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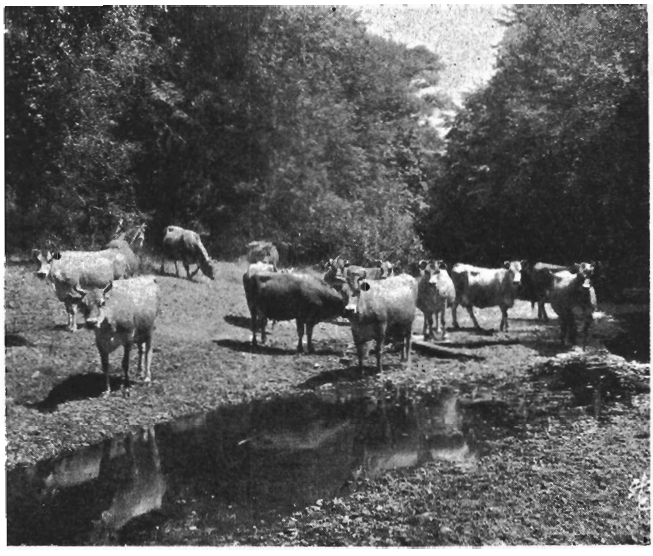
Cream Refrigeration on the Farm and the Quality of Butter Manufactured



Agricultural Experiment Station
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SUMMARY

1. The purpose of the experiment was to study various methods of cooling and storage of cream on the farm including mechanical refrigeration and to determine the quality of butter that could be made from cream when held on the farm by the method that proved most satisfactory when the cream was shipped to the creamery twice weekly.

2. Cream cooled and held in a tank filled with water at 60° F., the water being changed twice daily, remained sweet for 18 hours but was sour on the second day (42 hours) with an acidity of .4 to .5 percent.

3. Cream cooled in the same way except that the tank was filled with water at 50° F. was on the dividing line between sweet and sour cream on the second day (42 hours) with an acidity of .20 percent and sour with an acidity of .41 percent on the third day (66 hours).

4. Cream held in an ordinary ice refrigerator at 45° F. cooled more slowly than when held in a tank of water at 50° F. for the first 7 hours. It had an acidity of .19 percent on the second day (42 hours) and an acidity of .23 percent on the third day (66 hours).

5. Cream cooled in an electric refrigerator having dry storage remained sweet for twice-weekly shipments both with natural air circulation and with forced air circulation.

6. Cream cooled in refrigerated water at a temperature of 35° to 40° F. dropped from 80° to 56° F. in one hour and remained sweet and of good quality for four days (90 hours).

7. Cream held in refrigerated water for 6, 12, 18, 42, 66, and 90 hours and then graded by experienced judges showed no apparent tendency to develop objectionable qualities with increased length of storage period.

8. Refrigerated cream was received at the Oregon State Agricultural College Creamery from three farms for a period of 12 consecutive months, to be used for the manufacture of butter. From the total of 47,634 pounds of cream received, 17,684 pounds of butter were manufactured in 93 churnings.

9. The farms were located at distances of 5, 20 and 30 miles from Corvallis. Tank-type refrigerators with water at a temperature of from 35° to 40° F. were used. The cream was shipped to the creamery from each farm twice weekly.

10. The cost of the electric refrigerators used in the experiment was approximately $500 each. Two of the refrigerators provided for cream refrigeration only and one provided for both cream and household refrigeration in separate compartments.

11. The average daily power consumption to operate the electric refrigeration was 2.0 to 2.8 Kwh. The engine-operated refrigerator consumed 0.3 gallon of gasoline per day.

12. The cost of refrigeration including interest and depreciation allowance of 15 percent on a $500 investment was from 1.3 to 4.4¢ per pound of butter-fat.

13. The daily butter-fat production was the major factor causing variation in the cost of refrigeration per pound of butter-fat on the three farms.

14. The premium of 3¢ per pound of butter-fat produced a profit above the cost of refrigeration on the two farms producing 11 and 20 pounds of butter-fat per day, respectively, but did not produce a profit on the third farm having a daily production of 6.5 pounds of butter-fat per day.

15. The flavor of the cream when received was always excellent, with the exception of a few lots that had feed flavor.

16. The average monthly temperature at which the cream was received ranged from 44° to 50° F. during the colder months and from 51° to 57° F. during the warmer months. The average temperature of the cream for the year was 50.2° F.

17. The majority of the shipments of cream contained from 0.12 to 0.14 percent acid calculated as lactic. Only in one instance did the acidity exceed 0.2 percent.

18. Determinations of the number of bacteria present in the cream when received at the creamery were made. A few lots of cream contained comparatively large numbers of bacteria, but it was never possible to detect any undesirable flavors either in the cream or in the butter manufactured from it that could be associated with the growth of the organisms.

19. The scores of the fresh butter made both with and without starter ranged from 90.5 to 95 and averaged 92.62. Of the scores 83 percent were 92 and above.

20. The scores of the butter after it had been held for one month at from 35° to 45° F. ranged from 89 to 94 and averaged 91.9. The average decrease in score during the holding period was 0.72 point.

21. The scores of the butter after being held for six months at from zero to 10° F. ranged from 89.66 to 94, with an average score of 92.11. The average decrease during holding was 0.51 point.

22. The average score of the butter made during January was 91.7 and the average monthly scores of the butter made during the period February to December inclusive ranged from 92.3 to 93.2. Several of the lots of butter made during January were criticized for feed flavor. It is significant that the average scores of the butter made during the five warmest months were uniformly high, ranging from 92.4 to 93.2.

23. Of the 93 churnings, starter was used with 59 and no starter was used with 34. The butter made with starter scored 1.07 points higher when fresh, 0.47 point higher after one month, and 0.77 point higher after six months than the butter made without starter. There was a larger percentage of samples that scored 92 and above after each holding period of the butter made with starter than of the butter made without starter.

24. The average score of the fresh butter when starter was used was 93, the scores ranging from 90.5 to 95.0. Of the scores 93.23 percent were 92 and above. The average score of the butter after a one-month holding period at from 35° to 45° F. was 92. After a six-month holding period at from zero to 10° F. it was 92.4.

Cream Refrigeration on the Farm and the Quality of Butter Manufactured*

By

F. E. PRICE, C. J. HURD, and G. H. WILSTER

PURPOSE OF THE EXPERIMENT

CREAM refrigeration on the farm, as an important aid in maintaining cream quality, is of vital interest to dairy producer and manufacturer alike. If the producer, through refrigeration on his dairy farm, can supply cream of quality better than he now supplies to be made into butter, he can expect to receive a better price. The creamery can pay a better price because with improved cream it can manufacture butter of higher quality that will sell for a better price.

On account of the low production of cream on many Oregon farms and high transportation cost, farmers have difficulty in getting their cream to the creameries in such condition that it will lend itself to the production of the highest-quality butter. Oftentimes the cream is held on the farm until a sufficient quantity has been collected so that it can be shipped economically. Under average conditions on the farm, the cream is held at temperatures favorable for the development of micro-organisms. As a result the cream very often arrives at the creamery sour, yeasty, and with undesirable flavors developed in it. Only butter of mediocre quality can be produced from such cream.

The purpose of the first part of this experiment was to study various methods of cream cooling and storage on the farm in order to determine the quality of the cream that could be maintained by the respective methods for twice-weekly shipment to a creamery, particularly as they related to butter quality.

The purpose of the second part of this experiment was to study the quality of butter that could be made from cream cooled and held on farms for twice-weekly shipment by the method that proved most satisfactory in the first part of the experiment.

Increased returns to dairyman and creameryman being the object of cream refrigeration on the farm, an investigation was made of the economic importance of quality butter. The results of this study, together with a resumé of previous work bearing on cream refrigeration, are summarized before presenting the results of the main studies.

*The experiment herein reported was conducted cooperatively by the departments of Agricultural Engineering and Dairy Husbandry. Mr. L. D. Searing, graduate assistant in Dairy Husbandry, manufactured the butter during the entire experiment.

ECONOMIC IMPORTANCE OF QUALITY BUTTER

A previous report* by the Oregon Agricultural Experiment Station called attention to the need for a study of methods for improving the quality of cream delivered to the creameries for manufacture into butter. It had been found that a large number of creameries were receiving cream that was sour when it arrived. The study showed that it was not possible to manufacture butter scoring uniformly 92 to 93 except from sweet cream free from undesirable flavors. It was therefore stated that under the usual conditions of storage on the farm, cream should be delivered with greater frequency and should be protected during transit.

The Department of Dairy Husbandry has conducted monthly butter scorings during the past three years, for which the majority of the creameries in the state have sent samples of butter representative of their first-grade churnings. During the three years, the results of these butter scorings have clearly indicated† that there is a need for improvement of the butter made in Oregon. Of 435 samples of butter examined during the first year of the scorings (1929-30), 59.1 percent scored below 91. Of 487 samples examined during the third year of the scorings (1931-32), 60.57 percent scored below 91. During the third year of the scorings a higher percentage of butter has scored 92 or above than during the first year, but the percentage scoring below 91 has shown no material change. Practically all of the butter scoring below 91 was made from sour cream that had been neutralized before pasteurization. Since approximately 60 percent of the butter examined during each of the three years has scored below 91, it is apparent that there has been no improvement in quality in the case of more than half the cream delivered to the creameries, and that the plants making butter from this quality of cream have not been able to increase the score of the butter.

The demand for high-grade butter is increasing. Several of the largest retail butter distributors that formerly sold butter chiefly of a medium or low grade are now featuring butter scoring "extra" or higher. Consumers are apparently becoming discriminating. Demand for higher-grade butter is reflected also in the market quotations for the various grades of butter. According to the United States Department of Agriculture, the difference between the average yearly wholesale prices on the San Francisco market for butter of 92 and 90 score, ranged for the six years 1926-1931 from 1.54¢ to 3.04¢. The average difference for the six years was 2.23¢. This means 2.77¢ per pound butter-fat. The San Francisco office of the Bureau of Agricultural Economics, U. S. Department of Agriculture, reports‡ that sales of butter of 88 and 89 score are not sufficient in the San Francisco territory to warrant keeping records of the prices paid.

The difference between the wholesale price of butter of 92 score and of 90 score at the present time (early June 1932) is only from 1.5¢ to 2¢ per pound. This is equivalent to from 1.86¢ to 2.48¢ per pound of butter-fat. On a percentage basis, it will be found that when the price of 90-score

*Larrabee, E. S., and Wilster, G. H. 1929, *The Butter Industry of Oregon.* Oregon Agr. Expt. Sta. Bul. 258.

†Wilster, G. H. 1929-32. Yearly Reports of Monthly Butter Scorings and Analyses Conducted by Department of Dairy Husbandry, Oregon State Agricultural College.

‡McCampbell, F. H. 1932. Personal communication to the authors.

butter is 16¢ and that of 92-score butter is 17.5¢ or 18¢, the 92-score butter sells at a price 9.4 or 12.5 percent greater, respectively, than the low-scoring butter; whereas when the prices of 90-score and 92-score butter are 38.62¢ and 40.85¢ respectively (the averages for the years 1926-1931 inclusive), the 92-score butter sells at a price 5.77 percent greater than the lower-scoring butter. This emphasizes the advantage of producing the highest-grade butter even when prices are low. The difference in price between various grades of butter justifies paying a differential in the price for the different grades of cream.

Butter manufactured by the best methods from sweet cream of good flavor should score at least 92. High-acid, yeasty, or otherwise badly fermented cream usually results in butter scoring 88 to 89.

Oregon ships most of its surplus butter to California. At present approximately 6,000,000 pounds are sold yearly by the Oregon creameries on the California market. If this butter all scores 92 or higher, on the basis of the foregoing difference between 90 and 92 score butter, using the average for the six years of 2.23¢, $133,800.00 more will be realized for the butter than if it scores only 90. Undoubtedly a large percentage of this butter does score 92 or higher, and is sold at the top price. But this serves to illustrate the advantage of producing only butter of the highest grade.

A large amount of cream received at the Oregon creameries comes from small- or medium-sized dairy herds. Very often it is not possible or economical, because of high transportation costs, to get the cream to the creamery oftener than once or twice weekly. As most of the farms do not have facilities for properly cooling and storing cream, holding it for long periods of time on the farm usually causes a lowering of the quality of the cream. This may result in a reduction in the price which the producer is receiving for the cream especially when it is sold to a creamery which pays a premium for the higher-grade cream. In order to maintain high quality, it is necessary either (1) to make frequent deliveries, such as daily or every other day, coupled, of course, with the observation of proper sanitary methods of production and the protection of cream during transit, or (2) to use improved methods of cooling and storing on the farm. When cream is kept on the farm for several days at temperatures favorable for the development of bacteria, yeasts, and molds, serious deterioration in the quality of the cream may take place through the development of acidity and undesirable flavors and odors. If, on the other hand, the temperature of the cream is low enough to prevent the development of micro-organisms, it should be possible to hold the cream on the farms for from 3 to 4 days without any significant decrease in the quality.

RESUMÉ OF PREVIOUS WORK

Available data are very limited on the effect of cooling cream by means of water on the quality of the butter obtained. Data are entirely lacking on the effect of refrigeration of cream on the farm on the quality of the butter obtained.

Hunziker, Mills, and Switzer* in 1916 studied the effect of cooling cream by means of running water as shown in the quality of the resulting butter. Cream produced on 40 farms near Purdue University was used. One-half of the producers held the cream on the farm in cooling tanks with water at temperatures ranging from 54° to 68° F., and averaging 58.8° F., while the other half held the cream under atmospheric temperature conditions with a temperature ranging from 42° to 87° F. and a mean daily temperature ranging from 56° to 75° F. The cream was gathered by the creamery trucks twice weekly. The tank cream had an average acidity during the experiment of .38 percent, and the no-tank cream had an acidity of .52 percent. The tank cream contained an average of 147,125,000 bacteria per c.c. when delivered to the creamery, and the no-tank cream contained 226,750,000 bacteria per c.c. The average score of the butter made from the tank-cooled cream was 90.69, and that of the butter made from the no-tank cream was 88.36. There was a difference of 1¢ a pound in the price obtained for the two grades of butter. The investigators state: "The quality of the butter on the market depends more on the quality of the cream from which it is made than on any other condition incident to production, manufacture, and transportation of the butter. In order that the cream may arrive at the creamery in good condition, it must be cooled promptly and be kept cool until it leaves the farm."

Martin and Caulfield† in discussing the problem of butter improvement in Kansas concluded that through the use of mechanical refrigeration, new information on starters, neutralization and churning, together with other scientific knowledge, the butter industry has been developed to a point where further progress is going to be very slow unless there is an improvement in the quality of the cream delivered to the creamery. They are of the opinion that the task of producing high-quality cream is neither difficult nor time consuming. They are of the opinion that the time is not far distant when mechanical refrigeration will be used extensively for cooling and storing cream on the farm . They point out that premiums of from 3¢ to 10¢ per pound of fat above the price for fat in sour cream are being paid for fat in sweet cream.

Manhart‡ is of the opinion that the quality of American butter cannot be improved very much, if any, unless the quality of the raw material, cream, is improved. This improvement must be accomplished by the cream producers.

Barr§ of the Department of Agriculture, Ottawa, Canada, made a study of different methods of cooling and storing cream on the farm. He states that much of the cream sent to creameries is kept in cellars. In his experiment it was found that it was not possible to keep cream sweet for 36 hours, or for delivery every other day, in cellars as cool as the ordinary run of farmhouse cellars. When the cream was left uncovered it developed a strong cellar flavor, and the butter had a tendency to become rancid.

*Hunziker, O. F., Mills, H. C., and Switzer, H. B. 1916. *Cooling Cream on the Farm*, Indiana Agr. Expt. Sta. Bul. 188.

†Martin, W. H., and Caulfield, W. J. 1929. *Producing Quality Cream*, Kansas Agr. Expt. Sta. Cir. 154.

‡Manhart, V. C. 1923. *Better Cream for Buttermaking.* Indiana Agr. Expt. Sta. Cir. 113.

§Barr, Geo. H. 1931. *The Care of Cream for Buttermaking.* Department of Agriculture, Ottawa, Canada. Pamphlet No. 37—New Series.

With an average cellar temperature of 63.5° F., the acidity of the cream at the end of 36 hours was 0.47 percent, at the end of 60 hours it was 0.50 percent, and at the end of 72 hours it was 0.52 percent. When the cream was placed in insulated tanks containing ice-water, the acidity at the end of 36 hours was 0.157 percent and at the end of 60 hours it was 0.165 percent.

Gamble* of the United States Department of Agriculture states that dairymen lose thousands of dollars annually because of poorly cooled milk and cream. These losses occur, he states, because the milk or cream is returned by dealers to the farmers and because of low-grade manufactured products which bring low prices. He states that 80 percent of all the milk and cream sold from farms in the United States is produced in sections where natural ice can be had for the harvesting. Of Oregon only the far eastern part is included in the sections where natural ice can be obtained.

FACTORS INFLUENCING BUTTER QUALITY

The factors influencing butter quality may be grouped as follows:

A. Health of the cows and stage of lactation.
B. The feed of the cows and the time of feeding.
C. Weeds eaten by the cows.
D. Sanitation on the dairy farm (condition of the cows, buildings, utensils, and the milker).
E. Methods of cooling, storing, and transporting the milk or cream.
F. Kinds of containers and condition of the containers used for the milk or cream.
G. Age of the cream when used for butter.
H. Method of butter manufacture in the creamery.
I. Sanitary condition in the creamery.
J. Kind and condition of buttermaking equipment.

Defects in the quality of butter may arise from a lack of observance of the proper methods of producing and handling the milk or cream. Very frequently butter is criticized for having a feed or weed flavor, old-cream flavor, or other undesirable flavor resulting from improper handling of the cream on the farm. If the cows are fed strong-smelling succulent feeds or if they eat weeds shortly before milking, the milk will become tainted. Milk very readily absorbs barn odors such as from old manure, decomposed feeds, strong-smelling feeds, fly spray, etc.

The taints cannot be removed from the cream by the ordinary processes used in butter manufacture. If cream grading is not practiced at the creamery, a can of tainted cream added to a vat of cream of good flavor will cause the whole churning of butter to become tainted.

If cream, even though produced under good conditions, is held on the farm for several days at temperatures favorable for the growth of microorganisms, a sour, yeasty, vinegar or other undesirable flavor may develop. Only butter of a grade lower than "extra" can be made from such cream.

*Gamble, J. A. 1927. *Cooling Milk and Cream on the Farm.* U. S. Dept. of Agric. Farmers' Bulletin No. 976.

If in addition to holding the cream at temperatures favorable for the growth of micro-organisms, the cream is produced under unsanitary conditions such as when the cows are dirty, the milkers' hands unwashed, and the dairy utensils not washed and sterilized after use, the cream will become seeded with countless micro-organisms that will ferment some of the constituents of the cream with the production of a very undesirable flavor.

It is already commonly known among dairymen that if the feeding of the cows is properly managed, the milking and separating done in accordance with accepted sanitary standards, and the cream placed in a good container and cooled quickly, a high-grade product can be obtained. It is also known that unless very cold water is available or ice is used, the cream will become sour in a day or two, even when it is produced under satisfactory conditions for producing cream of a good flavor and of a low microbial content.

EXPERIMENTS WITH VARIOUS METHODS OF CREAM COOLING

Method of conducting the cream-cooling experiment. The cream used for the cooling and storage experiment was purchased from two farms having eight cows each, located near the State College. The average production for the 16 cows during the experiments was 14 pounds of butterfat per day. The cream was separated on the farms immediately after milking and was delivered to the laboratory within one hour. The cream was approximately 80° F. when it arrived at the College. The room in which the various refrigerators and cooling tanks were placed was held at 80° F. during the day and allowed to cool at night.

Approximately three gallons of cream were obtained from the two farms both evening and morning. The cream from the two farms was poured into one 5-gallon can for cooling for the first 12 hours, after which the cream from two milkings was poured together into one can and the surplus excluded from the test.

The maximum time which cream was regularly held with the various methods of storage was 90 hours. This provided for the oldest cream when shipping to the creamery twice weekly. When the cans of cream were removed from their respective places of storage they were held for four hours in the 80° F. room in order to allow for the average time cream would ordinarily be in transit from the farm to the creamery. All data referring to time of storage of the cream include this four-hour period.

The quality of the fresh cream and the conditions under which it was produced were representative of careful cream producers.

The measures of quality used included (1) a determination of the acidity of the cream expressed in percentage of lactic acid, (2) grading of the cream by competent judges, and (3) a determination of the numbers of bacteria present in the cream when fresh and at the end of each storage period.

Cooling and storage methods studied. Six different methods or conditions of cooling and holding cream were studied in order to determine

the effectiveness of each in maintaining cream quality for twice-weekly shipment to a creamery for buttermaking. These were as follows:

1. Cooling and storage in a tank filled with water at 60° F. changed morning and evening.

2. Cooling and storage in a tank filled with water at 50° F. changed morning and evening.

3. Cooling and storage in an ice refrigerator (dry storage).

4. Cooling and storage in an electric refrigerator (dry storage).

5. Cooling and storage in an electric refrigerator (dry storage) using an electric fan for rapid circulation of the air around the cans.

6. Cooling and storage in a tank-type electric refrigerator (wet method).

The water-tank method of cooling and storing the cream was included in the experiment because it appeared to be the simplest and least expensive method. The several methods and the results obtained are discussed in turn.

Cream cooled and stored in a tank filled with water at 60° F. changed morning and evening. The rate of cooling is shown graphically in Figure 1 by curve C. The cream cooled to 68° F. in one hour and to 63° F. in two hours and remained below 65° F. during the 12 hours, after which the tank was refilled with water 60° F. in temperature.

The cream from the evening milkings remained sweet when held overnight in the tank of 60° F. water and was taken from the tank and placed in the 80° F. room for four hours to represent the probable summer conditions of transporting to the creamery. When held at this temperature it was sour on the second day (42 hours) with an acidity of 0.4 to 0.5 percent. When the cream was held to be shipped on the fourth day (90 hours) it reached an acidity of 0.77 percent. This demonstrated that much of the cream held on a farm in the warm season by this method for twice-weekly shipment would have a high acidity.

Cream cooled and held in a tank filled with water at 50° F. changed morning and evening. The cream cooled to 65° F. in one hour. In 2½ hours the temperature was reduced to 56° F. and the temperature of the water had increased to 55° F. By the end of the 12-hour storage period in the 80° F. room the water in the tank had increased to a temperature of 60° F. and the cream to 59° F. The cream was not stirred during the first 12 hours. The rate of cooling by this method is shown graphically in Figure 1, curve D.

The acidity of the cream after 18 hours was practically the same as when it was received from the farm. On the second day, which completed a 42-hour storage period, the acidity was 0.20 percent, which is on the dividing line between sweet and sour cream. The percentage of acid on the third day, which was 66 hours of storage, was 0.41. On the fourth day, which was 90 hours of storage, it was 0.62 percent.

These tests showed that when cream was held in a tank of water at 50° F. with the water changed morning and evening all of the cream could be kept sweet for delivery every second day.

Cream held in a refrigerator cooled with ice, average temperature 45° F.—dry storage. The rate of cooling of the cream in the ice refrigerator was very slow as is shown in Figure 1 by curve E. It required 7 hours for the cream to cool from 80° F. to 56° F. by this method, whereas it took less than 3 hours to cool it to the same temperature in the tank of 50° F. water. The cream was cooled to 50° F. in 12 hours in the refrigerator cooled with ice and remained below 50° F. during the storage period.

The cream cooled and held by this method had an acidity on the second day (42 hours) of 0.19 percent. On the third day (66 hours) it had an acidity of 0.23 percent, which is slightly sour to the taste. Cream held four days (90 hours) by this method had an acidity ranging from 0.42 to 0.51 percent.

Cream held in an electric refrigerator—dry storage. The daily range in the temperature of the refrigerator was 28° to 40° F. with an average of 34° F. The rate of cooling of the cream by this method was only slightly faster than in the ice-box as shown in Figure 1 by curve F. Nine hours were required to cool the cream to 50° F., twelve hours to cool it to 40° F., and 48 hours to cool it to 35° F. The cream was not stirred during the first twelve hours.

The cause of the slow cooling was apparently the warm-air blanket around the can and not a low heat conductivity of the cream to the side of the can. Thermo-couples were placed ¼ inch from the outside of the cream can and temperatures were recorded while cooling the cream from 80° F. in a refrigerator with an average air temperature of 34° F. This test showed that the temperature ¼ inch from the can was 14° to 20° F. higher than the refrigerator temperature. In another test a fan was used to keep the cold air of the refrigerator circulating around the can of cream in order to study the temperature differential in the cream at the center and near the side of the can. The temperature differential in the cream was found to be only 3° to 6° F. while cooling from 80° F. These tests led to the study of cream cooling in a refrigerator with forced air circulation.

Cream held in a refrigerator cooled by electric refrigeration—air circulated by a fan. This storage test was the same as the preceding one except than an eight-inch electric fan was used to circulate the air around the can of warm cream when it was placed in the refrigerator and the temperature of the refrigerator was from 30° to 35° F. The fan was set to operate for three hours after each can of cream was placed in the box and was stopped by an automatic switch. By this method the cream was cooled much more rapidly than by any of the previous methods. Cream at a temperature of 80° F. cooled to 50° F. in one and one-half hours. See Figure 2, curve A. This demonstrated that rapid cooling could be accomplished in dry cold-storage by circulating the air. The cream did not increase in acidity when held 90 hours by this method.

The temperature of the cream was held at approximately 32° F. after the first 24 hours of each storage period.

Cream held in a tank of water maintained at a temperature of 35° to 40° F. by electric refrigeration. The rate of cooling the cream by this method was practically identical to the cooling in dry storage with circulated air. The cream was cooled from 80° F. to 56° F. in one hour and to 37° F. in four hours by this method. See Figure 2, curve B.

When cooled and held by this method, the cream remained sweet with an acidity of 0.16 and maintained a good flavor for 90 hours. The numbers of bacteria present in each lot of cream showed consistent increase. The bacterial counts of the fresh cream ranged from 1,000 to 36,000 bacteria per c.c., while those of the 90-hour-old cream ranged from 70,000 to 1,500,000 bacteria per c.c.

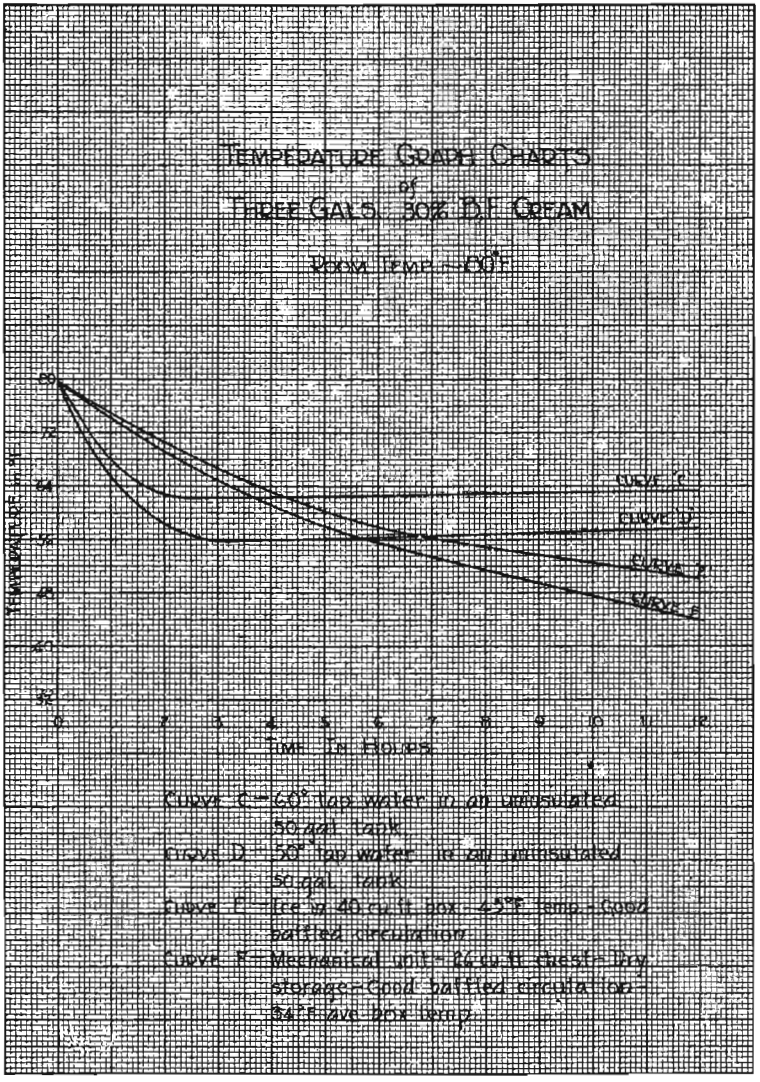

Figure 1. Curves showing the rate of cooling of cream by different methods in five-gallon cans.

Grading of refrigerated cream. Since there was an increase in the numbers of bacteria present in the cream when held in refrigerated water for shipment twice weekly (66 or 90 hours) a special series of tests was conducted to determine whether or not experienced judges of cream could distinguish between the flavor and odor of cream that was only a few hours old and the flavor and odor of the cream cooled to a temperature of from 35° to 40° F. and held at this temperature for one to four days. Samples were taken from the cans of cream that had been held in refrigerated water for 6, 18, 42, 66, and 90 hours respectively, and these samples were graded by a representative of the United States Department of Agriculture and a member of the Dairy department of the State College. The samples were numbered and the judges did not know the age of the samples. The judges established grades A, B, C, and D, which are described in Table I.

The results of grading 115 samples of cream from the five storage periods of from six hours to four days are given in Table I.

TABLE I. GRADING OF REFRIGERATED CREAM

Cream cooled and held in refrigerated water at a temperature of 35° to 40° F.

Hours in storage	Frequency of the cream samples in four grades*				Number of samples
	Grade A	Grade B	Grade C	Grade D	
6	14	6	2	1	23
18	10	10	3	0	23
42	14	6	3	0	23
66	18	5	0	0	23
90	12	6	4	1	23

*Grade A. Sweet, no undesirable flavor.
Grade B. Sweet but lacking delicate flavor.
Grade C. Sweet but slightly off flavor.
Grade D. Sweet but stale or undesirable flavor.

Approximately the same number of samples of cream from the various periods of storage from 6 to 90 hours were placed in the two highest grades. This test showed that it was impossible to distinguish consistently between the flavor and odor of the cream that was six hours old and of cream that had been held in the refrigerator for from one to four days.

EXPERIMENTAL RESULTS OF THE MANUFACTURE OF BUTTER FROM REFRIGERATED CREAM

One of the purposes of the cream-refrigeration project was to determine the relation of the quality of the cream to the score of the butter that could be made from it. It was therefore necessary to obtain a sufficient supply of cream which would be held on the farm where it was produced for twice-weekly shipment to the college creamery for the manufacture of butter.

Selecting and equipping farms to supply refrigerated cream for buttermaking. In order to use the commercial-size pasteurizer and churn regularly operated in the college creamery, at least 400 pounds of cream was necessary for each churning. The cream production of three farms having from 10 to 20 cows each was secured for the buttermaking experiment. Each of the three farms was equipped with tank-type dairy refrigerators to

cool and hold the cream for shipment to the college creamery twice weekly, this type of equipment having shown very satisfactory results in the study of various methods of cream cooling. The cream was shipped from each of the farms on the same day. An average of 500 pounds of cream was received at the college creamery for each churning.

FARM No. 1 was located approximately 30 miles from the College and shipped 450 to 550 pounds of cream per week which ranged in percentage of fat from 28 to 35, the average being 32.7. The dairy refrigerator shown in Figure 3 was installed on this farm. It had a ½ horse-power motor and compressor and had a liberal amount of room for 4 ten-gallon cream cans. The refrigeration unit kept the water in which the cans of cream were placed at from 35° to 40° F. The cost of this equipment was $600.00. The refrigeration capacity of this unit was greater than was required, but a smaller unit was not available.

FARM No. 2 was located approximately five miles from the College and shipped 250 pounds of cream per week which ranged in percentage of fat from 24 to 38, the average being 29.5.

This farm did not have electric power to operate the ½ horse-power electric motor with which the refrigeration unit was equipped. In order to serve this farm with mechanical refrigeration the electric motor which operated the refrigerator compressor was removed and a countershaft was installed in its place. The V-belt pulley and fan propellor were removed from the motor and installed on the countershaft to serve in the same way as when they were on the electric motor. The countershaft was driven by a flat belt from a 1½ horse-power gasoline engine. This arrangement required that the engine be started manually and it was stopped by a special short-circuiting switch connected to the engine ignition system and operated by the pressure-vacuum switch which was standard equipment of the electric refrigerator.

The refrigerator box was of the top-opening tank type of 4 ten-gallon-can capacity with a 20-gallon brine tank in the center, in which the refrigeration coil was installed.

A preliminary test of this refrigeration equipment was made in the laboratory in which a five-gallon can filled with water at a temperature of 90° to 95° F. was cooled in the evening and in the morning for five days to represent the approximate equivalent of cooling five gallons of cream twice daily. Twenty gallons of brine of a specific gravity of 1.200 were required to fill the brine tank. Seventy-six gallons of water were put into the cream cooling compartment, bringing the height of the water level to 12½ inches with no cream cans in the refrigerator.

A total of 45 gallons of water was cooled from 95° to 37° F. in cream cans.

The results of the five-day test were as follows:

The engine operated approximately 27 hours or 5½ hours per day.

3.5 gallons of gasoline were used or approximately 1 pint per hour.

The maximum temperature of the tank water was 46° F. and the minimum was 35° F.

The range in the room temperature was from 60° to 85° F.

The compressor was set at 7 inches of vacuum and 8 pounds pressure.

It was found from this test that two operating periods per day for the compressor were sufficient to keep the refrigerator water below 40° F. It was concluded that the most satisfactory and convenient time to start the engine was at the time the cream was placed in the refrigerator.

It was also found that a tank-type dairy refrigerator with 20 gallons of brine and with 12 to 18 inches of water in the tank had sufficiently high thermal conductivity to cool the water in the tank to 35° F. before the compressor built up a high vacuum and was stopped by the automatic switch.

FARM No. 3 was located approximately 20 miles from the College and shipped 135 pounds of cream per week which ranged in percentage of butter-fat from 26 to 35, the average being 30.5.

The special combination dairy and household refrigerator box used on this farm, shown in Figure 4, was designed by the Agricultural Engineering department of the Experiment Station.

The refrigerator compressor was operated by a ½ horse-power electric motor. The refrigerator provided for cream cooling and storage in the tank compartment and for household use on the dry-storage side. Both compartments were cooled by conduction from the walls of a 30-gallon brine tank located between the two compartments and in which the refrigerator coil was located. The household compartment had a capacity of 12 cubic feet. The cream cooling compartment held 2 ten-gallon and 2 five-gallon cream cans. The box was constructed of galvanized iron and insulated with three inches of cork. The cost of this box including the adjustable shelves was $190.00. The compressor and motor cost $210.00 and the refrigerator coil $73.00, making a total of $473.00.

This refrigerator was designed for the purpose of serving the dairy farm needs with a combination refrigerator for both cream cooling and food storage at a slight or no additional investment above the cost of an ordinary tank-type dairy refrigerator. Construction details of this refrigerator are shown in Figure 9.

Equipment and methods used during the experiment. The cream was collected by a Southern Pacific train from Farm No. 1 at Derry at 10:13 a.m. and from Farm No. 3 at Independence at 10:30 a.m., every Tuesday and Friday. The cream was unloaded at the station at Corvallis and delivered at 1:00 p.m. to the creamery. The cream from Farm No. 2 was transported by truck directly to the creamery, also arriving at about 1:00 p.m.

On receipt at the creamery, the temperature of each can of cream was recorded. The cream was weighed, samples were taken for butter-fat and acidity tests, and the cream was then dumped into a 200-gallon-capacity coil vat pasteurizer. After thorough mixing, a sample was taken for determination of the bacteria present. In determining the number of bacteria the plate method was used in accordance with the method recommended by the American Public Health Association. The cream was pasteurized by heating it to a temperature of 145° F. and holding it at this temperature with the lids closed for a period of 30 minutes. The cream was then cooled to from 35° to 40° F. except when starter* was used. All cream was held over night to be churned the following morning.

*Details on the use of starter in butter manufacture are given in Station Bulletin 301, *Design of Equipment and Method for Preparing Starter for Oregon Creameries and Cheese Factories.*

Some creameries in Oregon use starter in buttermaking and others do not. It was therefore decided to alternate the two methods of manufacture at intervals of approximately one week. The starter used was made from a mixed culture of lactic acid producing and citric acid fermenting bacteria. The culture was obtained from the Iowa Agricultural Ex-

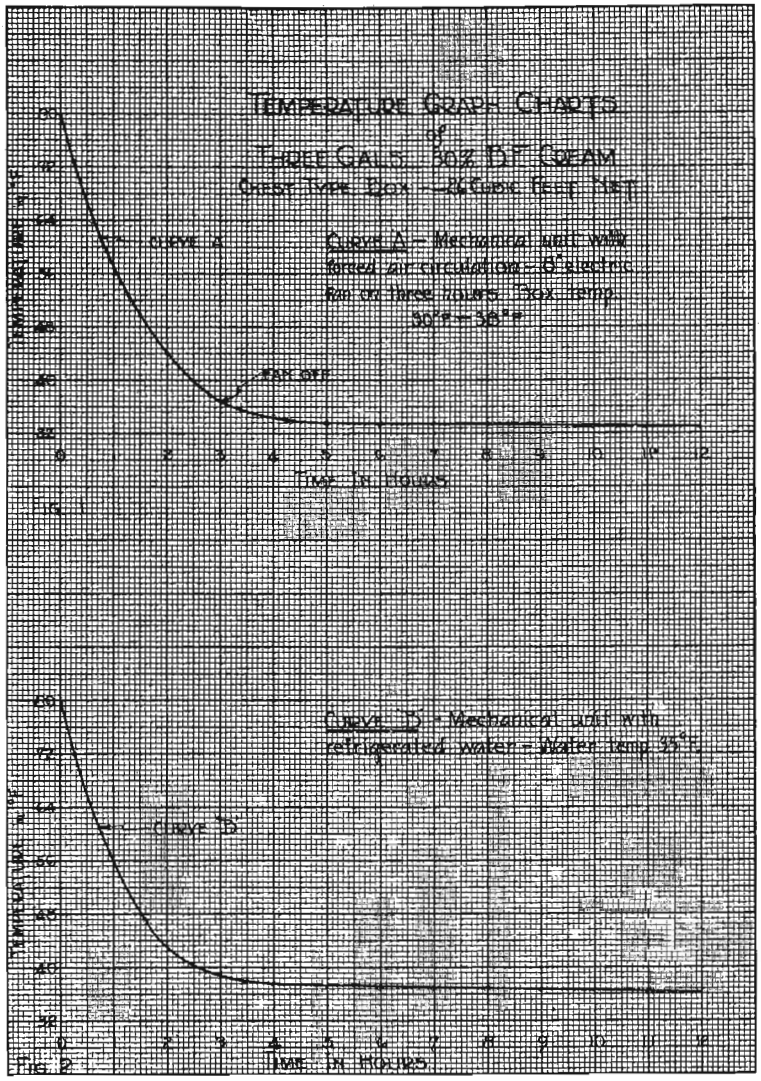

Figure 2. Curves showing rate of cooling of cream in five-gallon cans in two different types of refrigerators.

periment Station. A starter possessing a very desirable flavor and aroma was always obtained with this culture. When making the starter, the most favorable conditions for the development of desirable flavor and aroma in the starter through the action of the micro-organisms were maintained. When starter was used it was added when the cream after pasteurization was slightly above 70° F. When the temperature reached 70° F., further cooling was stopped, the lids of the vat were closed, and the cream left at this temperature until an acidity of from 0.28 to 0.30 percent, calculated as lactic acid, had been developed. The cream was then cooled to a temperature of from 35° to 40° F. and left overnight for churning the following morning.

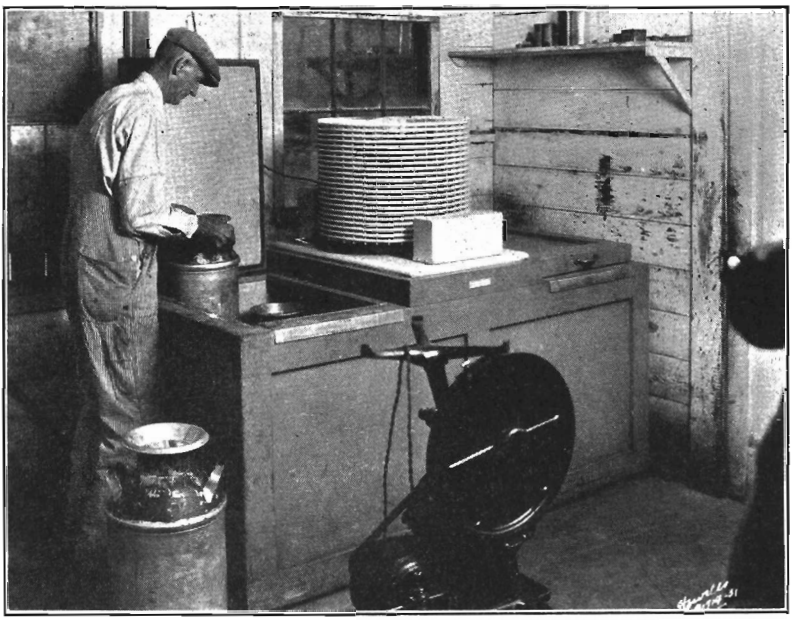

Figure 3. The electric refrigerator used on Farm No. 1.

The churn used during the entire experiment was of 600-pounds-butter capacity. An average of about 500 pounds of cream was used for each churning. Before the cream was transferred from the vat to the churn, care was taken to rinse thoroughly all the equipment, such as the pump, pipes, and churn, first with boiling water and then with cold water so as to eliminate as far as possible any micro-organisms that might have been present on the interior surfaces of the equipment.

It was the purpose during the experiment to make butter of a uniform composition whether ripened or sweet cream was used—the butter to contain 80.5 percent fat, 16.5 percent moisture, 2.2 percent salt, and 0.8 percent curd. The salt used was of the same brand throughout the experiment.

Three representative samples of butter were taken from each churning. These samples were kept at a temperature of from zero to 10° F. until the first subsequent scoring. The scoring was done once a month. One sample was then scored as fresh and the other two samples were placed in rooms kept at from 35° to 45° F. and from zero to 10° F. respectively. The sample kept at the higher temperature was to be scored after a period of one month and that kept at the lower temperature was to be scored after a period of six months. A number was used to designate each sample and the identity and method of manufacture of the butter were unknown to the judges. The judging was done by Mr. R. E. Cavett of the Ideal Dairy Company, Portland; Mr. J. E. Draper of the U. S. Department

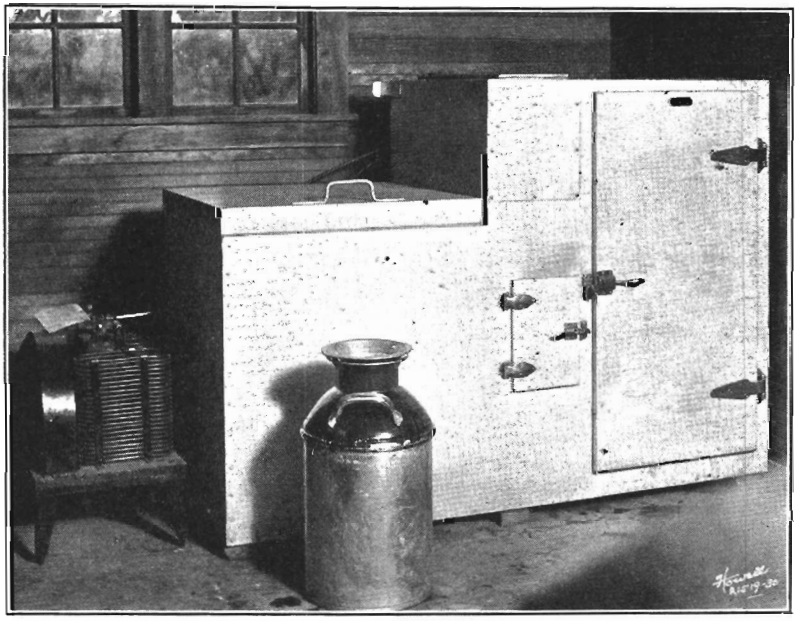

Figure 4. The combination dairy and household electric refrigerator used on Farm No. 3. The cream cooling and storage tank is shown on the left, the small ice making compartment is in the center and the household compartment is on the right.

of Agriculture, Portland; Mr. H. C. Raven of the Raven Dairy Company, Portland; and Mr. L. B. Ziemer, formerly of the State Department of Agriculture, Salem. At least three of these judges were present at each of the scorings. When scoring, each judge reported his score on a card and handed it to the secretary. Whenever there was a disagreement regarding the score, the butter was rescored and an agreement reached.

The cream used for the experiments was produced during a period of 12 consecutive months. From a total of 47,634 pounds of cream received 17,684 pounds of butter were manufactured in 93 churnings.

Cost of cream refrigeration. The refrigeration equipment used on the three farms varied in cost between slightly less than $500 to approximately $600. Because of the short time covered in the experiment, no attempt was made to compare the interest and depreciation cost on the respective farms. A charge of 15 percent has been made on a valuation of $500 for each refrigerator installation to cover interest, depreciation, and repairs. This amounts to $75.00 per year, $6.25 per month, or about 20¢ per day.

Each of the electric refrigerators operated entirely satisfactorily and without repairs. The engine-operated refrigerator which required manual starting gave better service than was expected in the beginning and although not to be compared with the full automatic electric refrigerator, it proved to be practical. Farms using an engine to operate the milking machine and pump water could easily operate these and a refrigerator at the same time.

The kilowatt-hours of electricity and the gasoline consumption of the engine required to operate the refrigerators are given in Tables II, III, IV, and summarized in Table V.

Farm No. 1 produced an average of 20 pounds of butter-fat per day, with an average consumption of 2.0 Kwh. per day. The cost of operation for the 4 ten-gallon-can refrigerator then amounted to 6¢ per day (3¢ per kwh.). Added to interest and depreciation charges of 20¢ per day this makes a total cost of 26¢ per day. The daily premium for sweet cream at 3¢ per pound of butter-fat amounted to 60¢ per day, leaving a profit for refrigeration of 34¢ per day, or $10.20 per month.

The butter-fat production on Farm No. 3 averaged only 6.5 pounds per day, which produced a premium of 19.5¢ per day. The average power consumption per day for a period of one year was 2.8 Kwh. costing 8.4¢ (3¢ per Kwh.), which was greater than on the farm with three times the production. This was due largely to the combination cream and household refrigerator which provided 12 cubic feet for household use. A very conservative allowance for power to operate the household side of the refrigerator would be 40 Kwh. per month or 1.3 Kwh. per day. The household refrigeration was charged with $200 of the $500 investment. The costs chargeable to the cream refrigeration then amounted to 4.5¢ for power and 12¢ for interest and depreciation, a total of 16.5¢ per day. It is evident that with this small production of only 6.5 pounds of butter-fat per day, cream refrigeration could not show more than a very slight profit.

The gasoline consumption was 0.3 gallon per day on Farm No. 2, with the engine-operated refrigerator. With a small allowance for oil, the cost amounted to 5¢ per day. The interest and depreciation charge of 20¢ per day makes a total daily cost of refrigeration of 25¢ per day. The average daily production of 11 pounds of butter-fat per day made a daily premium of 33¢ per day or 7¢ above the total costs for refrigeration.

Since ordinarily it will require 12 to 15 cows to produce an average of 10 pounds of butter-fat daily, this appears to be the minimum size of herd that would make electric refrigeration of the cream profitable when a premium of 3¢ per pound is obtained and the refrigerator investment is approximately $500.

If the cream can be transported to the creamery and premium grade maintained at less cost than by refrigeration, it is apparent that this would be the more profitable method.

The largest item of refrigeration cost was for interest and depreciation on the refrigerator investment. An entirely satisfactory home-made tank-type refrigerator can be constructed of concrete or of wood with a metal tank, with 3 inches of cork-board insulation or its equivalent, for from $50 to $75 as explained in Oregon Experiment Station Bulletin 268.* The price of a ⅓ horse-power electric motor, refrigerator compressor, and the

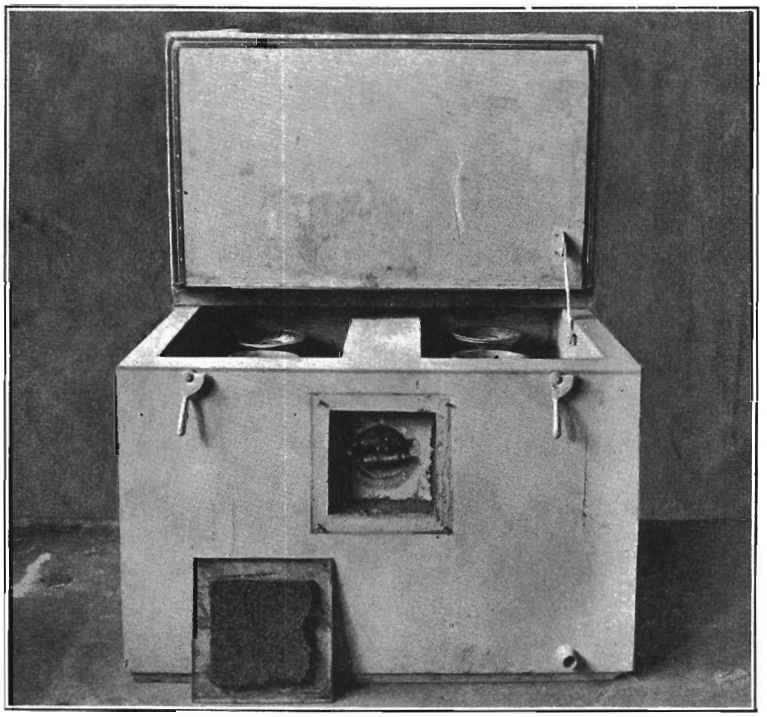

Figure 5. Refrigerator used on Farm No. 2. The refrigeration unit was operated by a 1½-horse-power gasoline engine.

*_Mechanical Refrigeration of Milk in a Tank-Type Refrigerator_, by F. E. Price, C. J. Hurd, and G. V. Copson.

necessary refrigeration coil of standard make is at present $218. This price includes installing the equipment. This would then make a total investment of $268 to $293, and would reduce the daily cost of interest and depreciation from 20¢, as charged in this experiment, to 11¢ to 14¢ per day. A ¼ horse-power refrigeration unit costing $135, plus $50 for the coil, making a total cost of $185 exclusive of the box, should serve dairies producing 2 to 4 gallons of cream per day.

The amount of electricity required to refrigerate the cream has been determined by this experiment and can be used in estimating future installations. Farms requiring smaller cream refrigerators will use less electric power than those reported in this experiment.

TABLE II. POWER CONSUMPTION ON FARM NO. 1

Motor ½ horse-power on compressor. Refrigerator capacity 4 ten-gallon cans.

Date	Time	Total power consumption
	Days	*Kwh.*
1930		
June 14	0	0
July 21	37	96
September 18	96	262
November 24	163	378
1931		
January 24	224	462
March 20	279	554
May 22	342	674
July 22	403	814
August 10	422	859

Average power consumed per day 2.0 Kwh.
Average cost of operation per day @ 3¢ per Kwh., 6.0¢.

TABLE III. POWER CONSUMPTION ON FARM NO. 3

Combination dairy and household refrigerator; ⅓ horse-power motor used to operate the compressor.

Date	Time	Total power consumption	Remarks
1930	*Days*	*Kwh.*	
August 13	0	0	
September 12	30	160	Removed the refrigerator to use in an exhibit.
September 29	30	160	Returned the refrigerator.
October 20	51	241	
December 8	120	300	
1931			
March 17	210	516	
June 5	290	757	
August 10	356	987	

Average Kwh. consumption per day, 2.7.
Average cost of operation per day at 3¢ per Kwh. for both household and cream refrigeration, 8.21¢.

TABLE IV. OPERATING DATA FOR FARM NO. 2

Operating data for ½ horse-power electric 4-can dairy refrigerator converted to 1½ horse-power gasoline-engine operation.

	27 days Sept. 4-30	31 days Oct. 1-31	30 days Nov. 1-30
Hours compressor operated	73.5	67.5	31.5
Gallons gasoline consumed	10.5	9.5	4.5
Pounds of butter-fat produced	293.0	338.0	240.0
Pounds cream cooled	879.0	1,014.0	720.0
Hours compressor operated per day	2.7	2.17	1.0

Average fuel consumption per day 0.3 gallon.
Average daily cost of gasoline and oil 5¢.

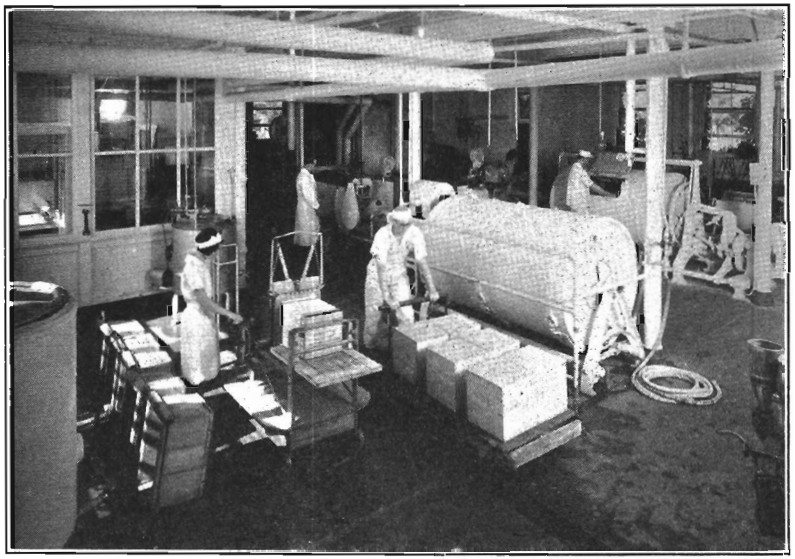

Figure 6. The butter making equipment used during the experiment.

Temperature of the cream when received at the creamery. The temperature at which the cream was received, shown in Table VI, ranged from 37° to 66° F., and averaged 50.2° F. for the whole year. The average monthly temperature of the cream when it was received at the creamery was found to follow a reasonably uniform curve. Starting with January at 45.7° F. the temperature increased in July and August to the high points of 57° F. and 56° F. respectively, from which the temperature consistently decreased to another low point of 44.1° F. in December. The months in which an average temperature of more than 50° F. occurred were May, June, July, August, and September. The mean monthly atmospheric temperatures at Corvallis for the same year were obtained from the U. S. Weather Bureau. These temperatures were plotted on a graph together with the average monthly temperatures of the cream when received (Figure 7).

TABLE V. COST SUMMARY FOR THE THREE FARMS ON WHICH REFRIGERATORS WERE USED

	Average butter-fat per day	Fuel or power used per day	Operating cost per day	Estimated interest and depreciation per day	Total cost per day	Daily premium at 3¢ per lb. butter-fat	Total cost per pound butter-fat	Net profit per day
	Lb.		¢	¢	¢	¢	¢	¢
Farm No. 1	20.0	2.0 Kwh.	6.0	20	26.0	60.0	1.3	34.0
Farm No. 2	11.0	0.3 gal. gasoline	5.0	20	25.0	33.0	2.3	7.7
Farm No. 3*	6.5	2.8 Kwh.	8.4	20	28.4	19.5	4.4	8.9 loss
Farm No. 3† (Cream Refrigeration)	6.5	1.5 Kwh.	4.5	12	16.5	19.5	2.7	3.0
Farm No. 3† (Household Refrigeration)	.....	1.3	3.9	8	11.9	.....	....	.....

*Charging entire cost of combination household and cream refrigeration to the cream.

†Charging 45 Kwh. per month to the household refrigerator and $200 of the investment, an average power consumption and a very low investment item for a 12-cubic-foot electric refrigerator.

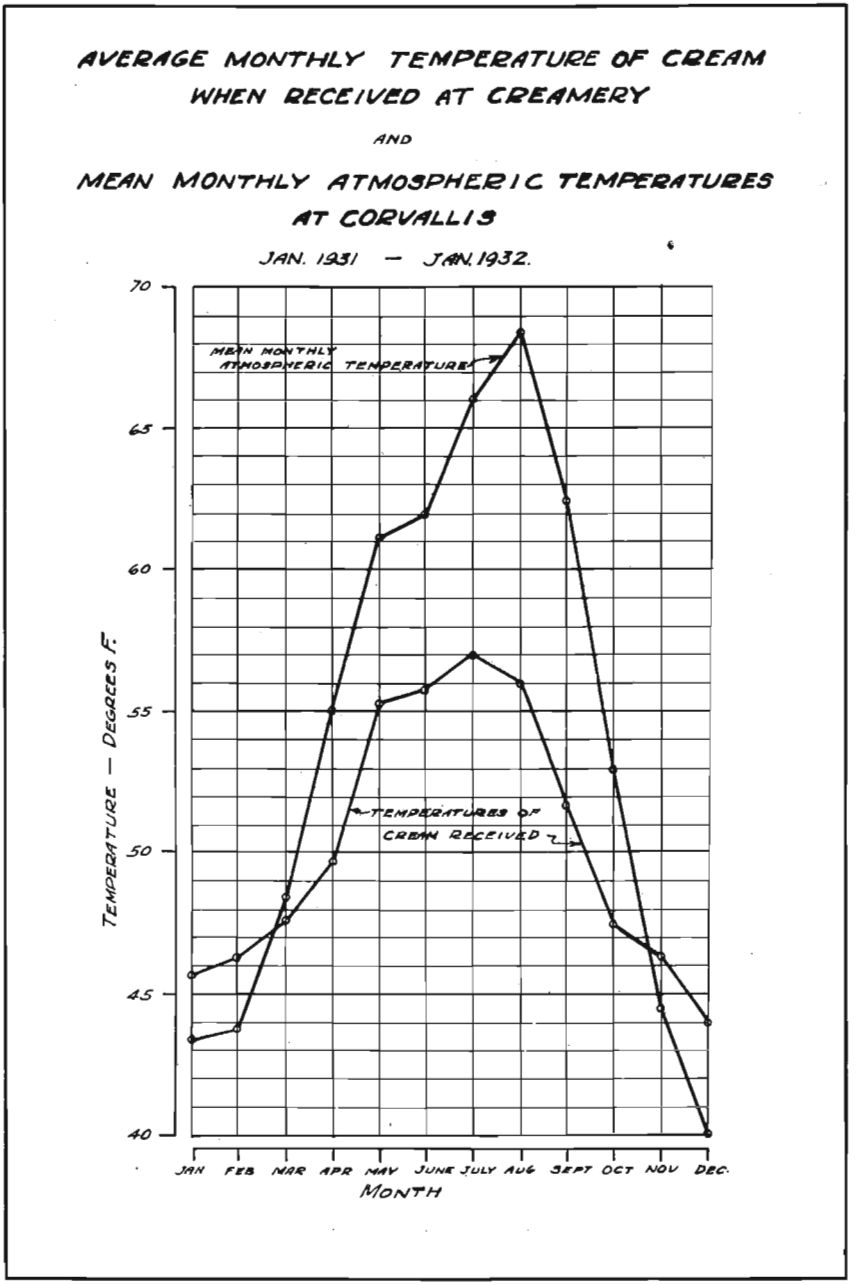
AVERAGE MONTHLY TEMPERATURE OF CREAM
WHEN RECEIVED AT CREAMERY
AND
MEAN MONTHLY ATMOSPHERIC TEMPERATURES
AT CORVALLIS
JAN. 1931 — JAN. 1932.
MEAN MONTHLY ATMOSPHERIC TEMPERATURES
TEMPERATURES OF CREAM RECEIVED
TEMPERATURE — DEGREES F.
70
65
60
55
50
45
40
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC.
MONTH

Figure 7.

In an analysis of the two curves, it is seen that the curves bear a fairly definite relation to each other. Since the mean temperature is merely a midpoint between the maximum and minimum temperatures of each month, the seeming inconsistencies in the two curves are easily explained. The temperature curve giving the average monthly temperature during the hours of the days when the cream was in transit would be more accurate, but this was not obtained.

TABLE VI. AVERAGE MONTHLY TEMPERATURES AT WHICH CREAM WAS RECEIVED FROM ALL FARMS, THE RANGE IN TEMPERATURES DURING EACH MONTH AND MONTHLY MEAN ATMOSPHERIC TEMPERATURES

Month	Average cream temperature	Range in cream temperature	Mean atmospheric temperature
	Degrees F.	*Degrees F.*	*Degrees F.*
January	45.7	43-48	43.6
February	46.2	43-49	43.7
March	47.5	45-53	48.6
April	49.7	44-56	55.3
May	55.3	49-61	61.3
June	55.9	52-63	62.0
July	57.0	51-66	66.2
August	56.0	54-58	68.4
September	51.7	50-55	62.5
October	47.5	43-53	53.0
November	46.3	39-55	44.6
December	44.1	37-51	40.0

According to the data given in Table VII it is noted that the temperature of the cream from Farm No. 1, shipped a distance of 30 miles, ranged from 38° to 66° F., with an average of 51.2° F. for a full year. The temperature of the cream from farm No. 2, transported a distance of 5 miles in an uncovered truck ranged from 37° to 68° F., with an average temperature of 48.2° F. for the year. The temperature of the cream from Farm No. 3, shipped a distance of 20 miles, ranged from 36° to 65° F., with an average of 50° F. for the year.

The time in transit for the cream from Farm No. 1 was approximately 3¼ hours; from Farm No. 2 it was approximately ¾ hour; from Farm No. 3 it was approximately 2¾ hours. There seems to be a slight relationship, though not proportional, between the temperature at which the cream was received (or the rise in temperature between shipping and receiving) and the distance the cream was shipped. Other factors may have influenced the temperature rise, such as time left out of the refrigerator before shipping, the amount of warm cream poured into the cold cream before shipping, and the type of conveyance by which the cream was transported.

Acidity of the cream when received at the creamery. Table VIII shows that the acidity of the cream when received at the plant ranged during the year from 0.11 to 0.21 percent, with an average of 0.135 percent, calculated as lactic acid. In only one instance did the acidity exceed 0.20 percent. The majority of the shipments of cream contained from 0.12 to 0.14 percent acid.

TABLE VII. YEARLY AVERAGE TEMPERATURES AT WHICH CREAM WAS RECEIVED FROM EACH FARM AND RANGE OF TEMPERATURES

	Range in temperatures	Average temperature at which received	Distance shipped	Approximate time in transit
	Degrees F.	*Degrees F.*	*Miles*	*Hours*
Farm No. 1	38-66	51.2	30	3¼
Farm No. 2	37-68	48.2	5	½
Farm No. 3	36-65	50.0	20	2¾

TABLE VIII. ACIDITY OF THE CREAM WHEN RECEIVED AT THE CREAMERY

(Calculated as percentage of lactic acid)

Month	Average acidity	Range in acidity
	%	%
January	0.136	0.11-0.16
February	0.126	0.11-0.14
March	0.144	0.14-0.15
April	0.142	0.13-0.15
May	0.151	0.12-0.20
June	0.147	0.13-0.17
July	0.144	0.12-0.18
August	0.152	0.12-0.21
September	0.139	0.11-0.17
October	0.136	0.11-0.17
November	0.132	0.12-0.14
December	0.138	0.13-0.15

Number of bacteria in cream when received. Determinations were made of the bacteria present in 65 lots of refrigerated cream before pasteurization. Of these, it was found that

7 contained less than 100,000 bacteria per c.c.
18 contained from 100,001 to 500,000 bacteria per c.c.
15 contained 500,001 to 1,000,000 bacteria per c.c.
18 contained 1,000,001 to 5,000,000 bacteria per c.c.
6 contained 5,000,001 to 10,000,000 bacteria per c.c.
1 contained 10,000,001 to 15,000,000 bacteria per c.c.

Except in a few instances when the acidity of the cream at time of receiving it at the creamery reached about 0.2 percent, it was never possible to detect any flavors that would result from the fermentation caused by micro-organisms. The single sample which contained more than 10,000,000 bacteria per c.c. had a desirable flavor and aroma; the acidity of the cream was 0.21 percent; the score of the butter, when fresh, was 93.5, and when the butter was six months old it was 92.0.

The bacteria-killing efficiency of pasteurization was in most instances high. The efficiencies ranged from 81.600 to 99.997 and averaged 98.299 The counts after pasteurization were relatively low. In a series of 65 lots of cream, the number of bacteria present after pasteurization ranged from 100 to 54,000 per c.c., and averaged 5,700 per c.c.

Types of bacteria present in the refrigerated cream. In a study of the types of bacteria present in the refrigerated cream when received at the creamery, tubes of sterile litmus milk were inoculated with bacteria isol-

ated on agar plates. Of 855 litmus milk cultures, 19.6 percent were acid coagulators, 23.6 percent were acid non-coagulators, 19.5 percent were alkali formers, 7.4 percent were inert, 20.5 percent were acid peptonizers, 0.9 percent were alkali peptonizers, and 8.5 percent were neutral peptonizers. Pasteurization caused a decrease in the percentages of all the types present in the cream, with the exception of the non-coagulators, which showed an increase. It was noted that an average of 68.6 percent of the bacteria present in all the lots of cream examined after pasteurization were non-coagulators.

A study was also made of the different species of bacteria present in the cream. The study showed that the bacteria present in the refrigerated cream were of the same general types as are present in fresh milk produced on farms under similar conditions to those under which the milk was produced on the farms supplying the refrigerated cream.

Since the counts with some lots of cream were relatively high, there had apparently been some contamination of the cream with bacteria from utensils and other sources, and the organisms might have developed during the three- or four-day holding period, but their presence in the cream did not cause any undesirable flavors to be developed. A study of the effects of the growth of certain species of the organisms isolated from the cream on the flavor of cream inoculated with them was therefore not made.

Scores of the butter. In Table IX are shown the scores of the butter made in the 93 churnings when the butter was fresh, after it had been held in storage for one month at from 35° to 45° F., and after it had been held in storage for six months at from zero to 10° F.

TABLE IX. AVERAGE SCORES AND RANGE OF SCORES OF 93 CHURNINGS OF BUTTER (1) WHEN FRESH, (2) AFTER ONE MONTH AT FROM 35°-45° F., (3) AFTER SIX MONTHS AT FROM ZERO TO 10° F.

Butter	Score
Fresh butter	
Range in scores	90.50-95.00
Average score	92.62
After one month	
Range in scores	89.00-94.00
Average score	91.90
Average decrease in score	0.72
After six months	
Range in scores	89.66-94.00
Average score	92.11
Average decrease in score	0.51

The scores of the fresh butter ranged from 90.50 to 95.00, and averaged 92.62. After the butter had been held for one month, the scores ranged from 89.00 to 94.00 and averaged 91.90. The average decrease during the one-month period was 0.72 point. After the butter had been held for six months the scores ranged from 89.66 to 94.00 and averaged 92.11. The average decrease in score was 0.51.

From the frequency distribution given in Table X, it is noted that the majority, or 68.81 percent, of the samples of the fresh butter received

scores ranging from 92.0 to 94.0; 13.98 percent scored 94.0 and above and 17.21 percent scored below 92.0.

With the one-month-old butter, 50.54 percent of the samples scored 92.0 to 94.0, only 6.45 percent scored 94.0 and above, while 43.01 percent scored below 92.0.

With the six-months-old butter, 64.52 percent of the samples scored 92.0 to 94.0, 1.08 percent scored 94.0 and above, and 34.40 percent scored below 92.0.

These data show that the quality of butter when fresh was uniformly high. Nearly 83 percent of the scores of the fresh butter were 92.0 or higher.

The keeping quality of the butter was fairly good. The decreases in the score during the holding period were in general very slight. When the butter was held at from zero to 10° F. for six months, it kept better than it did when it was held at from 35° to 45° F. for one month.

TABLE X. FREQUENCY DISTRIBUTION OF THE SCORES OF THE BUTTER, 93 CHURNINGS

Scores	Fresh butter		Butter held for one month at 35° to 45° F.		Butter held for six months at zero to 10° F.	
	No. of churnings	Percentage of all	No. of churnings	Percentage of all	No. of churnings	Percentage of all
		%		%		%
94.5-95.0	5	5.38	0	0.00	0	0.00
94.0-94.5	8	8.60	6	6.45	1	1.08
93.5-94.0	12	12.90	10	10.75	5	5.38
93.0-93.5	18	19.35	5	5.38	22	23.66
92.5-93.0	15	16.13	10	10.75	13	13.98
92.0-92.5	19	20.43	22	23.66	20	21.50
91.5-92.0	6	6.45	13	13.98	11	11.83
91.0-91.5	9	9.68	13	13.98	14	15.05
Below 91.0....	1	1.08	14	15.05	7	7.52

Monthly variations in the scores of the butter. In Table XI are shown the average monthly scores of all butter made when it was fresh, after it had been stored for one month at from 35° to 45° F., and also after it had been stored for six months at from zero to 10° F.

The average monthly scores of the fresh butter, with the exception of that made during January when the score was 91.7, were consistently high. For the months February to December they ranged from 92.3 to 93.2.

The butter judges criticized for feed flavor approximately 50 percent of the butter made during January. This accounts for the lower average score of the butter made during this month as compared with the scores of the butter made during the rest of the year.

It is significant that the average scores of the butter made during the five warmest months—May, June, July, August and September—were uniformly high, ranging from 92.4 to 93.2. Butter made from cream held on the farms during the warm season stored in refrigerators for twice-weekly shipment to the creamery scored uniformly as "extra" grade.

The scores of butter held one month were not as uniform throughout the year as were the scores of the fresh butter. The butter made during January, March, July, August, and December scored below 92, and the butter made during the other months scored 92 and above after it had been held in storage for one month at from 35° to 45° F. The changes in the average monthly scores during the holding period ranged from an increase of 0.5 to a decrease of 2.1. The greatest decrease in the score took place with the butter made during July, August, October, and December. The butter made during the other months, with the exception of April, showed relatively small decrease. The butter made during April showed a slight increase in the average score during the holding period.

The scores of butter held six months were more uniform than those of butter held for only one month. The average scores of the butter made in January, February, May, and December were below 92, and the average scores of the butter made during the other months were 92 and above. Relatively slight decreases took place during the storage period. The butter made during April scored slightly higher on an average after the six-months holding period than when it was fresh. The butter made during January, February, June, September, and November showed slight decreases in score, but the decreases were too small to be of much significance, averaging less than 0.5 point. No decrease took place in the

TABLE XI. AVERAGE MONTHLY SCORES OF BUTTER WHEN FRESH, AFTER ONE MONTH, AND AFTER SIX MONTHS, 93 CHURNINGS

Month in which butter was manufactured	Average score when fresh	After one month at 35° to 45° F.		After six months at zero to 10° F.	
		Average score	Decrease	Average score	Decrease
January	91.7	91.5	0.2	91.5	0.2
February	92.3	92.1	.2	91.9	.4
March	92.4	91.9	.5	92.4	.0
April	92.3	92.8	.5*	92.6	.3*
May	93.2	92.9	.3	91.5	1.7
June	92.8	92.7	.1	92.6	.2
July	93.1	91.2	1.9	92.5	.6
August	92.7	90.6	2.1	92.0	.7
September	92.4	92.1	.3	92.1	.3
October	93.2	92.2	1.0	92.1	1.1
November	92.9	92.1	.8	92.7	.2
December	92.4	90.7	1.7	91.5	.9

*Increase.

score of the butter made during March. The butter made during May, October, and December showed the greatest decreases—1.7, 1.1, and 0.9 point, respectively. It may be stated, however, that at no time did any butter develop a pronounced undesirable flavor, such as fishy, tallowy, or pronounced storage. In many instances the judges stated that they thought they had been examining fresh butter, or butter not more than a few weeks old, when informed after the scorings that the butter was six months old.

The effect of the use of starter in the cream on the score of the butter. Of the 93 churnings previously discussed, 59 were made from cream with

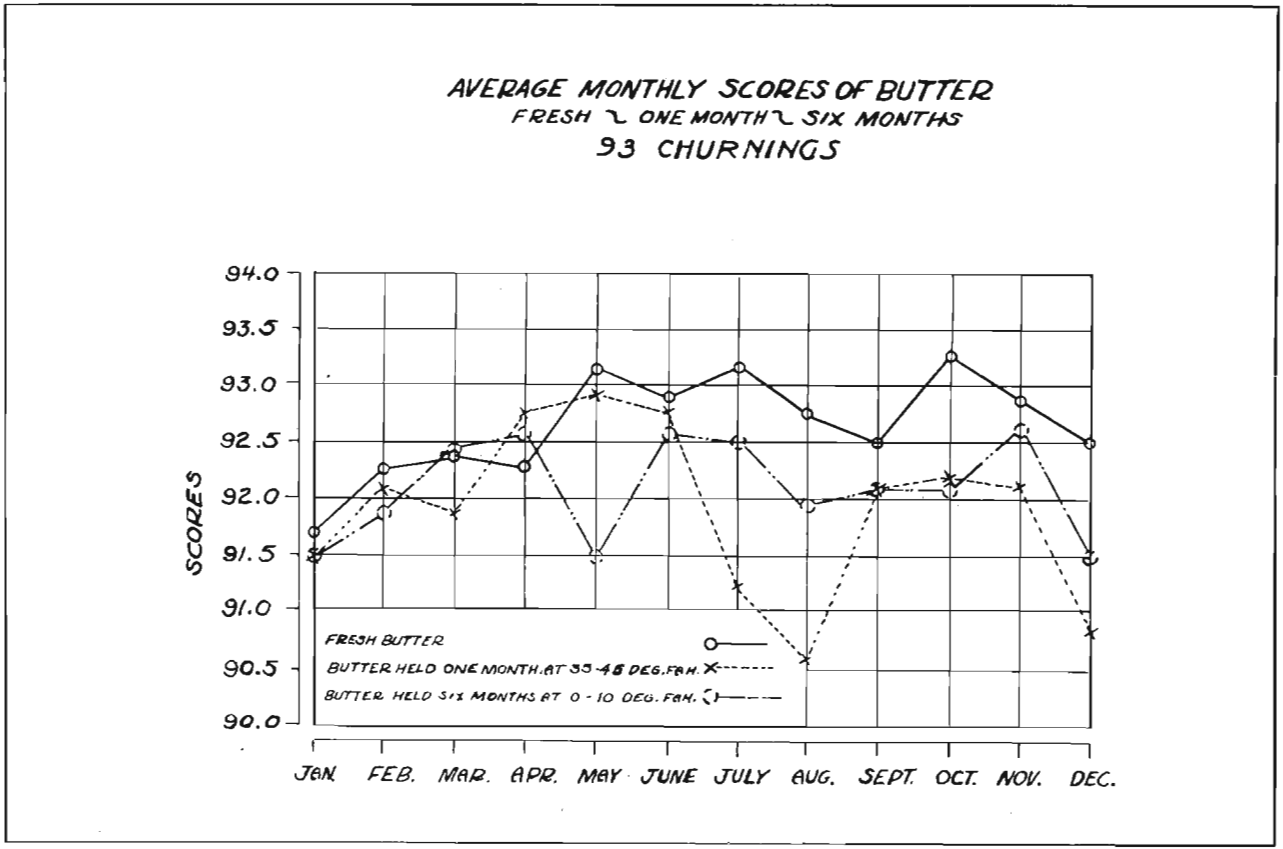
AVERAGE MONTHLY SCORES OF BUTTER
FRESH ~ ONE MONTH ~ SIX MONTHS
93 CHURNINGS
SCORES
94.0
93.5
93.0
92.5
92.0
91.5
91.0
90.5
90.0
FRESH BUTTER
BUTTER HELD ONE MONTH AT 35-45 DEG. FAH.
BUTTER HELD SIX MONTHS AT 0 - 10 DEG. FAH.
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.

Figure 8.

which starter was used, and 34 were made from cream with which no starter was used.

In Table XII are shown the results obtained by the use of each method of manufacturing butter. The scores of the fresh butter made from cream with which starter was used ranged from 90.5 to 95.0 and averaged 93.03; the scores of the fresh butter made without starter ranged from 90.5 to 93.5 and averaged 91.96. After a one-month holding period at a temperature of from 35° to 45° F. the scores of the butter made with starter ranged from 89.0 to 94.0 and averaged 92.07; the scores of the butter made without the use of starter ranged from 89.0 to 94.0 and averaged 91.6. The scores of the butter held for six months at from zero to 10° F. when starter was used ranged from 90.0 to 94.0 and averaged 92.4; the scores of the butter made without the use of starter ranged from 89.66 to 93.50 and averaged 91.63. As compared with butter made without starter, butter made with starter thus scored 1.07 points higher when fresh, 0.47 point higher after one month at from 35° to 45° F., and 0.77 point higher after six months at from zero to 10° F.

The decreases in the average score of the butter made with each method were 0.96 point and 0.63 point for the one-month and the six-months holding periods, respectively, when starter was used; when no starter was used, the decreases were 0.36 point and 0.33 point, respectively. The decreases in the average score were thus greater in the butter made with starter than in that made without starter. Butter made with starter, however, had an average score higher than 92 when the butter was fresh, and also after it had been held for one month and for six months. The butter with which no starter was used had an average score slightly less than 92 when the butter was fresh and less than 92 after both one month and six months.

From the frequency distribution of the scores of the butter shown in Table XIII it is noted that 93.23 percent of the scores of the fresh butter made with starter were 92 and above as compared with 61.77 percent for fresh butter made without starter. Only 6.77 percent of the scores of the fresh butter made with starter were below 92, while 38.23 percent of the scores of the fresh butter made without starter were below 92.

After the butter had been held for one month at from 35° to 45° F, 61.02 percent of the scores of the butter made with starter were 92 and above and 38.98 percent were below; 49.98 percent of the scores of the butter made without starter were 92 and above and 50.02 percent were below 92.

After the butter had been held for six months at from zero to 10° F. 77.97 percent of the scores of the butter made with starter were 92 and above, and 22.03 percent were below 92; 44.12 percent of the scores of the butter made without starter were 92 and above and 55.88 percent were below 92.

Occasionally a sample of butter scored higher at the end of the holding period than it did when it was fresh. It is possible, though not probable, that the quality of the butter improved during storage. A different standard by the judges over a period of time may account for the increase.

It is seen from these data that the butter made with starter and the butter made without starter was of high quality, since a large percentage

TABLE XII. AVERAGE SCORES AND RANGE OF SCORES WHEN FRESH, AFTER ONE MONTH, AND AFTER SIX MONTHS, OF BUTTER WITH WHICH STARTER WAS USED AND OF BUTTER WITH WHICH NO STARTER WAS USED

59 churnings of butter with which starter was used.
34 churnings of butter with which no starter was used.

	Fresh butter		After one month at 35° to 45° F.			After six months at zero to 10° F.		
	Range in scores	Average score	Range in scores	Average score	Average decrease in score	Range in scores	Average score	Average decrease in scores
Butter made with the use of starter	90.5 95.0	93.03	89.0 94.0	92.07	.96	90.0 94.0	92.40	.63
Butter made without the use of starter	90.5 93.5	91.96	89.0 94.0	91.60	.36	89.66 93.50	91.63	.33
Difference in favor of butter made with the use of starter	.....	1.07	.....	.47	.....	.....	.77	.....

TABLE XIII. FREQUENCY DISTRIBUTION OF SCORES OF BUTTER MADE WITH AND WITHOUT STARTER

Scores	Fresh butter			After one month at 35° to 45° F.			After six months at zero to 10° F.		
	No. of samples	Percentage of all scores		No. of samples	Percentage of all scores		No. of samples	Percentage of all scores	
		%			%			%	
Butter with which starter was used (59 churnings)									
94.5-95.0	5	8.47		0	0.00		0	0.00	
94.0-94.5	8	13.56		5	8.47		2	3.39	
93.5-94.0	10	16.95	93.23 percent 92.0 and above.	8	13.56	61.02 percent 92.0 and above.	6	10.17	77.97 percent 92.0 and above.
93.0-93.5	14	23.73		5	8.47		19	32.20	
92.5-93.0	10	16.95		3	5.09		8	13.56	
92.0-92.5	8	13.57		15	25.43		11	18.65	
91.5-92.0	1	1.69		8	13.56		4	6.78	
91.0-91.5	2	3.39	6.77 percent below 92.0.	9	15.25	38.98 percent below 92.0.	8	13.56	22.03 percent below 92.0.
Below 91.0	1	1.69		6	10.17		1	1.69	
Butter with which no starter was used (34 churnings)									
94.5-95.0	0	0.00		0	0.00		0	0.00	
94.0-94.5	0	0.00		1	2.94		0	0.00	
93.5-94.0	2	5.88	61.77 percent 92.0 and above.	2	5.88	49.98 percent 92.0 and above	1	2.94	44.12 percent 92.0 and above.
93.0-93.5	3	8.82		0	0.00		1	2.94	
92.5-93.0	5	14.71		7	20.58		5	14 71	
92.0-92.5	11	32.36		7	20.58		8	23.53	
91.5-92.0	5	14.71		5	14.71		7	20.58	
91.0-91.5	7	20.58	38.23 percent below 92.0.	4	11.77	50.02 percent below 92.0.	6	17.65	55.88 percent below 92.0.
Below 91.0	1	2.94		8	23.54		6	17.65	

of the scores of the butter made with the two methods was 92 and above. It is shown, however, that a better quality butter can be made with starter than without it, since a greater percentage of the scores of the butter made with starter were above 92 than of the butter made without starter.

It appears that there was very little difference between the keeping quality of the butter made with starter and that made without starter. The scores with starter decreased the most after both the one-month and the six-months holding period, but at the end of each holding period a considerably larger percentage of scores were above 92 than in the case of butter made without starter.

Comments of the judges on the butter with which starter was used were "creamy flavor", "sweet and clean", "fine aroma", "fine flavor." The comments of the judges on the butter with which no starter was used were "flat", "lacking in character", "insipid", "starter would improve", "tallowy."

Scores of butter entered in contests. Butter from the refrigerated cream to which starter was usually added was exhibited in five contests during the period of the experiment. The cream was handled by the regular routine method and no attempt was made to modify the method of butter manufacture. The names of the various shows where the butter was entered, the scores obtained, and the placings are given in Table XIV.

TABLE XIV. SCORES AND PLACINGS OF BUTTER EXHIBITED AT CONTESTS

Name of contest		Score	Placing
Pacific International Dairy Products Show, 1930, Portland		94.50	6th place (compl.)
National Creamery Buttermakers' Cold Storage Contest, 1931, St. Paul, Minnesota	June	93.50	Junior Class
	Oct.	94.25	4th Place
National Creamery Buttermakers' Fresh Butter Contest, 1931, Madison, Wisconsin		94.25	Junior Class 4th Place
Pacific International Dairy Products Show, 1931, Portland	Starter used	94.00	.....
	No starter used	92.50	..... (compl.)
Oregon State Fair, Salem, 1931		94.00	6th Place (compl.)

At the Pacific Internatioal Dairy Products Show held in 1930, butter was entered for complimentary score. The butter placed sixth high in a field of approximately 50 entries with a score of 94.50.

In 1931, a twenty-pound tub of butter sent to the National Creamery Buttermakers' Cold Storage contest obtained fourth place among 70 entries in the Junior contest, scoring 93.50 in June on entering cold storage and 94.25 in October when taken out of cold storage. The score increased 0.75 point during storage. Since the butter was scored competitively, the apparent increase in score may be explained by a greater decrease in the score of the other entries. An actual improvement in quality does not seem probable.

A tub of butter sent to the National Creamery Buttermakers' Fresh Butter contest in 1931 at Madison, Wisconsin, obtained fourth place among 73 contestants in the Junior contest, scoring 94.25.

At the Pacific International Dairy Products Show in 1931, two samples of butter were entered for complimentary score. Both samples were made from the same lot of refrigerated cream. Starter was added to the cream for one churning, and no starter was used for the other churning. The butter with which starter was used scored 94.00, while the butter with which no starter was used scored 92.50.

Butter was also exhibited for a complimentary score at the Oregon State Fair in 1931, where it placed sixth high with a score of 94.00.

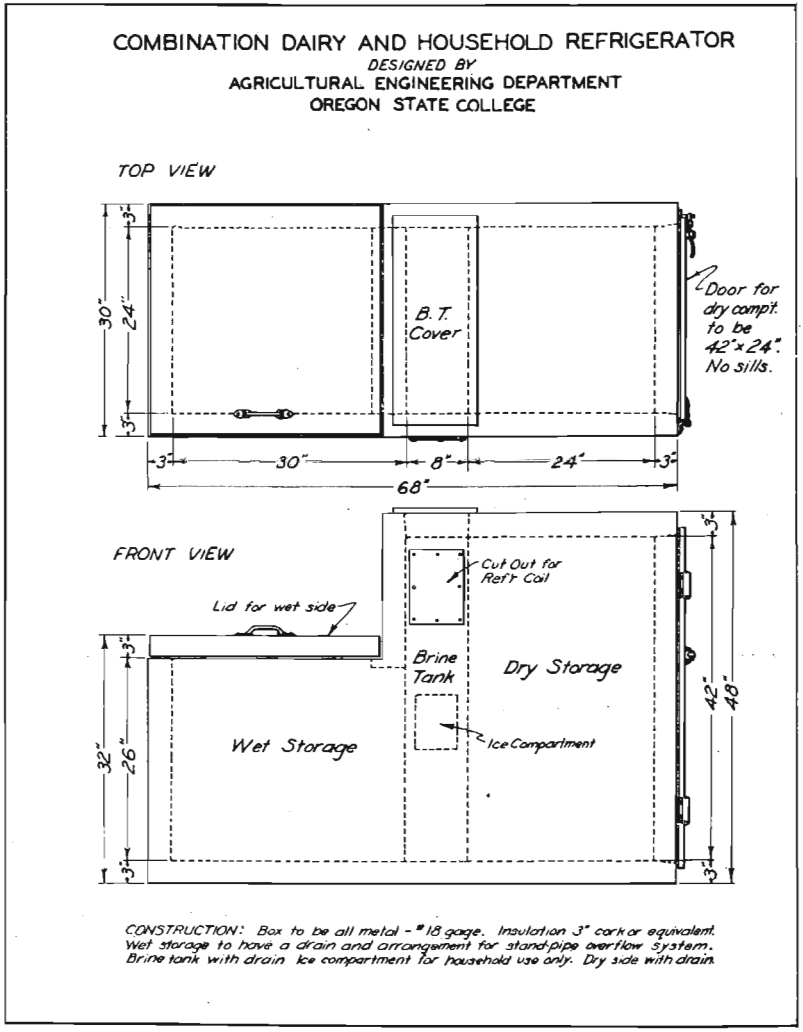

Figure 9

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