular	8	Not ripened held 12 hr.	.
17	.17	----	Regular	8	Not ripened held 12 hr.	.
18	.18	----	Regular	7	Not ripened held 12 hr.	.
19	.16	----	Regular	7	Not ripened held 12 hr.	.
20	.15	----	Regular + 0.15% citric acid	8	Not ripened held 12 hr.	.
21	.14	----	Regular + 0.15% citric acid	6	Not ripened held 12 hr.	.
22	.18	----	Regular + 0.15% citric acid	8	Not ripened held 8 hr.	.
23	.13	----	Regular + 0.15% citric acid	12	Not ripened held 8 hr.	.
24	.15	----	Regular + 0.15% citric acid	12	Not ripened held 8 hr.	.
25	.12	----	Regular + 0.15% citric acid	10	Not ripened held 8 hr.	.

ble XV

of High Scoring Butter

Method of using the ter culture	Acidity at churning in % Cream	Cream serum	Time of contest	Type of contest	Fresh butter score	Storage butter score	Criticism
ripened d 6 hr.	0.26	0.33	Dec. '31	State	94.00		
ripened d 6 hr.	.25	.32	Jan. '32	State	94.00		
ripened d 6 hr.	.27	.37	Febr. '32	National	93.16		Sl. coarse
ripened d 6 hr.	.24	.33	March '32	State	94.00		
ripened d 6 hr.	.26	.36	April '32	State	93.50		Sl. coarse
ened 1 hr. d 12 hr.	.27	.37	May '32	State	93.66		Sl. coarse
ripened d 12 hr.	.25	.33	June '32	National	94.25	93.50	
ripened d 12 hr.	.27	.37	July '32	State	92.00		Coarse
ripened d 12 hr.	.26	.36	Aug. '32	National	93.00		Sl. coarse
ripened d 12 hr.	.26	.36	Nov. '32	State	93.16		
ripened d 12 hr.	.26	.35	Dec. '32	State	93.00		
ripened d 12 hr.	.24	.33	Jan. '33	State	94.00		
ripened d 12 hr.	.23	.30	Febr. '33	National	94.00		
ripened d 12 hr.	.23	.31	March '33	State	94.00		
ripened d 12 hr.	.25	.35	April '33	State	92.50		Coarse acid
ripened d 12 hr.	.26	.37	May '33	State	92.00		Coarse acid
ripened d 12 hr.	.26	.36	June '33	National	94.00	93.50	
ripened d 12 hr.	.26	.36	July '33	State	92.00		Coarse acid
ripened d 12 hr.	.25	.35	Dec. '33	State	93.00		Sl. coarse
ripened d 12 hr.	.23	.31	Jan. '34	State	94.50		
ripened d 12 hr.	.24	.33	Febr. '34	National	94.00		
ripened d 8 hr.	.27	.36	March '34	State	93.00		Sl. coarse
ripened d 8 hr.	.24	.33	April '34	State	94.50		
ripened d 8 hr.	.26	.35	May '34	State	93.00		Sl. coarse
ripened d 8 hr.	.24	.33	June '34	National	94.25	94.00	
ripened d 8 hr.	.27	.36	July '34	National	93.00		Sl. coarse

17	.17	----	Regular	8	Not ripened held 12 hr.	.2	
18	.18	----	Regular	7	Not ripened held 12 hr.	.2	
19	.16	----	Regular	7	Not ripened held 12 hr.	.2	
20	.13	----	Regular + 0.15% citric acid	8	Not ripened held 12 hr.	.2	
21	.14	----	Regular + 0.15% citric acid	8	Not ripened held 12 hr.	.2	
22	.18	----	Regular + 0.15% citric acid	8	Not ripened held 8 hr.	.2	
23	.13	----	Regular + 0.15% citric acid	12	Not ripened held 8 hr.	.2	
24	.15	----	Regular + 0.15% citric acid	12	Not ripened held 8 hr.	.2	
25	.12	----	Regular + 0.15% citric acid	10	Not ripened held 8 hr.	.2	
26	.18	----	Regular + 0.15% citric acid	7	Not ripened held 8 hr.	.2	
27	.18	----	Regular + 0.15% citric acid	7	Not ripened held 8 hr.	.2	
28	.19	Neutralized to .1% using $NaHCO_3$	Regular + 0.15% citric acid	8	Ripened 1 hr. held 8 hr.	.2	
29	.17	Neutralized to .1% using $NaHCO_3$	Regular + 0.15% citric acid	9	Ripened 1 hr. held 8 hr.	.2	
30	.16	Neutralized to .1% using $NaHCO_3$	Regular + 0.15% citric acid	7	Ripened 1 hr. held 8 hr.	.2	
31	.13	Neutralized to .08% using Sesqui.	Regular + 0.15% citric acid	9	Ripened 1 hr. held 8 hr.	.2	
32	.13	Neutralized to .08% using Sesqui.	Regular + 0.15% citric acid	10	Ripened 1 hr. held 8 hr.	.2	
33	.15	Neutralized to .08% using Sesqui.	Regular + 0.15% citric acid	10	Ripened 1 hr. held 8 hr.	.2	
34	.14	Neutralized to .08% using Sesqui.	Regular + 0.15% citric acid	12	Not ripened held 8 hr.	.2	
35	.15	Neutralized to .08% using Sesqui.	Regular + 0.15% citric acid	9	Ripened 1 hr. held 8 hr.	.2	
36	.14	Neutralized to .1% using Sesqui.	Regular + 0.15% citric acid	10	Ripened 2 hr. held 8 hr.	.2	
37	.17	Neutralized to .1% using Sesqui.	Regular + 0.15% citric acid	10	Ripened 1 hr. held 8 hr.	.2	
38	.16	Neutralized to .1% using Sesqui.	Regular + 0.1% citric acid	10	Ripened 2 hr. held 8 hr.	.2	
39	.14	Neutralized to .1% using Sesqui.	Regular + 0.1% citric acid	12	Not ripened held 8 hr.	.2	
40	.18	Neutralized to .1% using Sesqui.	Regular + 0.1% citric acid	12	Not ripened held 8 hr.	.2	
41	.19	Neutralized to .1% using Sesqui.	Regular + 0.1% citric acid	12	Not ripened held 8 hr.	.2	
42	.19	Neutralized to .1% using Sesqui.	Regular + 0.1% citric acid	12	Not ripened held 8 hr.	.2	
43	.17	Neutralized to .1% using NaOH	Regular + 0.1% citric acid	14	Not ripened held 8 hr.	.2	
44	.17	Neutralized to .1% using NaOH	Regular + 0.1% citric acid	13	Not ripened held 8 hr.	.2	
45	.16	Neutralized to .1% using NaOH	Regular + 0.1% citric acid	14	Not ripened held 8 hr.	.2	

2 hr. pened	.26	.37	May '33	State	92.00		Coarse acid
2 hr. pened	.26	.36	June '33	National	94.00	93.50	
2 hr. pened	.26	.36	July '33	State	92.00		Coarse acid
2 hr. pened	.25	.35	Dec. '33	State	93.00		Sl. coarse
2 hr. pened	.23	.31	Jan. '34	State	94.50		
2 hr. pened	.24	.33	Febr. '34	National	94.00		
hr. pened	.27	.36	March '34	State	93.00		Sl. coarse
hr. pened	.24	.33	April '34	State	94.50		
hr. pened	.26	.35	May '34	State	93.00		Sl. coarse
hr. pened	.24	.33	June '34	National	94.25	94.00	
hr. pened	.27	.36	July '34	National	93.00		Sl. coarse
hr. d 1 hr.	.27	.36	Aug. '34	State	92.50		Coarse
hr. d 1 hr.	.24	.33	Sept. '34	National	95.25		
hr. d 1 hr.	.25	.34	Oct. '34	National	94.25		
hr. d 1 hr.	.25	.34	Oct. '34	State	93.50		
hr. d 1 hr.	.24	.32	Nov. '34	State	95.00		
hr. d 1 hr.	.24	.33	Dec. '34	State	95.00		
hr. pened	.23	.30	Jan. '35	State	93.00		Mild
hr. d 1 hr.	.23	.29	Febr. '35	National	94.75		
hr. d 2 hr.	.25	.34	March '35	State	93.00		
hr. d 1 hr.	.24	.33	April '35	State	94.50		
hr. d 2 hr.	.23	.30	May '35	State	93.00		Mild
hr. pened	.24	.32	June '35	State	94.00		
hr. pened	.22	.27	June '35	National	94.25	94.00	
hr. pened	.22	.26	July '35	State	94.50		
hr. pened	.23	.27	Aug. '35	National	95.00		
hr. pened	.23	.27	Aug. '35	State	95.00		
hr. pened	.24	.33	Sept. '35	National	96.00		
hr. pened	.24	.33	Oct. '35	National	95.00		
hr.	.24	.32	Nov. '35	National	95.25		

procedures were employed. These are summarized as follows:

1. Twelve churnings were made by adding 7 to 9 per cent of regular culture to the cream after cooling.
2. One churning was made by adding 7 per cent regular culture to the cream at 70° F., ripening for 1 hour and cooling.
3. In six churnings 7 to 8 per cent of modified culture was added to the cream after cooling.
4. Sixteen churnings were made, using 7 to 14 per cent culture which was prepared by adding 0.15 per cent citric acid to the milk, the culture was added to the cooled cream.
5. Ten churnings were made with 7 to 10 per cent culture which was prepared by adding 0.15 per cent citric acid to the milk; the culture was added to the cream at 70° F. and the cream was then ripened 1 hour and cooled.
6. In 18 churnings the acidity of the cream was neutralized to 0.08 per cent and after pasteurization, using various soda neutralizers. The cream was treated with culture and cooled; it was usually held from 6 to 12 hours at a low temperature before churning.

Since numerous treatments were used and only one churning was made from each lot of cream, comparisons are impossible. The results indicate that high scoring butter can be made with any of the treatments suggested. Using modified culture, butter entered in two national contests received scores of 94 and 94.25. In a general way it can be stated that the addition of 0.15 per cent citric acid to the milk intended for culture

resulted in the manufacture of higher scoring butter than had previously been obtained. The butter appeared to have a fuller flavor and this would be expected because of the importance of citric acid as a source of butter flavor and aroma materials. Still further improvement in the scores of the butter was noted as a result of neutralizing the acidity of the sweet cream back to 0.08 to 0.10 per cent after pasteurization. This practice made it possible to develop a higher degree of flavor in the butter, either by the addition of more culture or by ripening the cream, without the danger of developing a sour or coarse flavor.

GENERAL CONSIDERATIONS

Some of the results obtained which do not warrant definite conclusions are of interest in connection with the problem of flavor development in butter. When butter culture organisms are grown in milk very little flavor production takes place until the milk reaches a high degree of acidity. However, the addition of butter culture to pasteurized and cooled cream several hours before churning brought about little change in the acidity of the cream, but usually gave definite increases in the acetylmethylcarbinol plus diacetyl content of the cream. It was also noted that ripening the cream for a short period at 70° F. did not greatly affect the acidity of the cream, but did result in increases in the acetylmethylcarbinol plus diacetyl content of the cream in almost every trial.

When butter culture is held for long periods after ripening, some of its flavor constituents are often destroyed. Similarly, when cream to which butter culture had been added was held for a long period at a low temperature, there was a decrease in the acetylmethylcarbinol plus diacetyl content of the cream in many cases.

In general a high acetylmethylcarbinol plus diacetyl content in the cream was associated with a high scoring butter. The acetylmethylcarbinol and diacetyl were present in the butter serum and only a trace was ever

found in the butterfat.

The advantage shown by the use of modified culture over the use of ordinary culture was not so much a question of regular superiority of the modified culture as it was a question of uniformity of the culture. This indicates that much of the difficulty in the manufacture of regular butter culture is due to the failure of the normal butter culture organisms to grow in the proper proportion.

In the manufacture of butter higher in score than any of the commercial grades, the results indicate that the flavor of the cream and its subsequent treatment, with respect to neutralization and use of butter culture are of extreme importance. In many cases high scores were obtained on butter made from cream with a comparatively high original acidity. The fact that butter which won prizes in state and national contests was made from cream of rather ordinary quality, since there was but little opportunity to select the cream, emphasizes the value of the proper treatment of the cream in the manufacture of high scoring butter. Since many of the high scoring lots of butter were churned from cream of a low serum acidity, the judges evidently preferred a high flavor without much acid development.

CONCLUSIONS

1. With either sweet or sour cream, the addition of butter culture to pasteurized and cooled cream 16 hours before churning yielded butter which was significantly higher in score than butter made by the addition of the butter culture at the time of churning. This was true both when the butter was scored fresh and after cold storage. The addition of culture to cream 40, 64, 88 or 112 hours before churning did not give butter significantly higher in score than the addition of the culture 16 hours before churning. This was true both when the butter was scored fresh and after cold storage.
2. When compared to the addition of 8 or 10 per cent butter culture to pasteurized and cooled cream, the addition of 8 per cent butter culture to pasteurized cream at 70° F. followed by ripening for 1 hour before cooling, gave butter of a significantly higher score after the butter had been held for a few weeks at about 28° F.; when scored fresh and after cold storage there was no significant difference in the scores.
3. (A) The addition of 8 per cent culture to pasteurized and cooled cream followed by holding at 28° to 36° F., (B) the addition of 8 per cent culture to pasteurized and cooled cream with holding at 41° to 52° F. and (C) the addition of 8 per cent culture to

pasteurized cream at 70° F. followed by ripening for 1 hour, cooling and holding at 28° to 36° F., did not result in butter significantly different in score when fresh, after holding a few weeks at about 28° F. or after cold storage.

4. Butter made by the addition of 8 per cent butter culture to pasteurized and cooled cream was usually significantly higher in score than butter made without culture when scored fresh and also after holding a few weeks at about 28° F.; after cold storage there was commonly little difference in the scores.

5. With either sweet or sour cream, the use of modified culture resulted in butter significantly higher in score than the use of regular culture, or the use of no culture, when the butter was scored fresh or after holding a few weeks at about 28° F.; after cold storage there was no significant difference in the scores.

6. The neutralization of either regular or modified culture did not give butter significantly higher in score than the use of unneutralized culture when the butter was scored fresh, after holding a few weeks at about 28° F. or after cold storage.

7. The use of either regular or modified culture that had been neutralized gave butter significantly higher in score than the use of no culture when the butter was fresh; after cold storage there was not a significant difference in the scores.

8. Butter made using regular culture was significantly higher in score than butter made using pasteurized culture when scored

fresh or after holding a few weeks at about 28° F.; after cold storage there was no significant difference in the scores.

9. Butter made by the addition of diacetyl was not significantly different in score than butter made using butter culture when scored fresh, after holding a few weeks at about 28° F. or after cold storage.

10. Butter made by the addition of diacetyl was significantly higher in score than butter made without culture when scored fresh, after holding a few weeks at about 28° F. and after cold storage.

11. Butter made with the addition of acetylmethylcarbinol was not significantly different in score than butter made with or without culture, when scored fresh, after holding a few weeks at about 28° F. or after cold storage.

12. The addition of a culture of Streptococcus lactis to cream and acetylmethylcarbinol to the resulting butter did not give butter significantly different in score than butter made with butter culture when scored fresh, when scored after holding a few weeks at about 28° F., or when scored after cold storage.

13. Butter made by the addition of a culture of Streptococcus lactis to cream and acetylmethylcarbinol to the resulting butter was significantly higher in score than butter made without culture when fresh and after holding a few weeks at about 28° F.; after cold storage there was not a significant difference in the scores.

14. The addition of acetylmethlycarbinol to butter made from cream inoculated with a culture of Streptococcus paracitrovorus did not result in butter significantly higher in score than butter made with or without culture when scored fresh or after cold storage; the butter made with the addition of acetylmethylcarbinol and S. paracitrovorus was significantly higher in score than the butter made without culture when scored after holding a few weeks at about 28° F.

15. In the manufacture of butter higher in score than any of the commercial grades, either the addition of citric acid to the milk used in making the culture or the neutralization of the sweet cream after pasteurization resulted in higher scoring butter.

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