THE EFFECT OF ACIDITY ON KEEPING QUALITY OF BUTTER WITH SPECIAL REFERENCE TO SWEET CREAM BUTTER

THESIS FOR DEGREE OF M. S.

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The Effect Of Acidity On Keeping Quality Of Butter With Special Reference To Sweet Cream Butter

Thesis

Respectfully submitted to the Faculty of Michigan State College in partial fulfillment of the requirements for the degree of Master of Science.

By

Robert Edward Vincent

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INTRODUCTION

The art of buttermaking originated in Asia and Europe and from there was communicated to other parts of the world. Records from the Bible show that butter was used before 2000 B. C. (1) Butter was held in high esteem and was used for the holiest sacrifices. (2)

Buttermaking was confined in this country to the farm dairy until the middle of the nineteenth century, but about this time the factory system of buttermaking was introduced. About the time of the establishment of the early creameries many revolutionary inventions and investigations were given to the dairy world. Among these were pasteurization and the use of pure cultures for the ripening of cream and developing of desirable flavors and odors in the butter.

It is quite interesting to note the existing differences that have developed between what we term quality today and that of centuries ago. In mediaeval times people thought that butter should be stored for long periods to develop all sorts of odors and tastes before it was usable. Today the market demands a butter of distinguished quality.

Danish butter which is given first consideration by the critical English butter buyers is made primarily

from sweet cream slightly ripened by the addition of a starter. With the use of starter Danish buttermakers are enabled to control and maintain a uniform flavor in their butter.

The manufacture of sweet cream butter was begun in the United States about forty years ago. In recent years there has been an increased interest in the manufacture of sweet cream butter. A group of creameries in the State of Minnesota are making sweet cream butter, to which no starter is added. The cream must be sweet to the taste and the acidity not over 0.2 per cent by test. (3) The specifications used by this group are simply modifications of those drawn up by the Bureau of Dairying, United States Department of Agriculture to be followed in the manufacture of butter for the navy.

With the increased interest in sweet cream butter, the question arises as to its flavor and keeping quality as compared with that of sweet cream butter to which starter has been added. An attempt to answer this question is made in this thesis.

REVIEW OF LITERATURE

Sweet cream butter

In 1890 G. W. Curtis (4) of Texas made comparisons between sweet and sour cream butter. The sweet cream was divided equally, one-half churned immediately, while the other was allowed to become slightly acid before churning. The results showed that nearly like amounts of butter were obtained from each and that there was scarcely a noticeable difference between the two kinds of butter, the difference, if any, being in favor of the sweet cream butter and this due chiefly to the flavor.

During the same year G. E. Patrick (5) of Iowa State College repeated the experiment of Curtis. He concluded that there was no very marked difference in the keeping quality of the two butters, what difference there was being in favor of the sweet cream product. As to flavor, for the first two or three months most of the scorers preferred the ripened cream butter declaring that made from sweet cream to be comparatively "flat", "insipid" or flavorless", but the longer the butters were kept, even while both were still sweet, the less marked became the difference between them in this respect.

In 1892 Patrick (6) made nine comparative trials, by dividing by weight a quantity of sweet cream into two equal parts. One of these parts was churned immediately while the

other part was ripened at 60° F. for 24 to 48 hours. The sweet cream butter suffered less deterioration by keeping five months (50° F.) than did the sour cream product. The former acquired in a measure the flavor and aroma of ripened cream butter. In 1895 Patrick (7) repeated the same experiment and the results agree perfectly with the results obtained in 1892.

In 1904 (9) Dean compared butter made from sweet cream with butter made from sweet cream to which 20 to 30 per cent starter was added. The butter made by the latter method was superior in quality to that of the sweet cream butter. He also reported that when sweet cream to which 27.5 per cent starter was added at the time of churning, better results were obtained than from ripened cream.

Gray (10) of the United States Department of Agriculture in 1906 found that when butter was made from sweet cream, the product kept well while stored at -10° to 10° F. and, when removed from storage, this butter kept well, while butter made from sour cream kept well in storage at -10° to 10° F. but deteriorated rapidly after removal from storage, giving on the whole, results which were very unsatisfactory.

Charron and Shult (11) in 1907 found that when they compared sweet cream butter with ripened cream butter, the keeping quality of the sweet cream butter was superior to the keeping quality of the ripened cream butter and that by

the sweet cream process there is no greater loss of butterfat than when churning ripened cream.

Rogers, Thompson and Keithley (12) of the United States Department of Agriculture in 1912 found that the scores of various samples of butter stored for 40 days at 0° F., 150 days at 0° F., and 150 days at 20° F. respectively, ranged with two exceptions, above 90 for the butter made from cream with an acidity below 0.3 per cent, while those from cream testing higher in acidity were variable but usually scored below 90. The deterioration of the sweet cream butter at 20° F. was slight. The deterioration in the pasteurized, ripened cream butter stored at 0° F., was four times as great as that in the pasteurized, sweet cream butter at the same temperature.

In 1916 R. O. Potts (13) stated that the experience of those who have stored southern creamery butter indicated that it had about the same keeping quality as other creamery butter of the same grade or quality; and that low acidity, good quality of cream used, and good quality of butter were factors causing it to hold up better, in storage. He recommends that butter for storage be produced from pasteurized, sweet cream.

Mortensen (14) did considerable work with sweet cream butter. He divided a quantity of cream into three lots, one lot of which was cooled immediately to a temperature of 40° F., held for three hours or longer, and then churned sweet. A

second lot was cooled to 40° F., but from 10 to 20 per cent starter was added and then was held for three hours. The third lot was cooled to ripening temperature. Starter was added and the cream allowed to ripen until the desired acidity was reached. The butter made from ripened cream deteriorated faster than butter made either from sweet cream, or from sweet cream and starter. Where low ripening was employed, the ripened butter at the end of a two months cold storage period was of about the same quality as the sweet cream butter, and the sweet cream and starter butter. He stated also, that unless a creamery has a special demand for sweet cream butter, it would seem to be most advantageous to produce butter from cream ripened to a low degree of acidity.

The work of White (15) is the most recent on sweet cream butter. A quantity of sweet cream was divided into three equal parts. The acidity of "A" was 0.15 per cent; "B" was standardized to 0.25 per cent; and "C" standardized to 0.31 per cent acidity, using a good lactic culture for standardizing. In this series the acidity was standardized before pasteurization. In a second series the cream was pasteurized sweet, acidity averaging 0.15 per cent, divided in three lots, and each lot standardized to the same degree of acidity, as in the previous series, using a good lactic culture for standardizing. A third series was run in which cream was pasteurized sweet and two of the portions ripened to 0.35 and 0.45 per cent acidity, respectively, then churned.

Samples of all churnings were scored when fresh, then were stored at 0° F. for eight months and rescored. The conclusions drawn from these experiments were: there appeared to be no material difference in the keeping quality of the butter due to standardizing the acidity of the cream before pasteurization as compared with standardizing after pasteurization. Butter made from cream of 0.25 per cent acidity kept practically as well as that made from cream of 0.15 per cent acidity, while that from cream of 0.31 per cent acidity kept nearly as well. That from cream of 0.35 per cent acidity showed a materially lower score after storage, and that from cream of 0.45 per cent acidity a still lower score.

STARTERS

Starters were first used in 1776 when the Mongolian Kalmucks (16) added a natural starter to sour milk intended for churning. In 1887 a description of the method of using "lande wei" as a starter for Edam cheese was published in a pamphlet by Boekel (17). This starter was thought to exert a favorable effect on cheese defects and especially to prevent swelling or bloating. Before the development of artifical cultures buttermilk from a churning of good butter was apparently extensively used for starting the acid fermentation in cream intended for buttermaking.

The definition of a starter as given by Hunziker follows (18): "As used in the manufacture of butter by a starter is meant a mixed culture in milk or skim milk of lactic

acid bacteria and associated species capable of developing in milk, cream, and butter the flavor and aroma characteristic of good butter."

The use of pure cultures for the purpose of ripening cream was the result of work done by Storch (17). He studied organisms from sources such as buttermilk, butter, and ripened cream, and found that different acid producing forms induced very different flavors and aromas. Butter made from pasteurized cream with pure culture had a very normal, clean, mild acid flavors.

The first commercial starter cultures were made about 1890 (17). Conn, (19) answering an inquiry, stated that the question as to whether lactic acid bacteria themselves produce the aroma of butter or whether in addition other bacteria are important was not settled, but he pointed out that the so-called pure cultures are not all alike and that while most are pure cultures, some are mixtures of different organisms and that one culture contained no less than ten or twelve different species mixed together.

Hammer (20) found in a number of starters, of very satisfactory quality and from different sources, that more than one organism was present. Two organisms were isolated from starter which in combination gave a volatile acidity, approximately, the volatile acidity secured from the starter, although each of these organisms alone gave a volatile acidity considerably below the volatile acidity produced by the starters.

Hammer's work (17) showed that organisms in addition to Streptococcus lacticus are necessary in a good starter. The importance of these forms is evident from their ability to produce a satisfactory starter when either one or a mixture of the two are grown in combination with Streptococcus lacticus. The names of these organisms, as proposed by Hammer, are Streptococcus citrovorus and Streptococcus paracitrovorus. The production of a desirable starter seems to require the action of Streptococcus lacticus and one of the associated organisms.

The variation between starters and pure cultures of Streptococcus lacticus, in the per cent total acidity that is volatile at various times during the ripening period, offers another method of proving that starters are not pure cultures of Streptococcus lacticus (17). It is thought that the failure to maintain such a balance in practice is undoubtedly one of the reasons why unsatisfactory results are so frequently secured.

SUMMARY OF REVIEW OF LITERATURE

Cream ripened to a high degree of acidity is no longer tolerated by manufacturers of quality butter. Results from investigations show that butter made from unripened, pasteurized, sweet cream will maintain its quality during storage to a high degree, while butter from ripened, pasteurized cream usually deteriorates materially.

As to flavor, investigators find that for the first two or three months ripened cream butter is preferred to sweet cream butter, but the longer the butter was kept, the less marked becomes the difference.

OBJECT OF THE EXPERIMENT

The object of this experiment was primarily to determine:

1. The effect on the keeping quality of butter when starter has been added to sweet cream butter at the time of working.
2. The effect on the keeping quality of butter when starter has been added to sweet cream just before churning.
3. The effect on the keeping quality of butter when sweet cream has been ripened to 0.3 per cent acidity.
4. The effect on the keeping quality of butter when sweet cream has been ripened to 0.5 per cent acidity.
5. The effect of acidity on the composition of the butterfat.
6. The effect of acidity on the nitrogenous substance in the resulting butter.

PLAN OF EXPERIMENTAL WORK

Preparation of Starter

Mother Culture. To find which organism was best suited for use in this work a number of different cultures were obtained. These were propagated for about two months. At the end of this period it was decided that the culture furnished by Professor Hammer of the Iowa State College was best suited for the experiment.

Clean quart bottles were filled two-thirds full of skim milk, heated to 190° F. and held for one hour at that temperature. The bottles were then cooled to 70° F. At about 4:30 P. M. the cultures were examined and the best was transferred to the bottles of skim milk by means of spoons which had previously been boiled in water for an hour. Enough of the culture was used so that the milk would be curdled the next morning. The cultures were allowed to ripen over night at a temperature of 72° F. As soon as the cultures were curdled they were placed in a refrigerator, the temperature of which was 40° F., and were held at that temperature until time for transferring the cultures in the afternoon.

The skim milk to be used for starter for the problem was heated in a glass lined starter can to a temperature of 190° F. and held for an hour at that temperature. It was then cooled to 72° F. and inoculated with one per cent of the mother culture. As soon as the skim milk was curdled and the curd sufficiently formed it was stirred and then cooled with water.

Preparation of Cream for Churning

As soon as the cream was received it was weighed and mixed in a 200 gallon Wizard vat. A test was made to determine the degree acidity of the cream. A vat test was also made on the cream to determine the butterfat content. It was then pasteurized by heating to a temperature of 145° F. and held for 30 minutes. Regular observations of the thermometer were made so as to keep the temperature as constant as possible. The cream was cooled by water until it reached a temperature of 60° F. and ice was used to cool the cream to 40° F. at which temperature it was held over night.

The following morning the vat of cream was agitated so that the cream was thoroughly mixed, after which it was divided into five lots, each containing 256 pounds of 40 per cent cream. The method of treating each was as follows:

Lot 1. This cream was churned sweet, and a sample of butter saved from it to be used as a check.

Lot 2. This cream was churned sweet and starter was added to the butter before working at the rate of three per cent of the weight of the butterfat. The starter was mixed with the salt. The salt was then added to the butter and the working process continued.

Lot 3. Starter at the rate of three per cent of the weight of the cream was added to the sweet cream just before churning.

Lot 4. The sweet cream was warmed to 70° F. in the vat

and starter added at the rate of twenty per cent of the weight of the cream. The cream was ripened to an acidity ranging from 0.3 to 0.35 per cent and then cooled to churning temperature and held for at least two hours.

Lot 5. The sweet cream was warmed to 70° F. in the vat and starter was added at the rate of twenty per cent of the weight of the cream. The cream was ripened to an acidity ranging from 0.45 to 0.52 per cent. It was then cooled to churning temperature and held for at least two hours.

The Churning Process

A Simplex churn of 125 pounds capacity was used. The churning temperature was regulated so that it would require from 50 to 60 minutes for churning. The temperature ranged from 46° F. to 56° F. The butterfat content of Lots land 2 was 40 per cent; Lot 3, 38 per cent and Lots 4 and 5, 33 per cent. The churn was stopped when the butter granules varied from the size of wheat to corn kernels. The buttermilk was then drawn off and the butter allowed to drain thoroughly. The wash water was sprayed over the butter using as much water as there was buttermilk. The temperature of the water varied from two to three degrees below that of the buttermilk. The butter was washed twice in all churnings.

The amount of salt added to the butter was four per cent of the weight of the butterfat. The wet salting method was used, the salt being sprinkled over the butter. The

butter was worked until it had a compact body and a tough, waxy texture. A moisture test was then made and the butter worked so as to have, as near as possible, a 15.95 per cent moisture content, care being taken not to injure the body of the butter.

Preparation and Care of Samples

When the working process was completed, five one pound samples of each churning were taken and placed in pint Sealright containers. In taking the samples care was exercised to obtain as uniform a sample of the butter as possible. The samples were marked for identification and were dated. The samples were placed in cold storage at a temperature averaging 0° F. during a twenty-four hour period.

Judging the Butter

The butter was scored by Professor P. S. Lucas and the writer. The butter was scored after a storage period of one day, one month, three months, and will be scored again at the end of a six months storage period.

The score was made of flavor only, 45 points being allowed as a perfect score. The other points in the score card were allowed as perfect, hence in the tables, scores are given completely.

Chemical Analysis

In addition to scoring the butter a number of chemical

tests were made to determine if there is a relationship between these tests and the keeping quality of the butter. The following analyses were made: amino-nitrogen content, total nitrogen, acid number, iodine number, Reichert Meissl number, and the Kries test.

The amino nitrogen content of butter was run to determine the change, if any, in the nitrogenous substance of the butter after a storage period of three months. The amino nitrogen content of butter is expressed as the per cent of the total nitrogen.

In order to express the amino nitrogen in per cent of the total nitrogen, the total nitrogen content of the butter was also determined.

The acid number, iodine number, Reichert Meissl number, and the Kries test were run on the butterfat after a storage period of three months. This was done to determine whether or not the numbers had changed any from those determine when the butterfat was fresh.

The acid number is the number of cc. of .1 N. Na.OH required to neutralize the acids in 100 grams of butterfat. The iodine number is the per cent iodine absorbed by the butterfat. The Reichert Meissl number is the number of cc. of 1N. NaOH required to neutralize the soluble volatile acids in 5 grams of butterfat.

The Kries test is a measure of the oxidative rancidity in fats. Because this test is only qualitative, the results of this test are determined by the intensity of the color which is obtained.

Allof the following tests were run in duplicate.

Analysis on Cream

As soon as the cream was received the Babcock test for determining the butterfat content of the cream was made. At the same time a Mann's acidity test was made of the cream.

Analysis on Buttermilk

A Babcock test was made of the buttermilk to determine the butterfat content. Skimmilk bottles were used, and when the butterfat content was too high, milk bottles were used.

Analysis of Butter

Preparation of sample. The same of butter was completely melted by placing the closed jar in water at 100° to 110° F. It was then removed from the warm water and stirred until the butter solidified.

Determination of Moisture, Butterfat, Salt and Curd

The butter was analyzed for moisture, butterfat, salt and curd by the gasoline extraction method (21), which is a slight modification of the Kohman method (22).

Determination of Amino Nitrogen

For the determination of the amino nitrogen in the butter the procedure suggested by Ferris (23) for the preparation of the sample was followed. A 50 gram sample was weighed

in a 250 cc. glass stoppered bottle while the sample was of such consistency that it could be poured and yet not have any separation of the fat and curd. The bottle was next filled to the shoulder with petroleum ether. The fat was dissolved by shaking vigorously and the curd allowed to settle in a compact mass at the bottom by allowing it to stand for twenty-four hours. The ether layer containing the fat was siphoned off. To the residue was added 2.5 cc. of ten per cent acetic acid, 15 cc. of a saturated solution of picric acid, and enough distilled water to make a volume of 50 cc. The mixture was then filtered and the amino nitrogen determined by the use of the Van Slyke micro apparatus.

Determination of Total Nitrogen

The method followed in determination of total nitrogen was the Gunning method as given in Methods of Analysis (24) with the modification suggested by Scales and Harrison (25) for the absorption of the ammonia evolved. This involved the use of four per cent boric acid solution for the absorption of the ammonia and the use of brom-phenol as an indicator when titrating with standard sulphuric acid. The sample used was a portion that one prepared for the amino nitrogen determination.

Analysis of Butterfat

Preparation of sample. About one-half pound of butter was placed in a beaker and kept in water at a temperature

not higher than 110° F. When the butter was melted, the layer of melted fat was filtered through a dry filter paper held in a hot water funnel at a temperature not higher than 100° F.

Determination of Reichert Meissl Number

The Leffman and Beam method was used, as given in Methods of Analysis (24).

Determination of Iodine Number

The Hanus method was used as given in Methods of Analysis (24). The sodium thiosulfate solution was standardized against potassium bromate, potassium dichromate, and electrolytic copper.

Determination of Acid Number

About a ten gram sample of the melted fat was accurately weighed. Fifty cubic centimeters of a mixture of equal parts of neutral alcohol and benzene was then added. The mixture was next titrated with standard sodium hydroxide using phenolphthalein indicator. The number was calculated so as to be expressed as a number of cc. of .1 N. NaOH in 100 grams of butterfat. Benzene was used with the alcohol because Steele and Sward (26) found that this combination was preferable to alcohol alone in that the end point of the titration was much sharper.

Test for Oxidized Fat (Kries Test) (27 & 28)

Ten centimeters was measured into a test tube and ten centimeters of concentrated hydrochloric acid was added and the mixture shaken for thirty seconds. Ten cubic centimeters of a freshly prepared one per cent ether solution of phloroglucinol was added and the mixture shaken as before. The mixture was allowed to stand. A recognizable red or pink shade in the acid laver was regarded as a positive test and a faint orange or yellow color was regarded as a negative test.

RESULTS AND DISCUSSION

Curd Content

Casein, albumin, ash and lactose are commonly, though incorrectly called "curd" by the buttermaker (21).

The curd content of butter is determined and expressed in one or the other of two entirely different ways, which yield results in per cent curd, that differ from one another. One method is to determine the nitrogen content of butter, and by multiplying the analysis by the factor 6.38, the result is taken as per cent protein. This represents the true curd content. The other method is to determine the per cent curd by difference, that is by deducting the sum of the per cent of fat, moisture, and salt from 100. In this case the per cent curd so obtained embraces, aside from the protein, also the traces of ash, acid, and lactose contained in butter. This is termed physiological curd (38).

The results in Table I are expressed as physiological curd. The average results show a range from 0.96 to 1.09 per cent curd in the different lots of butter. The sweet cream butter had the lowest average curd content while the butter made from sweet cream to which a starter was added to the butter at the time of working had the highest curd content. The average curd content of the different lots showed only a slight difference. The range is so small that no fear need be held that any method discussed herein will affect the curd content of the resulting butter.

TABLE I. Curd Content.

	Series I.	Series II.	Series III.	Series IV.	Series V.	Series VI.	Series VII.	Series VIII.	Series IX.	Series X.	Series XI.	Series XII.	Average
	Per cent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Lot 1	1.08	1.00	1.08	1.04	1.05	.91	.95	.71	.95	1.00	.94	.82	.96
Lot 2	1.71	1.22	1.08	.97	1.00	1.10	1.00	.85	1.10	1.20	.93	.90	1.09
Lot 3	1.04	.97	1.04	1.08	.98	.98	.90	.95	1.00	.95	1.00	.95	.98
Lot 4	1.07	.96	1.02	1.00	1.00	.92	1.04	1.02	1.05	1.10	.95	1.06	1.01
Lot 5	1.04	.96	1.01	.95	1.10	1.04	.95	.81	.95	1.00	1.10	1.00	.99

Amino Nitrogen Determination

The Van Slyke method for the determination of amino nitrogen depends on the fact that nitrous acid reacts with free amino groups liberating nitrogen gas which is measured in a special burette. This method determines the amino nitrogen and also some of the free ammonia. It is found that the amount of nitrogen displaced from a protein by nitrous acid is a very small fraction of the total nitrogen but that as hydrolysis proceeds and the amino groups become free, the amount steadily increases.

The most common linkage by which amino acids are held together in the protein molecule is that involving their amino and carboxyl group and is called the peptid linkage. During the hydrolysis of a protein decomposition product, this linkage splits, giving rise to a carboxyl group and an amino group.

Ferris (23) found that the amino nitrogen content of sweet cream butter was 1.4 per cent of the total nitrogen while butter made from neutralized sour cream had a content of 3.3 per cent of the total nitrogen.

The average results of the amino nitrogen determination showed a slight increase with the exception of lot 4, but the increase in any case is too small to show any significance. The average results in terms of ascending values of the amino nitrogen and ammonia determination are lots 1, 2, 3, 5 and 4.

TABLE II. Results of Amino Nitrogen Determination. (1)

Series	Lot 1		Lot 2		Lot 3		Lot 4		Lot 5	
	Time in Storage		Time in Storage		Time in Storage		Time in Storage		Time in Storage	
	1 day	90 days	1 day	90 days	1 day	90 days	1 day	90 days	1 day	90 days
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
I.	2.73	1.88	1.09	1.91	1.43	2.62	7.10	3.48	3.02	2.57
II.	1.10	1.32	1.32	2.00	1.49	2.57	1.26	3.19	2.24	1.77
III.	.78	2.38	2.00	2.17	2.73	2.66	5.17	1.69	2.50	2.63
IV.	3.88	1.67	2.71	1.76	1.68	3.60	2.38	2.72	.76	2.69
V.	.78	2.20	.76	1.48	1.56	2.12	1.88	2.88	1.35	2.53
VI.	1.72	1.65	2.27	1.75	2.65	2.09	1.26	2.37	4.71	2.46
VII.	.86	3.91	1.07	1.71	1.50	1.84	1.21	1.02	1.87	2.72
VIII.	1.67	1.06	1.06	1.58	1.15	1.01	.59	2.70	.96	2.86
IX.	.71	1.21	.88	1.68	.97	1.29	1.77	1.36	1.34	1.58
X.	1.23	.99	2.49	1.74	3.61	1.47	1.64	2.01	1.29	2.04
XI.	1.26	1.63	1.77	1.82	1.56	2.25	2.19	2.10	2.75	2.73
XII.	1.28	1.27	1.22	.91	1.66	1.74	2.27	1.44	1.83	.71
Average	1.50	1.76	1.55	1.71	1.83	2.10	2.69	2.25	2.05	2.27

(1) Figures as given are based on per cent of total nitrogen.

Nitrogen Determination

Nitrogen in butter is found in the non-fatty portion and also in the portion of the butter that contains the lecithin. The lecithin content is very small and, therefore, contains only a very small amount of nitrogen. The larger portion of the nitrogen is found in the non-fatty portion of the butter.

Richmond (31) found that the average nitrogen content of sweet cream butter was 0.1000 per cent while that of ripened cream butter was 0.1320 per cent. The results of nitrogen determination are given in Table III. The average of each lot for the nitrogen content are shown in Figure I. The average results of each lot showed that sweet cream butter has a lower nitrogen content than that of ripened cream butter. The results also show that the nitrogen content of the butter is slightly higher after a storage period of three months.

TABLE III. Results of Nitrogen Determination.

Series	Lot 1		Lot 2		Lot 3		Lot 4		Lot 5	
	Time in Storage		Time in Storage		Time in Storage		Time in Storage		Time in Storage	
	1 day	90 days	1 day	90 days	1 day	90 days	1 day	90 days	1 day	90 days
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
I.	.0597	.0700	.0746	.0831	.0759	.0843	.0632	.0709	.0619	.0734
II.	.0587	.0649	.0686	.0698	.0825	.0844	.0650	.0796	.1015	.1069
III.	.0802	.0597	.0773	.0676	.0546	.0533	.0654	.0672	.0714	.0744
IV.	.0642	.0616	.0705	.0705	.0683	.0585	.0726	.0753	.0723	.0759
V.	.0739	.0676	.0790	.0736	.0726	.0666	.0846	.0700	.0777	.0668
VI.	.0696	.0691	.0667	.0623	.0577	.0579	.0962	.0868	.0830	.0816
VII.	.0602	.0651	.0788	.0821	.0653	.0620	.0850	.0852	.0810	.0826
VIII.	.0665	.0697	.0672	.0690	.0649	.0820	.0799	.0765	.0868	.0903
IX.	.0724	.0691	.0805	.0660	.0823	.0739	.0986	.1003	.0804	.0941
X.	.0724	.0763	.0625	.0760	.0593	.0712	.0813	.0921	.0816	.0904
XI.	.0601	.0632	.0614	.0715	.0578	.0662	.0766	.0938	.0731	.0840
XII.	.0671	.0896	.0835	.0852	.0720	.0826	.0801	.0830	.0863	.0924
Average	.0671	.0688	.0725	.0730	.0678	.0702	.0790	.0817	.0797	.0844

Lot 1
Lot 2
Lot 3
Lot 4
Lot 5
A
B
C
D
E
Nitrogen Determination
Per cent Nitrogen
.0800
.0700
.0600
1 day
30 days
Time

Figure I.

Reichert Meissl Number

Since the method used in securing the Reichert Meissl Number is only an arbitrary one, it is essential to adhere strictly to the conditions of operation as laid down, if comparative results are to be obtained, and, by so doing, over 80 per cent of the soluble volatile acids in butter can be secured in the distillate.

Jensen (32) states that the Reichert Meissl process yields with butterfat 85 to 88 per cent of the total butyric, 24 to 25 per cent of the caprylic, and 85 to 100 per cent of the capric acids. The amount of soluble volatile acid is likely to increase with the age of the sample (32).

Butyric, valeric, caproic, and capric acids are the only acids present in fats that can be distilled without decomposition under ordinary pressure. These acids have comparatively high boiling points, but owing to their vapor pressure they can be readily distilled from aqueous solutions with steam and are termed "Volatile" acids (32).

The quantity of soluble volatile acids is influenced to a notable extent by the seasons of the year, the nature of the feed, the period of lactation and the idiosyncrasy of the cow (33).

The results of the Reichert Meissl determination are given in Table IV. All of the results fall within the ordinary values obtained by other workers. The minimum and maximum range of the Reichert Meissl Number given in

Fundamentals of Dairy Science (34) are 23 and 36 respectively. All of the samples showed a slight decrease in soluble volatile acids at the end of a three months storage period.

Figure II shows the average number for each lot at the end of a one day storage period and also at the end of a three months storage period. The average of each lot gave a lower number at the end of a three months storage period than for a one day storage period. This is the reverse of what was expected since it has been found generally that the soluble volatile acids increased with the age of the samples.

However the differences are so slight that they may be due to experimental error. It is nevertheless interesting to note the slightly lower values in each case after a storage period of three months.

TABLE IV. Results of Reichert-Meissl Determination.

	Lot 1		Lot 2		Lot 3		Lot 4		Lot 5	
	Time in Storage		Time in Storage		Time in Storage		Time in Storage		Time in Storage	
Series	1 day	90 days	1 day	90 days	1 day	90 days	1 day	90 days	1 day	90 days
I.	27.19	26.52	27.00	26.46	27.16	25.44	27.42	25.32	27.12	25.77
II.	26.82	26.57	26.90	26.55	26.52	26.92	26.75	26.57	26.99	26.98
III.	27.20	25.54	26.78	25.79	27.14	25.88	27.32	25.69	26.10	25.87
IV.	27.08	26.45	26.68	26.80	27.26	26.21	27.48	26.59	26.82	27.00
V.	27.31	26.38	27.21	26.31	27.79	26.80	27.84	26.84	27.90	26.90
VI.	26.83	25.81	26.86	26.36	26.43	26.45	26.90	26.56	27.05	26.46
VII.	27.05	26.76	26.97	26.90	26.95	26.62	26.96	26.42	26.88	26.87
VIII.	27.37	26.15	27.22	26.59	27.09	26.81	27.59	26.85	27.67	26.52
IX.	26.93	26.63	27.18	26.35	26.98	26.40	27.50	26.89	27.06	26.84
X.	27.50	26.17	27.70	27.16	27.70	26.24	27.61	26.25	27.66	26.48
XI.	27.31	26.40	27.02	26.72	27.38	27.02	27.21	26.86	27.61	26.94
XII.	27.16	26.43	27.40	26.76	27.08	26.39	27.55	27.22	27.26	27.21
Average	27.15	26.32	27.08	26.56	27.12	26.43	27.34	26.50	27.18	26.65

Figure II.

c.c. of 0.1 N NaOH required to neutralize soluble volatile acid in 5 grams of fat.

Iodine Number (Hanus)

The amount of unsaturated fatty acids in a butterfat is greatly influenced by the kind of oil or fat given to the cow with the food (33). Heineman (35) found that the iodine number was irregular in the beginning, then increased gradually to within two or three months of the end of lactation, with a rather sharp rise during the last few weeks. The coincident increase of the melting point is probably due, as Eckles and Shaw (35) suggest, to a decrease in volatile acid such as butyric which has a melting point below that of oleic acid.

The unsaturated acids and their glycerids assimilate halogens with the formation of saturated compounds, and this property serves as a basis for their quantitative determination. The structure of unsaturated acids, particularly the position of the double bond in relation to the carboxyl group, influences the iodine absorption. If the double bond is located at a considerable distance from the carboxyl the results are generally normal but when relatively close together, the iodine number is likely to be below theory, although lengthening the absorption period increases the results (32).

The minimum and maximum iodine number, as given in the "Fundamentals of Dairy Science" (34), are 26 and 38 respectively. The results of the iodine number are given in Table V.

The iodine numbers for the first five series are very abnormal. Precautions, such as using acetic acids which showed no reduction with dichromate, were used. The sodium

thiosulfate solution was standardized by three different methods. The samples of butterfat were weighed into clean, dry, iodine flasks. The reason for the abnormal numbers for the first five series is unknown. The possibility of its being due to feed could not be determined because the source of the cream was unknown.

All of the samples showed a slight increase at the end of a three months storage period. Figure III shows the average iodine number for each lot at the end of a storage period of one day and also after a storage of three months. The average of each lot gave a higher number at the end of a three months storage period.

TABLE V. Results of Iodine Numbers Determination. (Hanus)

	Lot 1		Lot 2		Lot 3		Lot 4		Lot 5	
	Time in Storage		Time in Storage		Time in Storage		Time in Storage		Time in Storage	
Series	1 day	90 days	1 day	90 days	1 day	90 days	1 day	90 days	1 day	90 days
I.	40.16	41.93	40.26	42.96	40.35	42.63	40.39	42.56	40.43	42.56
II.	39.84	41.79	40.20	42.88	39.64	42.32	40.64	42.94	40.67	42.98
III.	39.97	42.41	40.07	43.18	40.09	42.62	40.22	42.99	40.17	42.53
IV.	37.96	38.74	38.24	38.54	38.00	38.59	38.43	38.58	38.02	38.90
V.	37.77	39.53	38.22	39.16	37.93	39.55	38.29	39.22	37.92	39.12
VI.	36.97	36.36	37.26	36.10	36.41	36.33	36.44	36.15	36.57	36.04
VII.	36.22	35.44	35.94	35.77	36.19	35.54	36.04	35.92	35.89	35.71
VIII.	34.87	35.71	35.08	35.57	35.49	35.57	35.46	35.88	34.97	35.95
IX.	34.88	35.06	34.92	34.42	34.73	34.70	34.72	34.81	34.98	34.72
X.	34.19	33.88	33.81	33.61	33.75	33.79	34.04	33.65	33.84	33.52
XI.	34.30	33.87	34.80	33.82	34.72	34.13	34.91	34.33	34.46	34.58
XII.	34.78	34.37	34.33	33.96	34.28	33.90	34.07	33.95	34.50	34.03
Average	36.82	37.42	36.93	37.33	36.80	37.47	36.97	37.58	36.87	37.55

Figure III.

Iodine Numbers.

Acid Number

The acid number of oils and fats varies with the purity, age, amount of hydrolysis, and oxidation they have undergone. Contact with fermenting or decaying matter, such as animal tissue, casein of butter and the marc of fruits, tends to rapidly increase the amounts of free acids due to fat splitting enzymes. Acidity in fats is not always a measure of rancidity, as hydrolysis may result from the action of enzymes in the presence of moisture without accompanying oxidation, which appears necessary fro the production of strong smelling, acrid tasting bodies that usually characterize rancid products (32). However, in the case of butterfat the development of free acids has frequently been termed rancidity; hydrolytic rancidity according to the terminology used by Palmer (36).

The limit of error in the determination of the acid number as given by Holland (32) of the Massachusetts Experiment Station is 0.10 milligram. The acid number of butterfat given by Palmer (36) is 0.56 milligrams of potassium hydroxide per gram of fat, or expressed in cubic centimeters of 0.1N sodium hydroxide per 100 gram of butterfat, it is about 10.

The results of the acid number determination are given in Table VI. The acid number for lots 1, 2 and 3 showed very little difference during a storage period of three months. Figure IV shows the average acid numbers for

each lot at the end of a one day and also a three months cold storage period. The average of lots 1, 2 and 3 showed a slight decrease after a cold storage period of three months. The acid numbers for lots 4 and 5 are very much higher than for the first three lots. Lot 5 is higher also than lot 4.

The lines on the graph of the acid numbers would lead to the belief that a relationship exists between the acidity of the cream and the acid number of the butterfat. The correlation between the acidity of the cream and the acid number was 0.428 ± 0.067. In this case the correlation has a value of 6.4 times the probable error. The relationship between the two factors is slightly significant so that the conclusion may be drawn that there is some relationship between the acidity of the cream and the acid number of the butterfat. It may be concluded from the results of these numbers that an increase in the acidity of the cream causes a slight tendency towards a higher acid number for the butterfat.

TABLE VI. Results of Acid-Number Determination (1)

	Lot 1		Lot 2		Lot 3		Lot 4		Lot 5	
	Time in Storage		Time in Storage		Time in Storage		Time in Storage		Time in Storage	
Series	1 day	90 days	1 day	90 days	1 day	90 days	1 day	90 days	1 day	90 days
I.	9.62	9.64	9.89	8.99	9.57	8.63	9.97	9.55	10.45	10.14
II.	9.94	9.78	9.18	8.87	9.29	8.59	10.37	9.69	10.37	10.44
III.	11.04	10.93	11.37	10.87	11.34	10.75	13.17	12.63	13.35	12.78
IV.	9.28	8.52	9.69	7.87	9.80	8.78	9.90	9.02	10.01	9.10
V.	10.98	9.95	11.77	10.07	11.85	10.12	13.18	11.66	13.36	12.37
VI.	8.70	7.75	8.61	7.93	8.66	8.04	9.52	9.47	10.25	9.92
VII.	13.23	12.69	13.32	12.84	13.34	12.71	14.24	13.96	15.16	15.04
VIII.	11.42	11.33	11.46	11.09	11.41	11.31	13.37	13.00	13.69	13.16
IX.	12.92	12.70	13.42	13.10	13.72	13.76	16.57	16.25	16.74	16.37
X.	11.82	11.54	11.61	12.02	11.68	11.81	14.50	14.04	14.70	14.14
XI.	12.25	12.09	12.45	12.19	12.41	12.08	13.57	13.02	14.16	13.45
XII.	12.63	12.57	12.67	12.40	12.92	13.29	14.19	14.41	15.09	14.89
Average	11.15	10.79	11.29	10.69	11.33	10.82	12.71	12.23	13.11	12.65

(1) Numbers expressed as number of cc of 0.1 N alkali in 100 grams of butterfat.

Figure IV.

Acid Number.

Text for Oxidized Fat (Kries Test)

The intensity of the Kries test of samples of an oxidized fat is proportional to the amount of oxygen it has absorbed, or, the amounts of fat necessary for equivalent color intensities are inversely proportional to the volume of oxygen absorbed (27).

The intensity of the Kries test is not proportional to the oxidative rancidity or tallowiness of a fat. A rancid fat will give a Kries test but many fats that have absorbed large quantities of oxygen show only faint traces of rancidity, or none, yet give intense Kries tests. Some evidence is found to indicate that oleic acid when autoxidized, may be the only unsaturated acid in fats that gives the Kries test (28).

Powick (8) found that the constituent of rancid fats responsible for the Kries test, is probably a derivative of epihydrin aldehyde. It is certain that this constituent gives rise to epihydrin alehyde when the rancid fat containing it is brought into contact with the concentrated hydrochloric acid used in the Kries test.

A positive reaction in the Kries test, when the test is performed in the usual manner, is not always a reliable indication of rancidity in fats. A large number of compounds react with phloroglucin hydrochloric acid to give a red color, that with the unaided eye cannot be distinguished from the color obtained with rancid fats. When the test is modified in such manner that the color obtained is examined spectro-

scopically, however, the modified test becomes a reliable index of the rancid condition (37).

The results of the Kries test are given in Table VII. As this test is a qualitative test only, a comparison between the five lots of each series could be made. All of the tests were very slight. It is interesting to note, however, that from the results of the qualitative test, the lot scoring the highest showed no increase in the average value of the Kries test, while the lot that scored the lowest showed the greatest increase in the average value.

TABLE VII. Results of Test for Oxidized Fat (Kries Test)[1]

Series	Lot 1 Time in Storage 1 day	Lot 1 Time in Storage 90 days	Lot 2 Time in Storage 1 day	Lot 2 Time in Storage 90 days	Lot 3 Time in Storage 1 day	Lot 3 Time in Storage 90 days	Lot 4 Time in Storage 1 day	Lot 4 Time in Storage 90 days	Lot 5 Time in Storage 1 day	Lot 5 Time in Storage 90 days
I.	+ +	+ +	+ + +	+ + +	+	+	+ +	+ +	+ +	+ + +
II.	+ +	+ +	+ + + +	+	+	+ +	+ + +	+ +	+	+ + +
III.	+ +	+ + +	+	+ +	+ + +	+	+	+ +	+	+ +
IV.	+	+ + +	+ + +	+	+ + + + +	+ +	+ +	+ + + +	+++++	+++++
V.	+	+ + + +	+	+++++	+	+	+ +	+ +	+ + +	+ + +
VI.	+	+ +	+	+ + +	+ + +	+ + + +	+	+	+ +	+++++
VII.	+	+	+	+++++	+	+ + + +	+ +	+ +	+ + +	+ + +
VIII.	+	+ + + +	+	+ + +	+	+ +	+ +	+	+ + +	+++++
IX.	+	+	+	+ + +	+	+ +	+ +	+++++	+ + +	+ + + +
X.	+ + +	+ +	+ +	+ + + +	+ + + + + + +		+	+++++	+ + + + +	
XI.	+ +	+ + +	+ + +	+ +	+ + + + ++		+++++	+ + + +	+	+++++
XII.	+ +	0	+	0	+ + +	+ +	+ +	+	+ +	+ + +
Average	1.58	2.25	1.83	2.66	2.25	2.08	2.08	2.58	2.50	3.66

(1) Relative strength of test when the five lots of each series were compared.

1. 0 no trace
2. + slight trace
3. + + heavier than 2
4. + + + heavier than 3
5. + + + + heavier than 4
6. + + + + + heaviest color

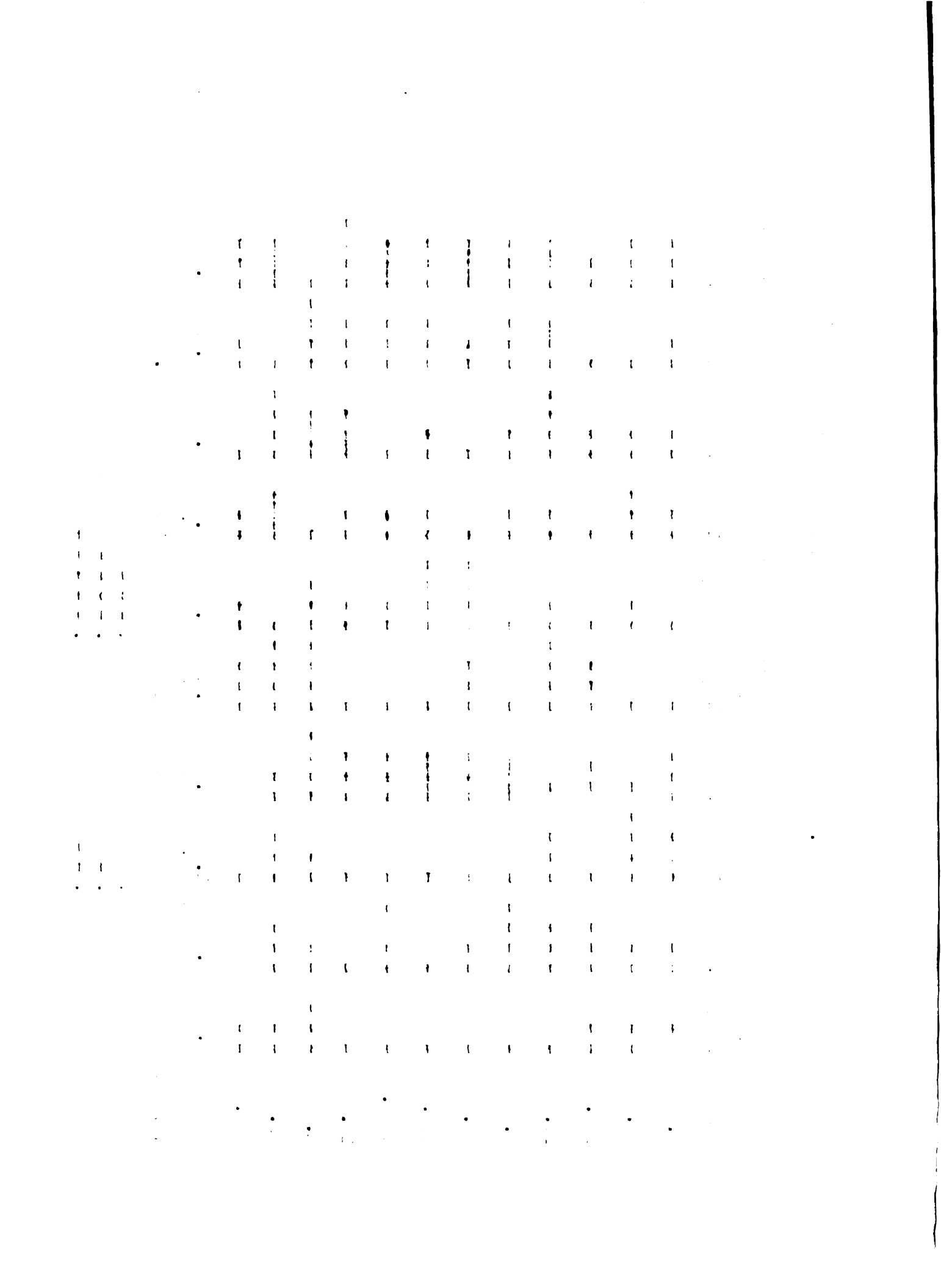

TABLE VIII. Results of Butter Scores.

	Lot 1			Lot 2			Lot 3			Lot 4			Lot 5		
	Time in Storage			Time in Storage			Time in Storage			Time in Storage			Time in Storage		
Series	1 da.	30 da.	90 da.	1 da.	30 da.	90 da.	1 da.	30 da.	90 da.	1 da.	30 da.	90 da.	1 da.	30 da.	90 da.
I.	92.	91.	91.	92.	93.	92.	93.	93.	93.	94.	91.	90.	91.5	91.	89.
II.	92.	91.5	91.	92.5	92.	92.	93.5	93.	92.	94.	92.	89.	92.	91.5	88.5
III.	91.5	90.	89.5	91.5	91.	90.	92.5	92.	90.	93.	92.5	88.5	93.	91.	88.
IV.	93.	92.	91.	92.5	91.5	92.	94.	93.	92.5	93.	91.5	88.	92.	90.	88.
V.	92.	92.	91.5	94.	93.	93.	94.	94.	93.	94.	92.	89.	92.	91.	88.
VI.	93.	92.	90.5	93.5	93.	92.5	94.	93.	93.	94.	93.	89.5	93.	90.	88.5
VII.	91.5	91.	91.	93.	92.	92.	94.	93.	93.	94.	91.	89.	92.5	90.	88.5
VIII.	92.5	91.	91.	92.5	93.	92.5	93.5	92.	93.	94.	89.	88.	92.5	90.	87.5
IX.	92.	91.	91.	94.	92.5	92.	93.5	93.	92.5	93.5	90.	89.	92.5	90.	88.
X.	92.	92.	90.	94.	93.	93.	94.	93.5	93.	93.5	92.	89.	93.	92.	88.
XI.	92.	91.	89.5	93.	93.	91.5	94.	93.	92.5	94.	92.	90.5	93.	91.	89.
XII.	92.	91.	91.	94.	92.	92.	93.	93.	93.	93.	91.5	89.5	92.	91.	89.
Average	92.13	91.21	90.66	93.04	92.42	92.04	93.58	92.96	92.54	93.66	91.46	89.08	92.42	90.71	88.33

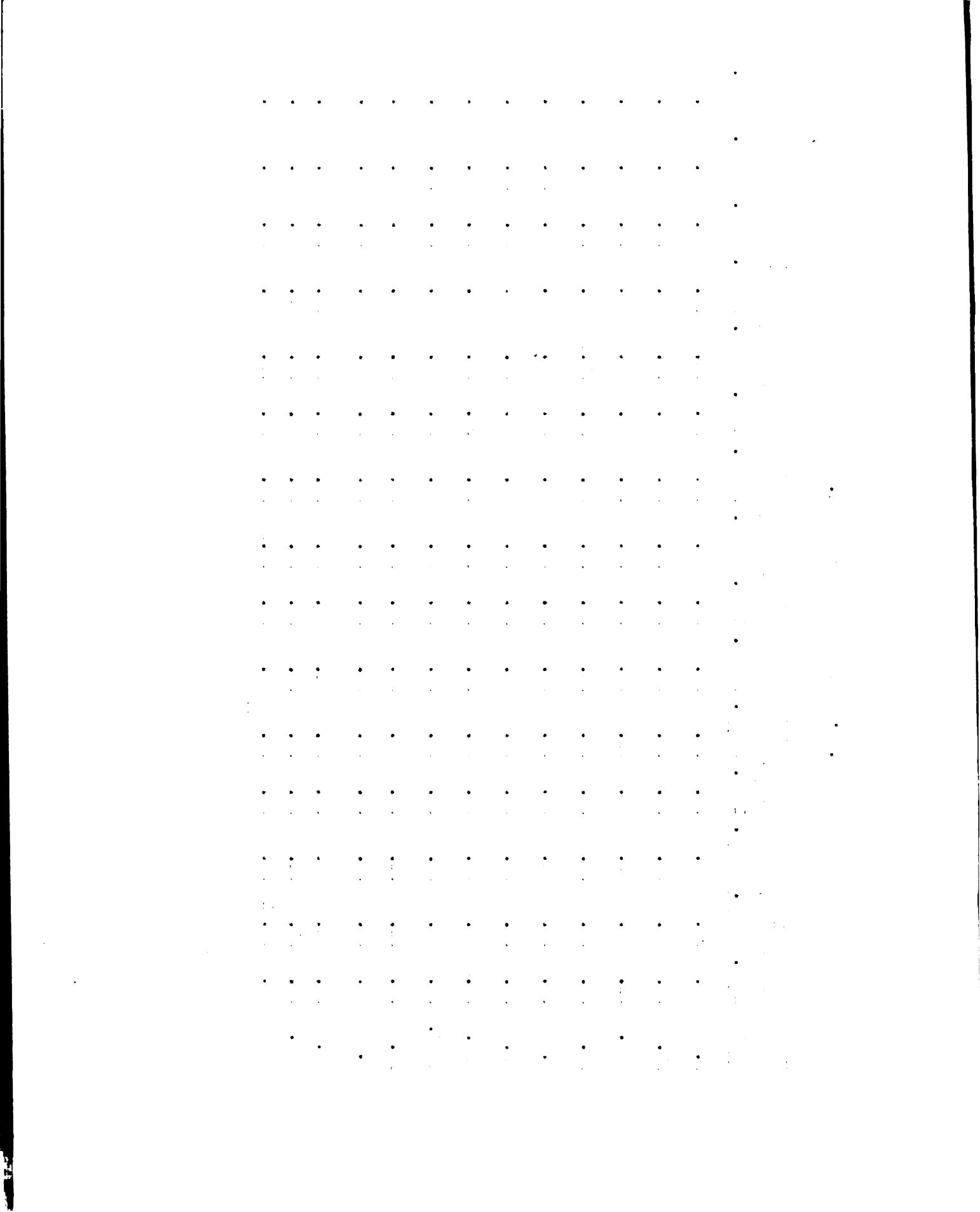

Figure V.

Butter Scores

Average Score for Each Lot

DISCUSSION of SCORES

Sweet Cream Butter

The average score for the sweet cream butter was the lowest of any of the lots of butter after a storage period of one day. The butter when scored was criticised as having no distinct flavor.

After a storage period of one month the sweet cream butter was placed in fourth place. The sweet cream butter scored a little lower than that of butter made from ripened cream which had been ripened to an acidity of about 0.3 per cent but scored higher than butter made from cream which had been ripened to an acidity of about 0.5 per cent.

After a storage period of three months the sweet cream butter scored higher than either of the two different lots of ripened cream butter. The average score of the sweet cream butter at the end of a one day storage period was 92.13; at the end of one month 91.29; and after a period of three months 90.66. The sweet cream butter had better keeping quality than that of the ripened cream butter.

Butter Made From Sweet Cream To Which A Starter Was Added To The Butter At The Time Of Working

After a storage period of one day the average score of the butter to which starter was added at the time of working was third highest. After a storage period of one month and three months the starter butter scored second

highest of the different lots. The average sco re after a storage period of one day was 93.04; at the end of one month 92.42; and after a period of three months 92.04.

The flavor of this butter (lot 2) was not as well developed as that of butter to which a starter was added just before churning. The keeping quality of the above two lots of butter were the same.

Butter Made From Sweet Cream To Which A Starter Was Added Just Before Churning

Butter made from sweet cream to which a starter was added just before churning scored as high after a storage period of one day as butter made from sweet cream which had been ripened to 0.3 per cent acidity.

When the starter butter was scored after a storage period of one month, it was given the highest score. The flavor of the starter butter was well developed.

After a storage period of three months the butter was scored again. This time it received the highest score of any of the other lots. When the starter butter was fresh the average score was 93.58; after a storage period of one month 92.96; and at the end of three months 92.54.

This butter besides having the best flavor also showed very good keeping quality. The starter butter after a storage period of three months lost only 1.04 in points while the butter made from ripened cream lost 4.58 points.

For a creamery using sweet cream in making butter, these results would indicate that it is best to add starter to the cream just before churning. Using this method, the flavor of the butter would score the highest when fresh or after a storage period of three months.

Butter Made From Sweet Cream Which Was Ripened To An Acidity Of 0.3 Per Cent

The butter made from cream ripened to 0.3 per cent acidity received the highest average score of any of the other lots of butter when fresh. The difference between the ripened cream butter and the butter to which a starter was added just before churning was very slight.

After a storage period of one month the ripened cream butter again scored higher than the sweet cream butter but lower than the starter butter. After a storage period of three months the ripened cream butter scored lower than that of sweet cream butter. The average score after a storage period of one day was 93.66; at the end of one month 91.46; and after a period of three months 89.08.

If the butter is to be consumed soon after it is made, the cream can be ripened to an acidity of 0.3 per cent but from these results the butter should not be held any length of time.

Butter Made From Sweet Cream Which Was Ripened To An Acidity Of 0.5 Per Cent

The butter made from cream ripened to 0.5 per cent

acidity higher than that of sweet cream butter when the butter was fresh. After a storage period of one month the ripened cream butter scored the lowest of any of the lots. When the butter was scored the flavor was criticised as being slightly off and in some cases slightly unclean.

When the butter was scored after a storage period of three months it again was scored the lowest. This time the butter was criticised at the time of scoring as being slightly fishy.

Summary of Results on Flavor

When fresh the untreated sweet cream butter (lot 1) scored the lowest. Butter made from sweet cream to which a starter was added to the butter at the time of working (lot 2) scored higher than butter made from sweet cream which had been ripened to an acidity of 0.5 per cent (lot 5). Lot 2 scored lower than butter made from sweet cream to which a starter was added just before churning (lot 3) or butter made from sweet cream which had been ripened to an acidity of 0.3 per cent (lot 4). Lots 3 and 4 scored the highest. The flavor of lots 3 and 4 as shown by the average score, showed very little difference. This slight difference could be accounted for as being due to experimental error. Lot 5 scored higher than lot 1 but lower than lot 2.

After a storage period of one month lot 1 scored slightly lower than lot 4 but higher than lot 5. The average

score of lot 2 was lower than lot 3 buthigher than lot 4. Lot 3 scored the highest. Lot 4 scored slightly higher than lot 1 but this slight difference could be due to experimental error. Lot 5 scored the lowest.

After a storage period of three months lot 1 scored lower than lot 2 but higher than lot 4. Lot 2 scored lower than lot 3 but higher than lot 1. Lot 3 again scored the highest. The average score of lot 4 was lower than lot 1 but higher than lot 5. Lot 5 scored the lowest.

Summary of Results on Keeping Quality

At the end of a storage period of one month, the difference between the average score of one day and one month for the untreated sweet cream butter (lot 1) was 0.84. Butter made from sweet cream to which a starter was added to the butter at the time of working (lot 2) and butter made from sweet cream to which a starter was added just before churning (lot 3) showed the best keeping quality. In both lots the difference was 0.61. The difference for butter made from sweet cream which had been ripened to an acidity of 0.3 per cent (lot 4) was 2.20, and for butter made from sweet cream which had been ripened to an acidity of 0.5 per cent (lot 5) was 1.71.

After a storage period of three months lot 2 and lot 3 again showed the best keeping quality. The difference between the average score of one day and three months for lot 1 was 1.47; lot 2, 1.00; lot 3, 1.04; lot 4, 4.58 and lot 5, 4.09.

CONCLUSIONS

1. The flavor of butter made from sweet cream to which a starter was added just before churning is superior to that of sweet crram butter after a storage period of one day, one month, and three months.

2. The flavor of butter made from sweet cream to which a starter was added to the butter at the time of working is superior to that of sweet cream butter after a storage period of one day, one month and three months.

3. The flavor of butter made from sweet cream ripened to an acidity ranging from 0.3 to 0.35 per cent is superior to that of sweet cream butter after a storage period of one day. After a storage period of one month there is no difference in flavor of the two butters. The flavor of sweet cream butter is superior to the ripened cream butter after a storage period of three months.

4. There is no difference in flavor between sweet cream butter and butter made from sweet cream which has been ripened to an acidity ranging from 0.45 to 0.52 per cent after a storage period of one day. The sweet cream butter is superior in flavor to that of ripened cream butter after a storage of one and three months.

5. The flavor of butter made from sweet cream to which a starter was added just before churning is superior to sweet cream butter to which a starter was added to the butter at the

time of working, after a storage period of one day, one month, and three months.

6. The keeping quality of sweet cream butter to which a starter was added to the butter at the time of working is superior to that of sweet cream butter after a storage period of one and three months.

7. The keeping quality of butter made from sweet cream to which a starter was added just before churning is superior to that of sweet cream butter after a storage period of one and three months.

8. The keeping quality of sweet cream butter is superior to butter made from sweet cream ripened to an acidity ranging from 0.3 to 0.35 per cent after a storage period of one and three months.

9. The keeping quality of sweet cream butter is superior to butter made from sweet cream ripened to an acidity from 0.45 to 0.52 per cent after a storage period of one and three months.

10. The keeping quality of sweet cream butter to which a starter was added to the butter at the time of working is the same as butter made from sweet cream to which a starter was added just before churning after a storage period of one and three months.

11. The acidity of cream does not effect the Reichert Meissl number, iodine number, amino-nitrogen content, or the Kries test.

12. A relationship exists between the acidity of the

cream and the acid number of the fat. The higher the acidity is developed in cream, the higher the acid number of the fat will be.

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APPENDIX

TABLE I. Churning Records.

Churn Number	Acidity of Cream	Churn Temp.	Time of Churning	Temp. of Buttermilk	Temp. of Wash Water	Revolutions Worked	Buttermilk Test	Overrun
	Per cent	°F	Minutes	°F	°F		Per cent	Per cent
Series I								
Lot 1	.15	50	45	54	55	30	.8	22.
Lot 2	.15	50	65	55	55	35	.5	22.
Lot 3	.17	50	55	54	55	45	.6	24.5
Lot 4	.30	53	20	56	55	30	1.1	22.
Lot 5	.43	49	35	52	55	25	.75	21.1
Series II								
Lot 1	.13	51	30	55	54	35	.70	20.6
Lot 2	.13	51	40	52	54	45	.50	23.5
Lot 3	.15	49	50	52	54	40	.50	20.6
Lot 4	.31	50	30	54	55	35	.60	23.5
Lot 5	.42	49	40	51	55	35	.25	22.7

TABLE I. Churning Records. (Cont'd)

Churn Number	Acidity of Cream	Churn Temp.	Time of Churning	Temp. of Buttermilk	Temp. of Wash Water	Revolutions Worked	Buttermilk Test	Overrun
	Per cent	°F	Minutes	°F	°F		Per cent	Per cent
Series III								
Lot 1	.13	50	55	55	55	40	.50	24.5
Lot 2	.13	49	80	54	55	35	.40	23.5
Lot 3	.15	50	65	54	54	40	.30	23.7
Lot 4	.38	49	40	55	55	35	.20	24.0
Lot 5	.48	49	60	54	54	30	.20	23.8
Series IV								
Lot 1	.14	52	45	56	55	40	.45	23.7
Lot 2	.14	50	60	55	55	40	.30	22.5
Lot 3	.16	52	50	56	55	40	.25	22.5
Lot 4	.35	46	55	51	53	35	.20	23.7
Lot 5	.47	49	80	55	53	35	.20	23.8

TABLE I. Churning Records. (Cont'd)

Churn Number	Acidity of Cream	Churn Temp.	Time of Churning	Temp. of Buttermilk	Temp. of Wash Water	Revolutions Worked	Buttermilk Test	Overrun
	Per cent	°F	Minutes	°F	°F		Per cent	Per cent
Series V								
Lot 1	.12	50	90	53	50	45	.30	22.5
Lot 2	.12	51	65	54	54	35	.30	23.5
Lot 3	.14	52	45	54	54	45	.35	22.5
Lot 4	.36	50	50	54	54	45	.20	23.5
Lot 5	.49	51	55	54	54	40	.20	24.0
Series VI								
Lot 1	.11	52	55	57	54	40	.50	23.3
Lot 2	.11	50	60	56	55	45	.80	24.2
Lot 3	.13	51	70	56	54	45	.40	23.3
Lot 4	.31	51	50	56	55	40	.40	23.3
Lot 5	.41	48	60	56	54	40	.30	24.0

TABLE I. Churning Records. (Cont'd)

Churn Number	Acidity of Cream	Churn Temp.	Time of Churning	Temp. of Buttermilk	Temp. of Wash Water	Revolutions Worked	Buttermilk Test	Overrun
	Per cent	°F	Minutes	°F	°F		Per cent	Per cent
Series VII								
Lot 1	.12	52	70	57	54	45	.40	20.1
Lot 2	.12	52	70	56	54	45	.30	22.1
Lot 3	.13	50	55	56	54	45	.30	21.1
Lot 4	.31	52	40	57	55	35	.30	23.0
Lot 5	.51	51	45	57	55	40	.25	21.1
Series VIII								
Lot 1	.14	54	60	58	53	40	.35	22.0
Lot 2	.14	52	65	56	54	45	.30	24.0
Lot 3	.15	52	70	56	54	45	.30	23.0
Lot 4	.32	50	40	55	54	40	.25	22.0
Lot 5	.32	50	40	55	54	40	.25	22.0

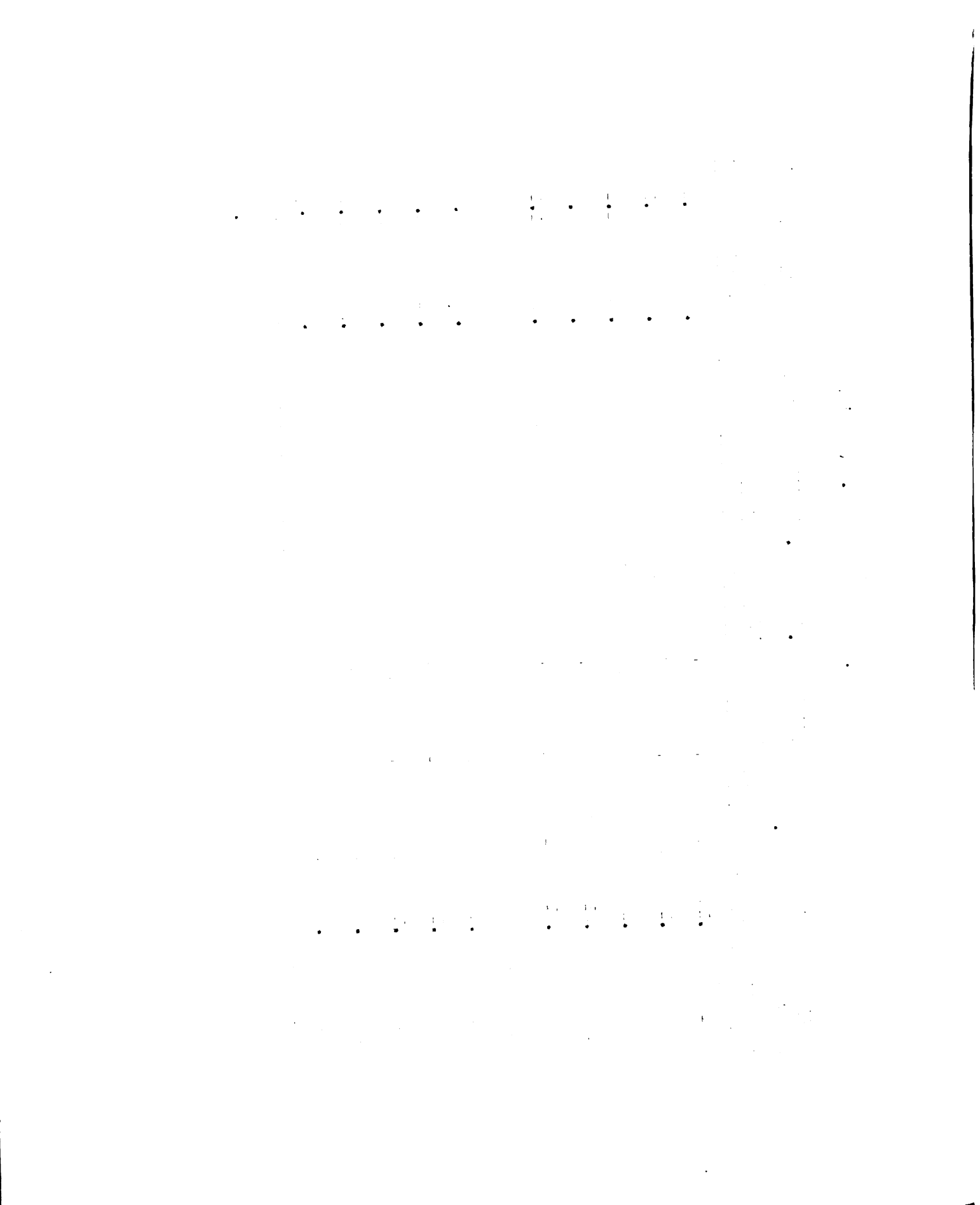

TABLE I. Churning Records. (Cont'd)

Churn Number	Acidity of Cream	Churn Temp.	Time of Churning	Temp. of Buttermilk	Temp. of Wash Water	Revolutions Worked	Buttermilk Test	Overrun
	Per cent	°F	Minutes	°F	°F		Per cent	Per cent
Series IX								
Lot 1	.13	52	70	56	53	40	.30	22.1
Lot 2	.13	50	90	58	53	37	.30	23.5
Lot 3	.14	56	45	58	54	40	.35	23.0
Lot 4	.31	50	50	55	54	40	.25	21.1
Lot 5	.51	51	50	55	54	35	.25	22.0
Series X								
Lot 1	.14	52	60	60	53	45	.35	24.0
Lot 2	.14	54	65	58	53	40	.30	23.0
Lot 3	.15	56	55	58	53	40	.30	23.0
Lot 4	.32	51	35	56	53	40	.25	23.6
Lot 5	.51	48	70	54	53	40	.20	23.6

TABLE I. Churning Records. (Cont'd)

Churn Number	Acidity of Cream	Churn Temp.	Time of Churning	Temp. of Buttermilk	Temp. of Wash Water	Revolutions Worked	Buttermilk Test	Overrun
	Per cent	°F	Minutes	°F	°F		Per cent	Per cent
Series XI								
Lot 1	.13	52	60	58	52	40	.35	22.0
Lot 2	.13	51	60	56	52	35	.35	23.0
Lot 3	.14	54	50	57	53	40	.30	23.0
Lot 4	.31	50	50	55	53	40	.25	22.0
Lot 5	.51	48	70	55	53	35	.20	22.0
Series XII								
Lot 1	.14	52	80	57	53	45	.35	23.0
Lot 2	.14	54	55	58	53	45	.40	24.0
Lot 3	.15	54	60	58	53	40	.30	23.0
Lot 4	.34	51	45	59	53	35	.25	24.0
Lot 5	.50	50	50	57	53	40	.20	24.0

TABLE II. Showing Fat, Moisture, Salt, and Curd Content of Butter.

Churn Number	Fat	Moisture	Salt	Curd	Churn Number	Fat	Moisture	Salt	Curd
	Per cent	Per cent	Per cent	Per cent		Per cent	Per cent	Per cent	Per cent
Series I					Series III				
Lot 1	80.73	15.70	2.49	1.08	Lot 1	80.61	15.70	2.61	1.08
Lot 2	80.40	15.50	2.39	1.71	Lot 2	80.59	15.95	2.38	1.08
Lot 3	81.10	15.50	2.36	1.04	Lot 3	80.57	15.90	2.49	1.04
Lot 4	80.80	15.70	2.43	1.07	Lot 4	80.67	15.95	2.36	1.02
Lot 5	80.68	15.90	2.38	1.04	Lot 5	80.85	15.90	2.24	1.01
Series II					Series IV				
Lot 1	81.10	15.60	2.30	1.00	Lot 1	81.08	15.60	2.28	1.04
Lot 2	80.48	15.90	2.40	1.22	Lot 2	80.89	15.90	2.24	.97
Lot 3	81.01	15.99	2.03	.97	Lot 3	80.71	15.80	2.31	1.08
Lot 4	81.35	15.95	1.75	.96	Lot 4	80.92	15.70	2.38	1.00
Lot 5	81.05	15.95	2.04	.96	Lot 5	80.80	15.85	2.40	.95

TABLE II. Showing Fat, Moisture, Salt, and Curd Content of Butter.

Churn Number	Fat	Moisture	Salt	Curd	Churn Number	Fat	Moisture	Salt	Curd
	Per cent	Per cent	Per cent	Per cent		Per cent	Per cent	Per cent	Per cent
Series V					Series VII				
Lot 1	80.73	15.95	2.27	1.05	Lot 1	81.10	15.80	2.15	.95
Lot 2	80.61	15.85	2.54	1.00	Lot 2	80.80	15.90	2.30	1.00
Lot 3	80.91	15.80	2.31	.98	Lot 3	81.00	15.90	2.20	.90
Lot 4	80.75	15.95	2.25	1.00	Lot 4	80.55	15.90	2.51	1.04
Lot 5	80.79	15.90	2.21	1.10	Lot 5	80.85	15.95	2.25	.95
Series VI					Series VIII				
Lot 1	81.13	15.70	2.26	.91	Lot 1	81.10	15.80	2.39	.71
Lot 2	80.85	15.80	2.25	1.10	Lot 2	80.75	15.95	2.45	.85
Lot 3	80.73	15.99	2.30	.98	Lot 3	81.05	15.85	2.15	.95
Lot 4	80.88	15.90	2.30	.92	Lot 4	80.65	15.95	2.38	1.02
Lot 5	80.82	15.90	2.24	1.04	Lot 5	80.81	15.99	2.34	.86

TABLE II. Showing Fat, Moisture, Salt, and Curd Content of Butter. (Cont'd)

Churn Number	Fat	Moisture	Salt	Curd	Churn Number	Fat	Moisture	Salt	Curd
	Per cent	Per cent	Per cent	Per cent		Per cent	Per cent	Per cent	Per cent
Series IX					Series XI				
Lot 1	80.80	15.80	2.45	.95	Lot 1	81.05	15.85	2.16	.94
Lot 2	80.30	15.95	2.65	1.10	Lot 2	80.80	15.90	2.37	.93
Lot 3	80.90	15.70	2.40	1.00	Lot 3	80.70	15.95	2.35	1.00
Lot 4	80.60	15.90	2.45	1.05	Lot 4	80.10	15.90	2.05	.95
Lot 5	80.85	15.95	2.25	.95	Lot 5	80.70	15.80	2.40	1.10
Series X					Series XII				
Lot 1	80.80	15.80	2.40	1.00	Lot 1	80.85	15.95	2.38	.82
Lot 2	80.35	15.95	2.50	1.20	Lot 2	80.70	15.90	2.50	.90
Lot 3	80.70	15.90	2.45	.95	Lot 3	80.90	15.80	2.35	.95
Lot 4	80.55	15.95	2.40	1.10	Lot 4	80.70	15.90	2.34	1.06
Lot 5	80.65	15.85	2.50	1.00	Lot 5	80.75	15.85	2.40	1.00