KEEPING QUALITY OF CREAM TO BE USED FOR BUTTERMAKING AS AFFECTED BY VARIOUS STORAGE TEMPERATURES

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1936

Submitted to the Department of Dairying

Oklahoma Agricultural and Mechanical College

In partial fulfillment of the requirements

for the Degree of

MASTER OF SCIENCE

1937

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ACKNOWLEDGEMENTS

The author wishes to take this opportunity of expressing his sincere appreciation to Professor E. L. Fouts for his most valuable suggestions given during the course of this study and the preparation of this thesis; and to Dr. J. I. Keith for his willingness in giving valuable suggestions and criticisms at all times.

The author is also indebted to Professor Earl Weaver, Dr. A. H. Kuhlman, and Professor P. C. McGilliard for their willingness to aid in promoting this study; and to W. V. Maddox, Creamery Superintendent, for his cooperation during the experimental study which required the use of creamery equipment.

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INTRODUCTION

The purpose of this experimental observation was to study the effects of various temperatures of storing cream, and the time element on the production of high quality cream. This study was made from the standpoint of the conditions as they exist on the average cream producing farm in Oklahoma.

In Oklahoma, as well as in many other states, the production of good quality cream is a complex problem. Most of the cream is produced by farmers having comparatively few cows. Only a small volume of cream is produced per farm. Since the sale of cream is not a main source of income for individual farmers, they are of the opinion that extra efforts would not increase the profits enough to warrant additional care in the production of high quality cream. Another drawback to quality cream production is the distance the average producer lives from the cream station or creamery. On an average this distance is about twelve miles, which means that cream will be delivered whenever the farmer feels it is convenient to go to town.

The rapid development of the dairy industry has created considerable misunderstanding between the cream producers, station operators, and buttermakers. Each censures the other for the poor quality butter produced. The cream station operator, and the buttermaker believe that poor quality cream production is due to lack of low temperatures of cooling and storing cream, and the lack of sanitary conditions on the farm. However, the cream producers are of the opinion that the recommendations by dairy specialists are too rigid and impractical, especially if they refer to temperatures of 50° F. or less for cooling and storing cream.

From the standpoint of economy, it is not profitable to these producers to obtain such low temperatures, especially if one considers the fact that most Oklahoma farmers produce cream in small quantities.

Therefore, the problem presents itself as to whether or not it is possible to produce high quality cream and still not use lower temperatures than are available on the average Oklahoma cream producing farm.

PLAN OF STUDY

The plan of this study was to determine the effects of storing the cream at different temperatures, for varying periods of time. Considering such factors as: flavor which was determined on the initial samples and on samples after being held for 2, 3, 4, and 7 days at 40° F., 50° F., 60° F., and 70° F. Acidity was determined by titrating a 9 gm. sample of cream with N/10 NaOH using phenolphthalein as indicator. Bacteria counts were made on Bacto nutrient agar, and Bacto nutrient caseinate agar. These counts were made according to the standards as given in the Standard Methods of Milk Analysis, Sixth Edition 1934. The cream was graded on the basis of flavor and acidity as set up by the United States Standards in Grading of Cream.

In order to experiment with cream produced under two different conditions, milk was obtained from the college herd. The conditions of production were more or less ideal as compared with the second lot which was obtained from a representative milk producer selling only a small volume of cream.

The milk was heated to 95° F., and separated by a thoroughly cleaned No. 1 De Laval Separator. This separator was washed and dried before skimming the second lot of milk, thus minimizing the possibility of contaminating one lot of cream with the previous lot separated.

Immediately after separation sterile cream jars were filled with each lot of cream, and the samples stored at 40° F., 50° F., 60° F., and 70° F. for 2, 3, 4, and 7 days. Percent of fat, percent of acidity, flavor, sediment, and grade of cream were determined on the initial lots of cream. The bacteria counts were made on standard agar and caseinate agar. Dilutions plated were 1-10,000, 1-100,000, 1-1,000,000, 1-100,000,000, and 1-1,000,000,000. The high dilutions were used in plating caseinate agar, and low dilutions on standard agar.

The bacteria plates were held at 37.5° F., and counts were made at the end of 48 hours. The cream was graded for each temperature, and for each holding period on basis of flavor and acidity.

REVIEW OF LITERATURE

Larsen and Jones (13) stated that cream must be stored at low temperatures in order to produce good quality butter. They recommended using as low a temperature as possible without actually freezing the product. Wilster, Hoffmann and Brandt (23) indicated that with a minimum temperature of 44° F., and a maximum of 65° F., the acidity of the cream increased to 0.64 of one percent, and because of the sour undesirable flavor developed, only a 90 score, or perhaps a 91 score butter could be made. Anthony (1) recommended for all cream to be cooled to 45° F., and kept under such conditions until enough was accumulated for churning, then raising the temperature to 75° F. until sufficient acidity had developed, Farrington (6) claimed that cream cooled immediately to 55° F. and kept at that temperature would produce excellent quality butter. Clark (5) was convinced that desirable results would be obtained if cream was cooled to 45° F. to 50° F. immediately after separation. Frandsen (8) reported that low temperatures were essential in retarding the growth of organisms, and were pertinent in the production of good quality cream.

Temperatures below 50° F. assist in delaying the development of off-flavors. They retard the growth of some undesirable organisms, and inhibit excess lactic acid production brought about by the Streptococcus lactis bacteria.

The buttermakers desire the prevention of sour cream flavor caused by excessive acidity. Greater amounts of neutralizer must be used to reduce the acidity which usually makes butter show neutralizer flavor. This flavor often causes the butter to fall below the score of 90, the lower limit of standard quality as determined by the butter market. The control over the acid production enables the creamerymen to inhibit the yeast and mold growth because of the preference of these particular organisms for an acid medium.

According to White (21) Maine was the first state in the United States to grade cream in 1908 and 1909. After a brief introduction to grading of cream, those using this practice were firmly convinced that it was a stepping stone in improving the quality of cream. Hunziker (11) stated that at first the cream was tasted. However, as the grading progressed, the cream buyers soon developed their sense of sight and smell. Moldy, caked cream, fermented and gassy cream was easily detected.

According to White, in 1910 the best plan provided for two grades of cream as follows:

> "No. 1.--Cream must be sweet with a clean flavor and a premium of from 1-3¢ per lb. be paid.
>
> "No. 2.--Cream may be sour but must have a clean flavor, for this grade a price which will follow market quotations of prices shall be paid.
>
> Cream not clean in flavor and consequently not included in either of these grades shall be rejected."

Many of the dairy authorities stated that before grading system was installed, 90% of the cream delivered to cream stations was sour, while afterwards about 95% of the cream reached the creameries in sweet condition.

White (22) stated that premium cream is fresh, sweet, and has less than 0.2 of one percent acidity. First grade cream contains less than 0.4 of one percent acidity with no objectionable flavors or odors.

Hunziker, Mills and Switzer (12) observed that cooling of cream was essential in the production of good quality butter. By this process undesirable fermentation, animal heat, and foreign odors were partially eliminated. They determined the effect of tank cooled and non-tank cooled cream upon the score, acidity, and the condition of butter. The temperature of cooling water was on an average 58.8° F., the acidity of non-tank cooled cream averaged 0.52 of one percent while the tank cooled cream the acidity averaged 0.38 of one percent. Upon shipping this butter to the New York market the non-tank cooled cream butter, two weeks later, scored on an

average of 88.36, while the tank cooled cream butter scored 90.69. These observations indicated that when cream was cooled, the butter, two weeks later, scored 2.5 points higher than the butter from the non-tank cooled cream.

Manhart (15) compared the effects of cooling and not cooling of cream upon the score of butter. A seven and a four day accumulation of cream were used and divided into two lots, one lot being cooled with water at 54° F., while the other lot was not cooled. It was observed that the minimum difference in score between cooled cream butters and not cooled cream butters was 0.5 of one point, and the maximum difference was 3.5 points. The average score of cooled cream butters was 2.05 points higher than not cooled cream butters.

The benefits derived from cooling of cream on the farm can easily be destroyed if the product is not kept under some refrigeration during transportation. According to Manhart, Horrall and Hienton (16) refrigeration of cream at the station during the period of accumulation is essential. If the temperature is not controlled while the cream is in transit, the quality of butter made from this cream will decrease. Mechanical refrigeration prevents, to some extent, mechanical loss caused by foamy cream. However, the practicability of cooling cream by mechanical refrigeration at the station is questionable.

Potts (19) reported that the production of good quality cream depends considerably upon inhibiting the development of high percent of acidity. In order to allow the proper amount of acidity to be produced, the cream should be cooled to at least 50° F. Warm cream should not be mixed with colder cream; for this practice speeds up acidity production, thus hastening souring.

Hopkins and Trout (10) stated that cream should be cooled to 55° F. during summer months and be delivered at least every other day. In winter

twice a week delivery is sufficient. Clean production and proper cooling enables the producers to furnish cream that will keep longer. Cream that is held for a long period of time, though still sweet, may become musty, stale, or otherwise off-flavored.

The cream producers must understand the market grades of cream, the requirements and characteristics of each grade. Without this knowledge, the producer works without a definite goal. In general, Hopkins and Trout state that the grades of cream adopted by the manufacturers of dairy products are as follows:

> "First Grade cream shall be that which is clean, sweet, and free from all undesirable flavors or odors.
>
> "Second Grade cream shall be that which may be slightly sour, which may contain undesirable flavors and odors to a moderate degree, which may be slightly foamy, yeasty, or "off" in flavor; or which may be too old or stale to grade as first.
>
> "Third Grade, or rejected cream consists of cream which is putrid, cheesy, rancid, curdy, musty, dirty, or otherwise unwholesome and should not be accepted by the creameryman."

Sommer (20) stated that flavor and aroma of butter depend upon many factors. They are as follows:

> "(a) The fat itself,
> (b) Foreign flavors and odors transmitted by the feed through the cow, and absorbed from surroundings,
> (c) Flavors and odors arising from fermentations,
> (d) Flavors resulting from chemical changes such as oily, tallowy, and fishy."

The first exposure of the product to foreign flavors and odors comes during the milking process. Milk is a very good solvent for volatile substances in the air, and is a good medium for growth of bacteria, yeast, and molds. The improper cooling of cream makes for undesirable fermentations, producing unclean, fruity, yeasty, and cheesy flavors depending upon the type of contamination.

The production of good quality cream goes back to the milking of the cows under sanitary conditions. There may develop a characteristic flavor

of butter due to hydrolysis of milk fat, brought about by an enzyme Lipase which causes the decomposition of the fat into its component parts, fatty acids and glycerol. The free butyric acid, if present in minute traces, may have a desirable influence upon the flavor, but in large quantities causes rancidity. The possible prevention of this undesirable flavor may be brought about by pasteurization at 145° F. for 30 minutes. It is, however, almost impossible for the farmers to pasteurize the small quantities of cream produced to destroy the enzyme Lipase. Therefore the cream should be properly cooled and delivered frequently. This is especially true toward the later part of the lactation period.

Hammer (9) concluded that the proper development of flavor and aroma depend, in addition to Streptococcus lactis, upon associated organisms Streptococcus citrovorus and Streptococcus paracitrovorus. Conditions favoring the development of the above organisms appear to be essential in the production of flavor and aroma in butter. Temperatures below 65° F. are not favorable for the growth of Streptococcus lactis and its associated organisms. These bacteria grow together most favorably between 68° F. to 70° F.

Winkjer, Burns and Burke (24) stated that butter of good quality could be made from cream received at the creamery fresh, sweet, and clean in flavor. That the most effective method for improving quality of cream delivered to the creamery is to pay for cream on the basis of grade of butter it will produce. It has been observed through past experience that when a creamery pays the same price for old, sour cream as for fresh cream, it will receive little of the latter. The cream producers will have no incentive to produce high quality cream since no extra profit would be obtained for additional care.

The following grade requirements have been recommended for creameries in sections where much of the cream is sour when delivered to the creamery.

"Grade 1: Cream from which the butter will score 92 points or higher. The cream shall be fresh and clean in flavor. The acidity shall not exceed 0.2 of one percent, and the fat content shall be not less than 30% nor more than 40%.

"Grade 2: Cream from which the butter will score at least 90 points. The cream shall be clean in flavor, the acidity shall not exceed 0.4 of one percent, and the fat content shall be not less than 30% nor more than 40%.

"Grade 3: Cream from which the butter will score at least 87 points. The cream may have undesirable and objectionable flavors but shall be free from strongly objectionable and foreign flavors such as onion, gasoline, and cheesy.

"Grade 4: Cream that cannot meet the requirements of Grade 3. Such cream should be rejected because butter made from filthy or badly decomposed cream cannot be sold legally as food."

In order to deliver cream that is fresh, clean, and fine in flavor the cream producer must prevent off-flavors from getting into the milk during the milking process. The farmer should have properly constructed utensils that are clean and in good condition. He should cool the cream promptly, keep it cool, and deliver it to the creamery or cream station four times each week. If no cooling facilities are available on the farm, the cream should be delivered daily.

Baltzer and Trout (3) have classified cream into several grades each having definite, well-defined characteristics. Supplies of cream received at the various creameries fall into several grades. Although the creameries may receive the cream without grading it, they are generally aware of the quality of cream being received, recognizing that a high quality product cannot be made from inferior raw material. In general the grades of cream recognized by creamery men are as follows:

"Special Grade: Special grade cream shall be that cream which is clean and entirely free from any "off" flavor or odor and which shall contain not to exceed .20 percent acidity calculated as lactic acid. Such cream lends itself readily to the making of 92 to 94 score butter. This is commonly called sweet cream.

"First Grade: First grade cream shall be that cream which is free from any objectionable flavor or odor and which shall contain not to exceed 0.60 percent acidity calculated as lactic acid. Such cream lends itself

readily to the making of 90 or higher score butter. This is mildly sour cream.

"Second Grade: Second grade cream shall be that cream which contains undesirable flavors such as weedy, cowy, unclean, barny, smothered, cellar, cheesy, stale, old, and others. It contains more than .60% acidity calculated as lactic acid. Such cream lends itself readily to the making of 87-89 score butter. It is very sour and lacks good flavor.

"Third Grade: Third grade cream shall be that cream which possesses objectionable flavor such as garlic, leeks, onions, kerosene, gasoline, and has excessive high acidity."

Cream should be scored on the basis of what the butter made from it will score. It follows then, that a cream scoring 92 points should yield a butter scoring 92 points; a cream scoring 89 should yield an 89 score butter, the condition of churning being the same in each case. The butter flavor is obtained from and is similar to the flavor observed in the cream from which it was made.

A premium product cannot be made from poor, second rate, raw material. If a good, clean-flavored cream is to be had, it must be obtained, first of all, from milk of similar characteristics. Dirty milk yields an unclean, off-flavored cream, and onion milk yields onion cream.

Most of the dairy specialists advocate cooling cream to at least 50° F. or less immediately after separation. The product may be clean as far as freedom from dirt, contact with unclean utensils, or off-flavors are concerned, yet sufficient microrganisms are present to sour the cream if they are given the opportunity to thrive.

Most of the bacteria found in milk or cream grow best between 65° F. to 100° F. During growth they change the lactose, or milk sugar, into lactic acid. When a sufficient quantity of lactic acid is produced, the cream becomes sour. However, cooling cream immediately to 50° F. after separation will retard the multiplication of the organisms present.

Although bacterial growth in cream may have been prohibited by the

control of temperature, cream does deteriorate with age. The cream should, therefore, be delivered to the creamery at frequent intervals to assure its arrival in first class condition. In general, this means that the cream should be delivered twice a week during the winter months and three times a week during summer months.

Prucha (18) obtained results which favor other factors besides cooling of cream as being essential in the production of good quality cream. It was observed that off-flavors developed at all temperatures, that rancidity and cowy flavors appeared at low temperatures, and yeasty and moldy flavors developed between 80° F. to 90° F. in three days. Prucha claims that the following factors are essential in the production of good quality cream:

"(a) Frequency of delivery,
(b) Utensils in good condition,
(c) Cleanliness, cows, barns, milkers, etc.,
(d) Temperatures at which cream is stored."

Prucha believes that the goal in good quality cream production is to produce cream that is mildly sour, clean, and free from off-flavors. This goal is best arrived at by cooling and storing cream at temperatures favoring lactic acid production. Storage temperatures of 60° F. to 65° F. are within the reach of most farmers, and this is a good temperature to cool and hold cream if it is delivered to the cream station or creamery twice a week.

The grading of cream is not a difficult task according to the Ohio's Cream Grading Manual (26). It simply requires the intelligent use of sight, smell, and taste senses.

The Mississippi Cream Grading Manual (25) presents the fact that the cream station operator must watch carefully for lumpy, feed flavor, and oily cream.

In the Southern States the grades of cream vary from those used in the Northern States. For example, Mississippi has four grades: sweet cream, first grade, second grade, and unlawful or rejected cream. Oklahoma's laws,

rules and regulations include first, second, and third grade, the latter grade being rejected. Indiana has several grades including sweet, first grade, second grade, third grade, and rejected cream. The third grade includes cream having cheesy, tallowy, stale, sour, onion, or metallic flavor.

Manhart (14) states that the Four Day Delivery Plan introduced in Indiana in 1927 has established a uniform system of buying cream on a grade basis. This system is stable and understandable to the producer as well as to the cream station operator. According to this plan the cream is graded as follows: Premium cream is sold at periods of not over four days, is free from objectionable flavors and odors at the time of delivery; Regular cream is sold at intervals of more than four days, or cream sold at intervals of four days or less with undesirable flavors and odors. Rejected cream is rancid, moldy, dirty, oily, onion, or garlic flavors, or in other words, unfit for human consumption.

The success of this plan depends largely upon the proper use of the Four Day Tag. This distinguishes the period of delivery. It permits the cream producer to sell his four day cream to any creamery operating on the Four Day Plan, and obtain the premium price because the date of the previous delivery is attached to the cream container. By means of this tag and the cream buyers record of cream purchases, the creamery and the grading individual are able to check on the interval of delivery. By this method, it is possible to prevent buyers of cream from paying the premium price to producers who are not entitled to it from the standpoint of frequency of delivery. Therefore, it is readily observed that all cream station operators are on the same basis in buying cream, thus a buyer is unable to take advantage of another by favoring certain cream producers.

Each grade of cream is marked by a colored tag; a blue tag represents premium grade; a red tag regular cream; a yellow tag onion cream. The

Four Day Tag is attached to the producer's cream container as a means of determining the last sale of cream.

Fouts and Keith (7) concluded that the proper cooling of cream on the farm is one of the essential steps in the production of good quality butter. However, they claim that under the conditions in Oklahoma, that it is not profitable to employ mechanical refrigeration due to small quantity of cream produced by individual farmers. Little cooling was, nevertheless, more desirable than no cooling. Due to these conditions, more weight should be placed upon frequency of delivery. If cream was produced under sanitary conditions, cooled to 50° F. or less and delivered three times a week it would grade No. 1 cream. Twice-a-week delivery will make the cream fall into the second class. If the cream was held at 75° F. it would fall into the second class unless daily deliveries are made. From these deductions one may conclude that Fouts and Keith are placing greater stress upon frequency of delivery than the previous workers indicated in their recommendations.

Since the temperature of well water on the Oklahoma farms averages about 58° F. to 60° F. it would be valuable for the producers to use either the Barrel Cooler or Evaporation Cooler recommended by Fouts and Keith, depending upon the volume of cream produced.

The Barrel Cooler can be used when fairly large quantity of cream is produced. The cooler consists of a barrel large enough to hold desired number of cream cans. It should be located between the well and the stock tank, in a shady place or in the milk house. By this arrangement the barrel can be kept supplied with fresh water at its minimum temperature while the stock tank is kept full.

If no objectionable off-flavors are present the cream can be held three days and still be graded first grade when delivered to the cream station.

The evaporation cooler is suitable to use when small quantities of cream are produced. This type of cooler consists of two pans, one being the size of can cover and the other at least six inches greater in diameter than the cream can. A piece of muslin sufficient in size to completely cover the lid and container is needed. The muslin is immersed in the water held in the two pans. This cooler should be placed in the shade and in a breeze because the cooling depends upon the evaporation of water. The two pans should be kept supplied with water so that the muslin will be saturated with water.

According to Fouts and Keith it was possible to cool cream to 75° F. by water having a temperature of 90° F., the outdoor temperature ranged between 100° F. to 105° F.

Post (17) lists the following cream grading states: Alabama, Arkansas, California, Illinois, Indiana, Iowa, Kansas, Kentucky, Minnesota, North Dakota, South Dakota, Missouri, Mississippi, Oklahoma, Oregon, Texas, Utah, Tennessee, Ohio, Washington.

Cream grading laws have been passed by Mississippi effective November 28, 1936; and by Alabama effective January 1, 1937. Oklahoma was the first state to pass a cream grading law; this law was passed in 1919.

According to Clarke (4) the cream improvement program was established in 1934. About this time the Food and Drug Administation, in cooperation with various state organizations, undertook the examination of extensive quantities of cream for butter making. The unfit cream being seized or condemned by the state authorities.

In 1935 four percent of the cans of cream examined were condemned while in 1937 only 2.88% were condemned.

In any cream improvement program it can easily be observed that corrective measures must be used to prevent cream from becoming unfit for

human use. This program should be aware of the following essentials:

1. Farm sanitation.

2. Frequency of delivery.

3. Cooling on farm and in transit.

4. Creamery sanitation.

It must be admitted that considerable progress has been made in teaching and encouraging cream producers to deliver their cream more frequently. However, the greatest problem before any cream producer is the production of milk and cream under sanitary conditions. At least 75% of the foreign material finding its way into milk is soluble. This cannot be removed by any process now known.

DISCUSSION OF RESULTS

Two lots of cream were studied in this experiment. The milk for the first lot of cream was produced under sanitary conditions. Immediately after being drawn from the cow, the milk was cooled to about 50° F. over a surface cooler, and held at this temperature until it was used in the experiment. The second lot of cream was separated from milk produced under poor conditions as compared with the production of milk for the first lot of cream. The milk was cooled in a stock watering tank and received very little stirring during the cooling period. When received at the laboratory the temperature was near 70° F.

Sediment tests were made on the cream. In all instances very little foreign material was present, not enough to be of any significance in this study. In no case did the sediment score fall below 9.6 when compared with the sediment scoring chart given in Judging Dairy Products by Nelson and Trout.

Table I

Average Bacteria Counts on Standard Agar and Caseinate Agar on Thirty-Nine Cream Samples Held at the Various Temperatures and Storage Periods. Lot I Cream.

	Temperature Held	Standard Agar	Caseinate Agar
2 Day Storage	40° F.	4,679,000	15,900,000
	50° F.	12,183,400	37,617,000
	60° F.	39,556,000	332,400,000
	70° F.	65,900,000	510,900,000
3 Day Storage	40° F.	29,080,000	26,170,000
	50° F.	66,430,000	128,107,900
	60° F.	73,450,000	440,020,000
	70° F.	79,000,000	637,000,000
4 Day Storage	40° F.	28,894,000	38,400,000
	50° F.	47,216,000	104,900,000
	60° F.	54,300,000	430,000,000
	70° F.	65,900,000	542,000,000
7 Day Storage	40° F.	11,950,000	42,950,000
	50° F.	21,280,000	189,850,000
	60° F.	43,200,000	874,000,000
	70° F.	54,660,000	1,102,000,000

FIGURE 1. EFFECT OF TEMPERATURE AND TIME OF STORAGE ON BACTERIAL COUNTS OF CREAM

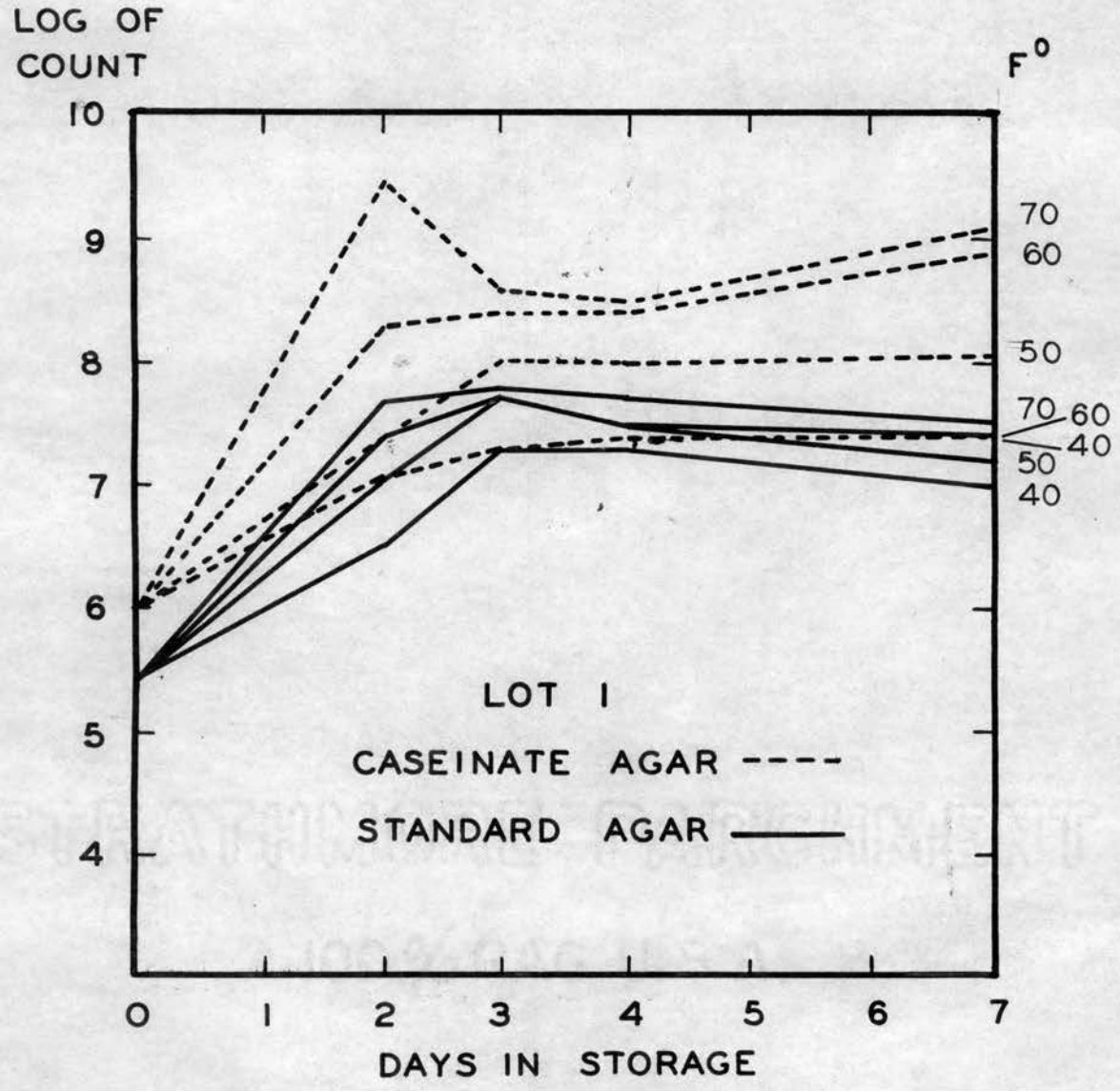
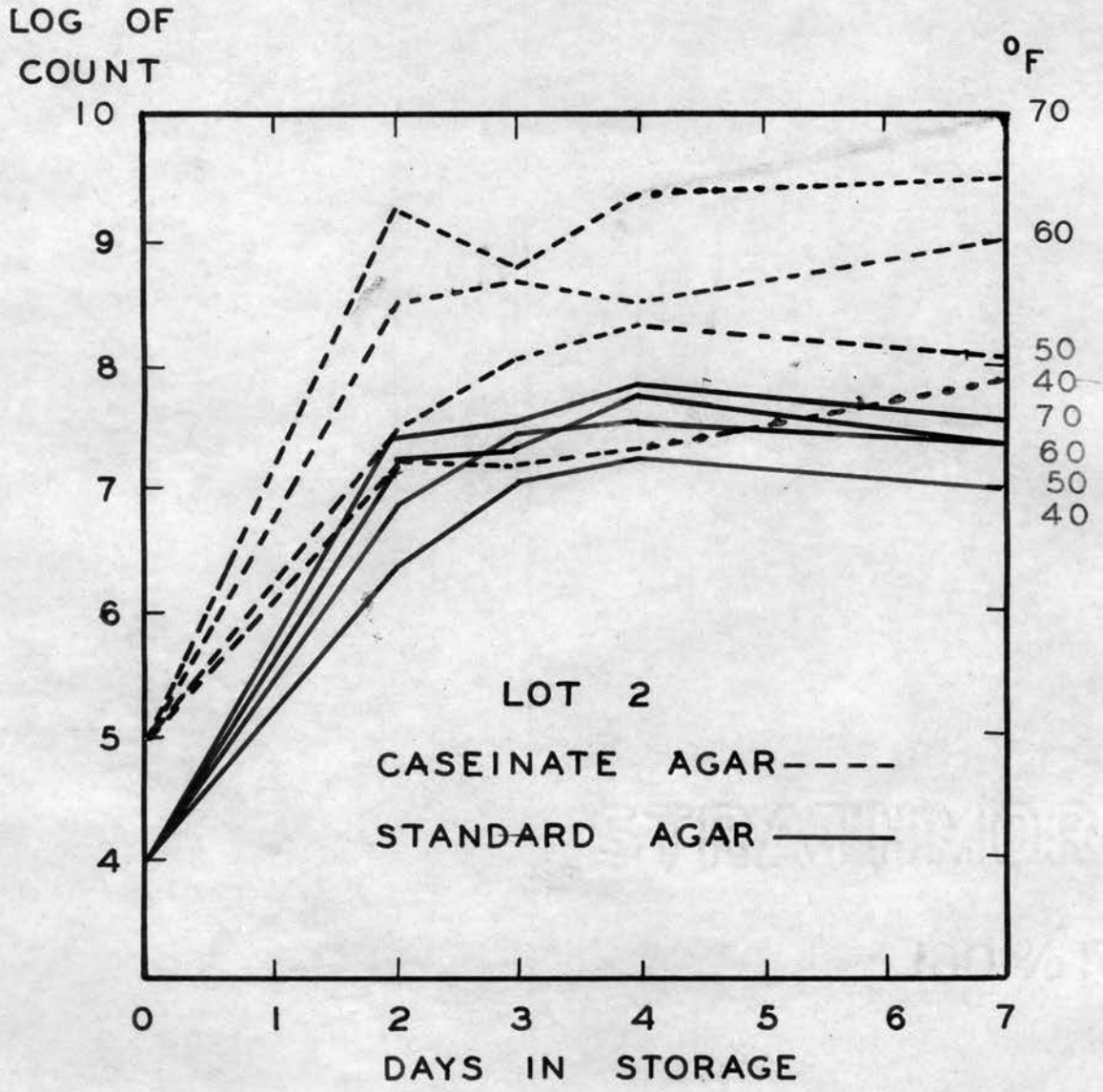


Table 2

Average Bacteria Counts on Standard Agar and Caseinate Agar on Thirty-Nine Cream Samples Held at the Various Temperatures and Storage Periods. Lot 2 Cream.

	Temperature Held	Standard Agar	Caseinate Agar
2 Day Storage	40° F.	4,298,000	19,050,000
	50° F.	8,024,000	37,140,000
	60° F.	21,990,000	393,700,000
	70° F.	33,500,000	2,342,000,000
3 Day Storage	40° F.	10,528,900	18,659,700
	50° F.	36,084,400	119,328,000
	60° F.	30,290,000	713,000,000
	70° F.	46,800,000	939,000,000
4 Day Storage	40° F.	17,649,000	33,420,000
	50° F.	55,384,000	271,400,000
	60° F.	72,130,000	462,000,000
	70° F.	79,600,000	4,128,000,000
7 Day Storage	40° F.	12,029,000	87,960,000
	50° F.	28,850,000	153,700,000
	60° F.	33,180,000	1,025,200,000
	70° F.	48,600,000	4,961,000,000

FIGURE 2. EFFECT OF TEMPERATUBE AND TIME OF STORAGE ON BACTERIAL COUNTS OF CREAM



From Tables 1 and 2, and Figures 1 and 2, it may be observed that in only one case were the standard agar counts higher than the caseinate agar counts on the same samples of cream held at the same temperature.

The maximum standard agar counts were obtained on Lot 1 cream at all temperatures between two and three days of storage, and thereafter the counts decreased. Lot 2 cream produced maximum standard agar counts between three and four days of storage after which a slight decrease occurred. These results would indicate that in Lot 2 cream organisms other than Streptococcus lactis variety were dominant because the acid producers show comparatively little growth on standard agar.

It may be also observed that in all but one case after the maximum standard agar counts were produced the caseinate counts increased while the standard agar counts decreased. This indicates that the acid producing organisms retarded the growth of bacteria incapable of souring the cream.

From the bacteria counts on standard and caseinate agar it may be observed that as temperature of storage increased, the difference between the counts became much greater. This again would indicate that few, if any, Streptococcus lactis bacteria thrive on standard agar, and that these acid producers retard the growth of other bacteria such as the proteolytic group, alkali and inert types.

There was very little difference between the ratios of the caseinate and standard agar counts. This would indicate that the percent of acid producers was about the same in the initial samples of the two lots of cream. At the end of two days of storage at 70° F. there occurred a sharp decline in number of bacteria on both lots of cream as indicated by the caseinate agar counts. This drop, however, did not have similar effect on the production of acidity. This would indicate that there was a decrease in the number of organisms other than Streptococcus lactis variety.

At 60° F. the caseinate agar counts on both lots of cream increased rapidly during the first two days of storage. After this period the counts increased rather slowly. This indicates that the acid producing organisms reach their maximum rate of growth during the first two days of storage. Since 60° F. is below the temperature at which the Streptococcus lactis growth dominates, these organisms produce a steady rate of growth instead of a more rapid increase in growth. It is also probable that the other organisms have some retarding effect on the rate of growth of the Streptococcus lactis organisms.

At 40° F. and 50° F. the caseinate agar counts on both lots of cream increased rapidly after two days of storage after which the rate of multiplication decreased. It may be also observed that the rate of growth of bacteria on caseinate and standard agar was about the same. This would indicate that at these low temperatures the acid producers and non-acid producers reproduced at about the same rate. However, after two days of storage, the Streptococcus lactis organisms established themselves more firmly in the cream. This had a greater retarding effect on the growth of the other bacteria than the low temperatures had on the growth of the ordinary souring bacteria present in cream.

It may be observed that the caseinate counts on lot two cream decreased at 50° F. after four days of storage; this is possibly due to the irregularity in the caseinate counts encountered during the entire experiment on cream samples held at the same temperature and storage period.

Table 3

Average Bacteria Counts Obtained on Standard Agar and Caseinate Agar on All Samples of Cream at Various Temperatures at the End of Seven Days of Storage.

No. of Samples	Storage Temperature	Bacteria per cc. Standard Agar	Bacteria per cc. Caseinate Agar
Lot 1 Cream			
10	Initial Lot	383,000	1,017,000
39	40° F.	18,650,750	30,855,000
39	50° F.	36,777,350	115,118,750
39	60° F.	52,625,500	519,105,000
39	70° F.	66,365,000	697,975,000
Lot 2 Cream			
10	Initial Lot	18,950	64,490
39	40° F.	11,126,250	39,772,425
39	50° F.	32,085,600	145,392,000
39	60° F.	41,897,500	648,475,000
39	70° F.	52,125,000	3,100,000,000

It may be observed from Table 3 that the caseinate agar counts were much greater than the standard agar counts. It may also be noticed that caseinate agar produced a greater variation in counts as temperature increased than did the standard agar.

The indications from Table 3 are that it does not necessarily mean that cream produced under sanitary conditions will have low standard agar counts. The above data indicate that lot one cream produced under sanitary conditions invariably gave higher counts on standard agar than the lot two cream. However, on caseinate agar the lot two cream produced

greater counts than lot one cream at the various storage temperatures. It may be observed from these results that there was little correlation between the bacteria counts and quality of cream, since lot two cream showed the lower count and still was produced under the least sanitary conditions.

Table 4

Average Acidity of the Cream Samples at Different Temperatures and Storage Periods of the Two Lots of Cream.

	Lot 1		Lot 2	
	Temperature Held	Percent Acidity	Temperature Held	Percent Acidity
2 Day Storage	Initial lot	.161	Initial lot	.144
	40° F.	.178	40° F.	.181
	50° F.	.202	50° F.	.199
	60° F.	.341	60° F.	.431
	70° F.	.567	70° F.	.563
3 Day Storage	Initial lot	.161	Initial lot	.144
	40° F.	.182	40° F.	.184
	50° F.	.269	50° F.	.274
	60° F.	.541	60° F.	.568
	70° F.	.680	70° F.	.639
4 Day Storage	Initial lot	.161	Initial lot	.144
	40° F.	.183	40° F.	.193
	50° F.	.370	50° F.	.344
	60° F.	.622	60° F.	.623
	70° F.	.742	70° F.	.671
7 Day Storage	Initial lot	.161	Initial lot	.144
	40° F.	.253	40° F.	.277
	50° F.	.553	50° F.	.616
	60° F.	.745	60° F.	.708
	70° F.	.804	70° F.	.757

FIGURE 3. TREND OF ACIDITY DEVELOPMENT IN CREAM DURING STORAGE

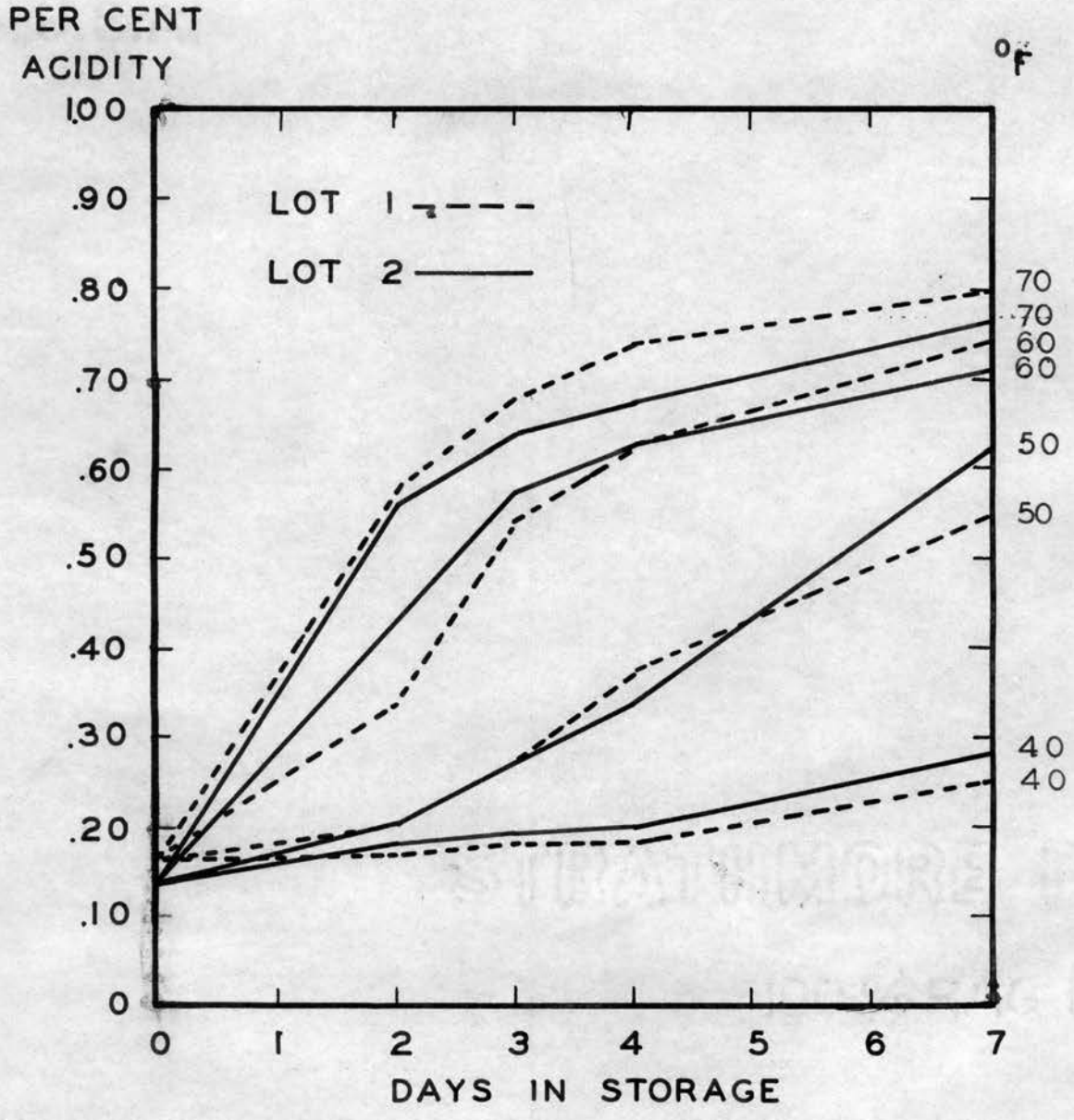


Table 5

Average Acidity of All Samples of Cream Held at Different Temperatures After Seven Days of Storage.

Lot 1 Cream			Lot 2 Cream		
No. of Samples	Temperature Held	Percent Acidity	No. of Samples	Temperature Held	Percent Acidity
10	Initial lot:	.162	10	Initial lot:	.144
39	40° F.	.199	39	40° F.	.209
39	50° F.	.348	39	50° F.	.358
39	60° F.	.562	39	60° F.	.582
39	70° F.	.698	39	70° F.	.657

It may be observed from Figure 3 that the two lots of cream showed a similar trend of acidity production at the different storage temperatures. From the data it may be observed that if cream is cooled and stored at 60° F., the minimum temperature of well water in Oklahoma, the acidity will be less than 0.6 of one percent. The cream would fall into the B grade from which a 90 score butter could be made provided no objectionable off-flavors were present. However, due to the fact that objectionable off-flavors developed in the cream samples studied only 20 percent of lot one and 50 percent of lot two cream samples would produce a 90 score butter after seven days of storage.

It must be admitted that acidity is only a minor factor in cream grading. However, in this experiment if the acidity of the cream was not within the limit established by the system used, the cream naturally fell into a lower grade even though it did not have bad off-flavors. Thus it may be stated that 90 percent of the cream samples held at 60° F. for three days would produce a 90 score butter. However, this cream must be produced under sanitary conditions and have no foreign material or objectionable off-flavors.

The cream samples were graded according to the United States Grades of Cream:

"AA. Grade: To make 93 score butter. Cream that is fresh, fine, clean and sweet, acidity of 0.2% or below.

"A. Grade: To make 92 score butter. Cream that is fresh, clean, and fairly sweet, acidity of 0.4% or below.

"B. Grade: To make 90 score butter. Cream that is fairly fresh, fairly clean and fairly sweet, acidity not to exceed 0.7%.

"C. Grade: To make 88 score butter. Cream that is yeasty, extremely stale, oily, metallic, bitter, cheesy, extremely sour, musty, weedy, or unclean.

"D. Grade: (Reject cream) To make 87 score butter or lower."

Table 6

Percent of Each Grade of Cream Resulting at Various Temperatures and Storage Periods. Lot 1.

Grades of Cream	Storage Temperatures			
	40° F.	50° F.	60° F.	70° F.
	Percent of Each Grade			
2 Day Storage				
AA	100	80	10	0
A	0	10	60	10
B	0	10	20	60
C	0	0	0	10
D	0	0	10	20
3 Day Storage				
AA	100	70	0	0
A	0	10	0	0
B	0	20	90	40
C	0	0	0	30
D	0	0	10	30
4 Day Storage				
AA	88.5	44.5	0	0
A	0	11	0	0
B	11.5	44.5	67	22
C	0	0	22	56
D	0	0	11	22
7 Day Storage				
AA	40	0	0	0
A	50	20	0	0
B	0	60	20	20
C	10	10	70	60
D	0	10	10	20

Table 7

Percent of Each Grade of Cream Resulting at Various Temperatures and Storage Periods. Lot 2.

Grades of Cream	Storage Temperatures			
	40° F.	50° F.	60° F.	70° F.
	Percent of Each Grade			
2 Day Storage				
AA	90	70	0	0
A	10	0	40	0
B	0	30	60	100
C	0	0	0	0
D	0	0	0	0
3 Day Storage				
AA	90	50	0	0
A	0	30	0	0
B	10	20	90	70
C	0	0	10	20
D	0	0	0	10
4 Day Storage				
AA	78	22	0	0
A	0	34	0	0
B	22	44	89	34
C	0	0	11	44
D	0	0	0	22
7 Day Storage				
AA	30	0	0	0
A	10	0	0	0
B	40	60	50	10
C	20	20	20	50
D	0	20	30	40

Table 8

Distribution of All Samples Studied According to Grade When Held at 60° F. for Four Days.

Grades of Cream	Percent of Each Grade at 60° F.		
	Lot 1 Cream	Lot 2 Cream	Average Percent
AA	0	0	0
A	0	0	0
B	67	89	78
C	22	11	16.5
D	11	0	5.5

From the above data it may be concluded that 78 percent of the cream samples of the two lots of cream could be cooled and stored at 60° F., and be delivered to the creamery at the end of four days and still produce a 90 score butter.

Figures 4 to 7 present the percent of each grade of cream obtained from 78 cream samples held at various temperatures and storage periods.

FIGURE 4 PER CENT OF AA GRADE CREAM RESULTING AFTER 2, 3, 4, AND 7 DAYS OF STORAGE AT 40°, 50°, 60°, AND 70° F.

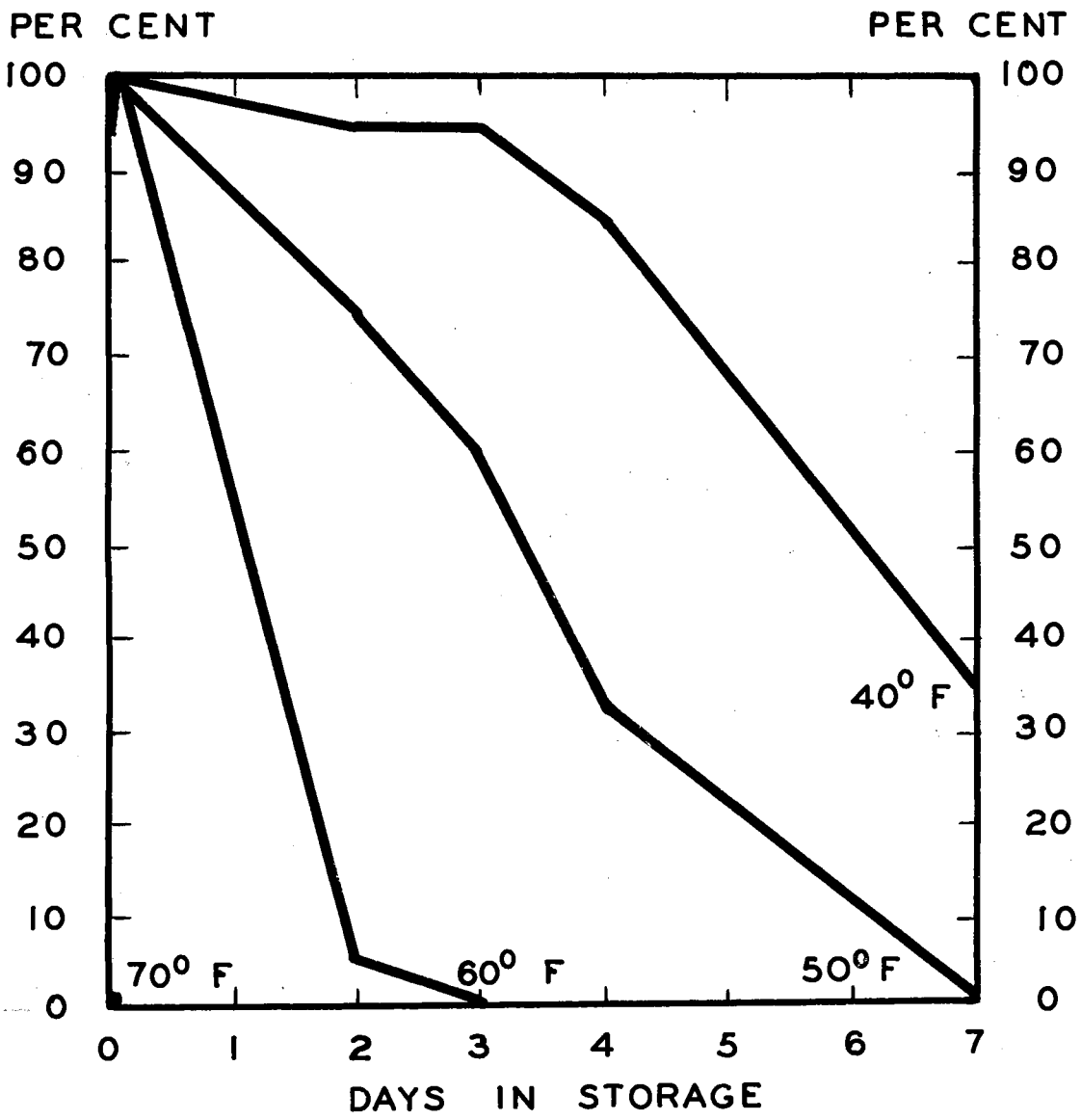


FIGURE 5. PER CENT OF A GRADE CREAM RESULTING AFTER 2, 3, 4, AND 7 DAYS OF STORAGE AT 40°, 50°, 60°, AND 70° F.

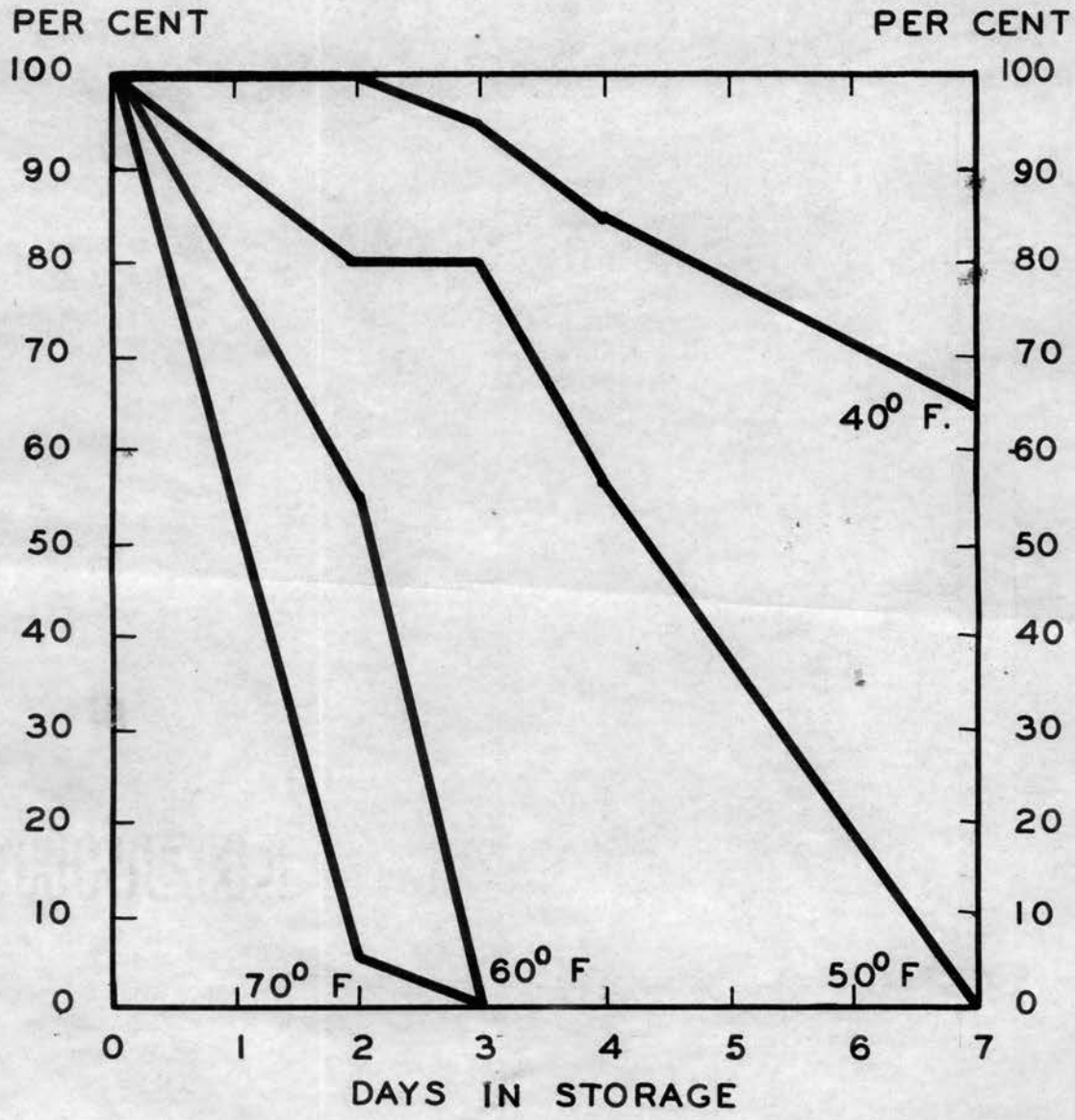


FIGURE 6. PER CENT OF B GRADE CREAM RESULTING AFTER 2, 3, 4, AND 7 DAYS OF STORAGE AT 40°, 50°, 60°, AND 70° F.

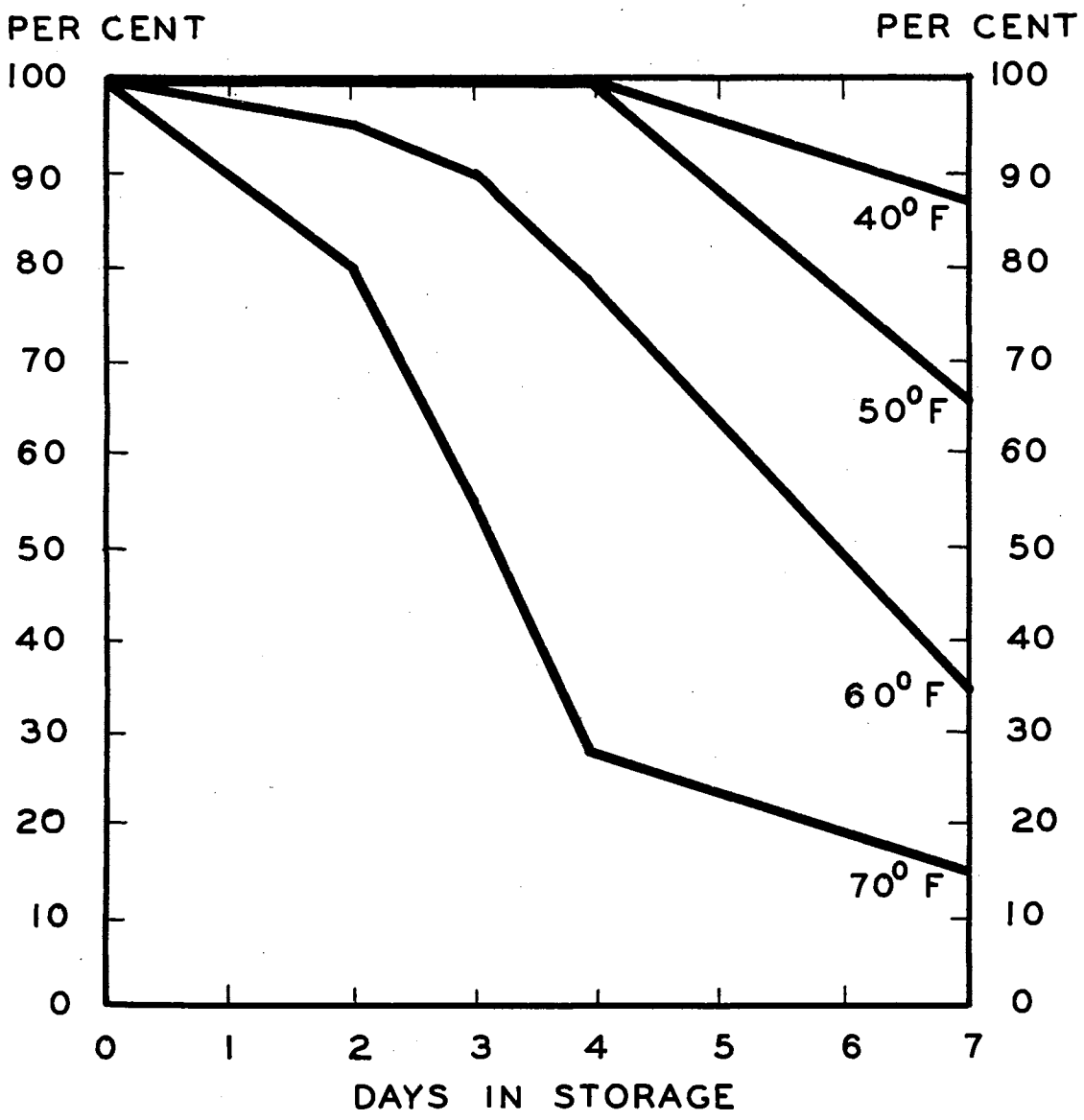


FIGURE 7. PER CENT OF C GRADE CREAM RESULTING AFTER 2, 3, 4, AND 7 DAYS OF STORAGE AT 40°, 50°, 60°, AND 70° F.

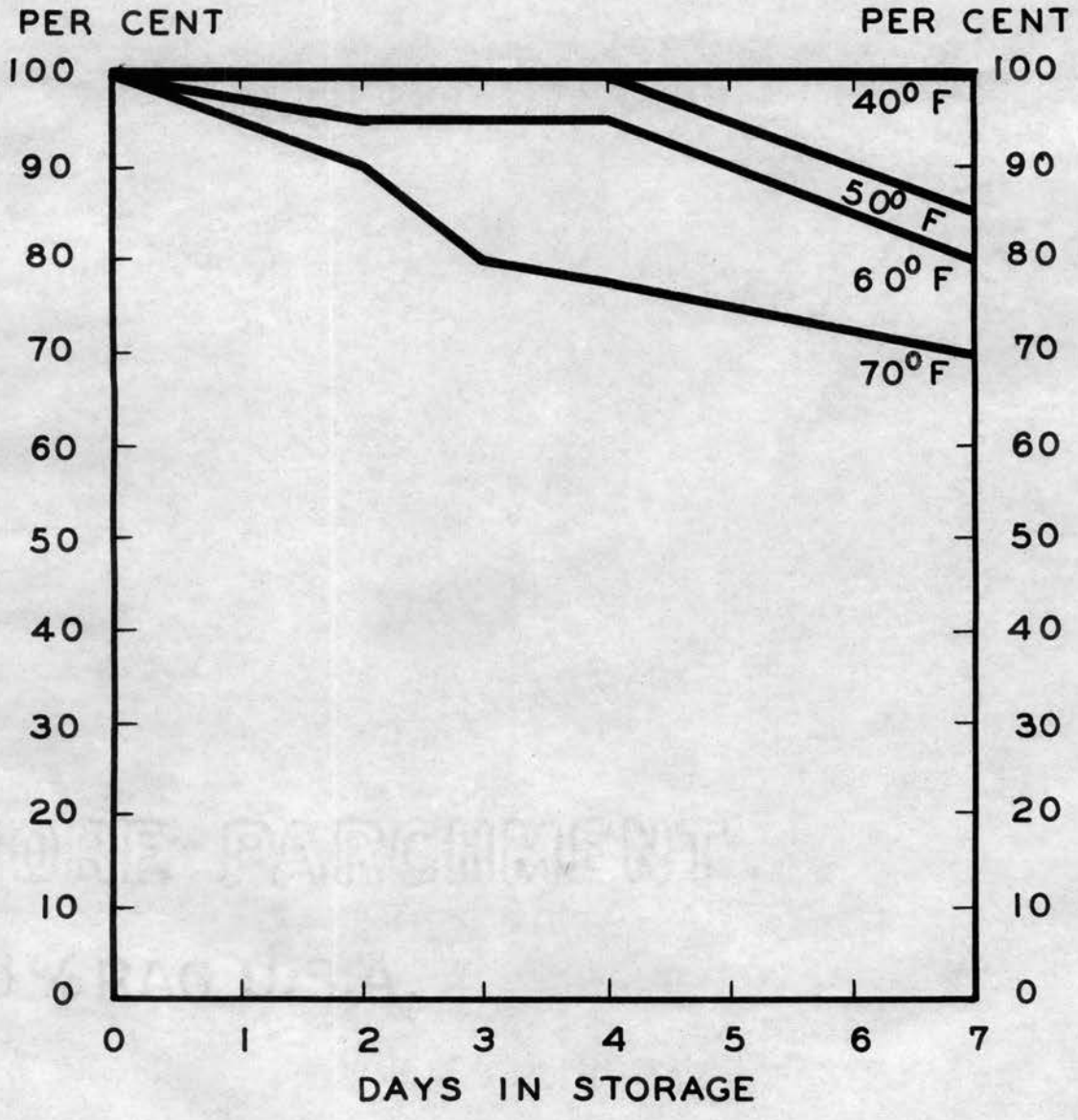


Figure 4 presents the percent of AA grade cream from which a 93 score butter could be made. It may be observed that as the temperature and time of storage increased, the percent of AA grade decreased. At 40° F. and 50° F. at least 60% of the cream samples would produce a 93 score butter after 3 days of storage; at 60° F. no samples graded AA after 3 days of storage; at 70° F. all the samples were out of the AA grade after 2 days of storage.

Figure 5 presents the percent of A grade cream from which a 92 score butter could be made. It may be observed that 65% of the 78 samples would produce a 92 score butter after 7 days of storage at 40° F.; at 50° F. only 56% would produce a 92 score butter after 4 days of storage; at 60° F. and 70° F. none of the samples graded A after 3 days of storage.

Figure 6 presents the percent of B grade cream from which a 90 score butter could be made. It may be observed that the entire lot of 78 samples would produce a 90 score butter after 4 days of storage at 40° F. or 50° F.; at 60° F., 78%, and at 70° F. only 28% of the 78 samples would produce a 90 score butter after 4 days of storage.

Figure 7 presents the percent of C grade cream from which an 88 score butter could be produced. At 40° F. all the samples would produce an 88 score butter after 7 days of storage; at 50° F., 85%; at 60° F., 80%; and at 70° F., 70% of the cream samples would produce an 88 score butter. However, all producers should prevent any of this grade of cream from being delivered to the cream station or creamery, thus eliminating from the market, butter scoring below 90.

CONCLUSIONS

1. Seventy-eight percent of all cream samples studied when cooled and stored at 60° F. would have produced a 90 score butter at the end of four days of storage.

2. Only about twenty-eight percent of the samples held at 70° F. for four days would yield a 90 score butter.

3. The prevention of foreign material and objectionable off-flavors from contaminating the cream is more important in the production of high quality cream than are low temperatures in retarding acid production.

4. Temperature of 40° F. had the greatest retarding effect on acid production.

5. Acid production was more uniform at 40° F. and 50° F. than at 60° F. and 70° F.

6. All the samples of both lots of cream stored at 40° F. and 50° F. would produce a 90 score butter after four days of storage.

7. Off-flavors developed more frequently at high temperatures than at low temperatures.

8. Streptococcus lactis growth was less effected by low temperatures than was the growth of non-souring types of organisms by the presence of the acid producers.

9. Practically no correlation existed between quality of cream and bacteria counts.

10. Bacteria counts cannot be used as a sole criterion by which quality of cream can be judged.

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