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Federal Butter Judges Standardize Methods of Grading Commercial Butter

# Holding Cream for Buttermaking

Bulletin 350

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Dairy Department  
AGRICULTURAL EXPERIMENT STATION  
South Dakota State College  
Brookings, S. D.

# Holding Cream for Buttermaking

D. H. JACOBSEN AND T. ALLEN EVANS\*

## Introduction

The question of holding cream in the creamery over Sunday or holidays long has been a perplexing one and much difference in plant practice has been found. In some cases the cream is held raw while in others it first is pasteurized and as the period of holding in such cases is about 48 hours, influence on cream quality might be considerable. If cream were held raw, even with some refrigeration, extension of the age of the cream might change the cream grade and consequently the quality of butter which could be made. Such changes are obviously important in management of creameries and they may result in considerable loss. Efforts toward cream improvement through frequent delivery of cream to the plant also would be thwarted by such a delay, if significant changes in cream quality occurred during the additional period.

On the other hand, if cream were pasteurized and held at refrigerator temperatures 48 hours before churning one might expect the progress of bacterial decomposition to cease and the quality of cream to remain the same throughout the holding period. This viewpoint is justified by the fact that greater numbers of bacteria are destroyed, especially the more active forms which are in the reproducing stage at the time of pasteurizing.

That considerable difference of opinion exists on this problem was indicated in a report by Totman.<sup>1</sup> Statements of four well-known butter research men were evenly divided on the question of holding cream over a 40-hour period. Two indicated that cream would make better butter if held raw. The others indicated that pasteurization would preserve quality more effectively.

In trials reported herein a comparison of the two methods has been made. The scores of the fresh butter as well as the keeping quality over a five-month period has been determined. It was thought that although the effect of the holding method on fresh score might not show a difference between methods, the keeping quality of the butter might be effected.

\* Dairy Husbandmen, South Dakota Agricultural Experiment Station. The authors acknowledge the assistance of C. C. Totman of the South Dakota State College Dairy Department in scoring the butter samples.

Much credit is due Roy C. Potts of the U. S. D. A. Agricultural Marketing Service and government graders, C. W. Fryhofer and Arthur B. Roppe, who cooperated in the grading of the butter in this work.

1. Totman, C. C. How should cream be held at the creamery. *Nat'l. Butter and Cheese Journal*. Apr. 25, 1938. pp 34-37.

### Previous Work

The influence of extended holding periods on raw cream quality has been recognized for many years. This phase of the present trials probably needs no discussion as acidity increase and gradual development of off-flavors due to chemical and bacteriological actions are well recognized. The influence of holding cream in a pasteurized condition, however, is not so well known. As both these conditions of holding are involved in these trials, some of the work on the holding of pasteurized cream is reviewed here.

The work of Mortensen<sup>2</sup> and others on pasteurization of cream for butter-making recognized possibility of the influence of organisms remaining after pasteurization. Their studies, however, gave no conclusive evidence of deterioration caused by these organisms, even though relatively large numbers remained in the pasteurized cream.

Powell<sup>3</sup> compared flavor and bacterial changes occurring during storage in sweet cream which had been flash pasteurized at various temperatures. He concluded that peptonizing bacteria percentages increased as the heating temperature was raised and tended to predominate in cream heated at 165 degrees F. or above. At the temperature of holding (35 degrees), the growth of organisms was more rapid in raw than in pasteurized creams. Flash pasteurization at 165 degrees prevented the development of bitter flavors commonly noted in the same cream held raw for 10 days. Although this work was done on sweet cream the general principles involved would apply in the cream used in the butter industry, and it might be observed that the organisms in pasteurized cream might under certain conditions be responsible for definite deterioration in the product.

In a study on the effect of cream holding methods by Totman<sup>4</sup> 51 churnings were made of cream of different grades. The results showed no significant advantage for either method of holding cream when only fresh scores were considered. Judging from the scores after storage the advantage was with the butter from cream held raw 48 hours. The lowest average score was obtained from that portion of each batch which was held pasteurized in the vat rather than in the cans. This portion was churned 4 to 15 hours after the beginning of each trial. Butter from cream which was pasteurized before being held showed marked decline in scores after the first month of storage. Condition of the coil vat was such that satisfactory temperature control was not obtained and bare copper surfaces were exposed. Both of these conditions no doubt, contributed to lowering of cream quality in this group and ultimately produced lower butter scores. As these results appeared to be quite

2. Mortensen, M., Gaessler, W. G., and Cooper, W. H. Pasteurization of cream for buttermaking. Ia. Agr. Exp. Sta. Bul. 156 (1918)

3. Powell, M. E. Flavor and bacterial changes occurring during storage of sweet cream which has been flash pasteurized at different temperatures. *Journal Dairy Science* 21 p. 219 (1938)

4. Ibid, page 2.



contrary to the generally accepted ideas on cream holding, it was deemed advisable to set up a similar experiment in which more supporting data as the use of starter, the bacterial counts and pH tests on the butter would be included.

## Methods

Cream in these trials was obtained largely from direct deliveries made to the college creamery and represented the average run of cream for eastern South Dakota. A few churnings of second-grade cream were obtained from a creamery shipping cream from stations in central South Dakota. The cream was graded and divided into three series. The first two series were of first-grade cream and included vats of cream with less than 0.60 percent acidity and only slight off-flavors. The third series included high acid cream of definite off-flavors which was considered second-grade. The experimental period covered a full year, but most of the churnings were made in spring and early summer.

In the series with butter culture, 6 percent of culture was added, both in the cream churned fresh and in that held raw 48 hours. In these churnings the culture was added after the cream had been pasteurized and cooled to 50 degrees F. and held with the cream during the period of tempering for churning. In the cream held 48 hours after pasteurization 1 percent of culture was added before holding.

The first series of nine vats of first-grade cream ranged in acidity content from 0.19 to 0.49 percent and was made into butter without use of butter culture. The second series of nine vats of first-grade cream ranged in acidity from 0.48 to 0.60 percent. Butter culture was used in this series. The third series of five vats of second-grade cream ranged from 0.68 to 0.78 percent acidity and was made into butter without butter culture.

Fat tests of these 23 vats of cream ranged between 24 and 33 percent with a mean of about 30 percent. The cream when received was placed in the refrigerator at 32-36 degrees until the 60 gallons required for the experiment were obtained, usually in about two days. The cream was dumped into the pasteurizing vat and mixed well. Twenty gallons then were drawn off in cans to be held raw at 32 to 36 degrees in the refrigerator. The remaining 40 gallons were neutralized and pasteurized by heating to 160 degrees for 20 minutes. After cooling to about 40 degrees the batch was split again and 20 gallons were held in the vat for three or four hours at 40 degrees and churned. After 48 hours the cream held pasteurized was churned and the cream which had been held raw for 48 hours was neutralized and pasteurized in the same manner as the original vat, and then tempered and churned.

All churnings were neutralized to 0.18 percent acidity, but those held in the pasteurized conditions for 48 hours frequently increased from 0.02 to 0.05 percent during holding. Churning was done in a 350 pound capacity, roll-less churn according to generally accepted plant methods. The butter was salted at a rate of 2 percent of finished butter.

Samples of cream were obtained at each stage of the experiment, including the mixed vat, the pasteurized cream, the pasteurized cream held 48 hours and the raw held 48 hours after pasteurization. These samples were plated for total lipolytic and proteolytic bacteria and also for yeasts and molds.

Butter from each churning was tested both for score and microbiological condition. One 20-pound tub from each churning was sent to government graders in Minneapolis and a portion of the same butter in a five-pound jar was kept for examination at the station.

A Kohman analysis of each churning of butter was made for moisture and salt content. The pH of the butter serum was determined electrometrically using a glass electrode and pH electrometer.

Microbiological analyses of both cream and butter were made by methods suggested by the Committee on Bacteriological Methods of the American Dairy Science Association.<sup>5</sup> Total bacteria and proteolytic bacteria were counted on beef infusion agar to which sterile skim milk had been added. Lipolytic bacteria were counted on the same kind of agar to which oil emulsion and Nile-blue sulphate had been added. The method was modified by adding 0.5 ml of sterile skim milk per plate which was found to stimulate growth of larger numbers of organisms in the presence of Nile-blue sulphate. Wesson oil was used in oil emulsion. All plates were incubated in a thermostatically-controlled refrigerator incubator at 70 to 72 degrees for four days and counted with a wide-field, low-power microscope, using magnifications of from 6x to 15x.

## Results

To maintain highest quality butter, the buttermaker usually churns cream received at the plant in the shortest possible time. This, in most cases, means churning one day's receipts on the same or following day. This practice was considered in these trials as a basis for comparison and each vat of cream was divided so a comparison of cream held pasteurized and of cream held raw could be made with that churned fresh.

Butter scores in Table I are averages obtained on the three methods of holding cream. The results represent three series: First-grade cream, first-grade cream with culture and second-grade cream. These three series were used in trials for purposes of showing the effect of holding creams of different qualities.

Results in Table I indicate that insofar as fresh butter scores are concerned, there was no great difference in quality due to holding methods. Differences up to 0.3 points in score were noted, but these differences do not seem significant when the method of measuring quality by flavor scoring is considered. As a variation of one point is occasionally noted between judges scoring the same butter, fractional differences between averages cannot be considered indicative.

5. Committee on Bacteriological Methods, American Dairy Science Ass'n. The Microbiological analysis of butter. *Journal Dairy Science* 16 pp 289-299 (1933)

Table I. The Influence of the Cream Holding Method on the Fresh Butter Score.

Cream Treatment	Kind of Cream					
	First Grade (No Culture)		First Grade (Plus Culture)		Second Grade (No Culture)	
	Number of churnings	Av. score	Number of churnings	Av. score	Number of churnings	Av. score
A. Churned fresh	9	90.7	9	91.0	5	90.2
B. Held pasteurized	9	90.6	9	91.0	5	90.3
C. Held raw	9	90.7	9	91.2	5	90.0

A slightly higher general level of scores was recorded with the culture-butter even though the original acidity of this cream was higher than the first-grade non-culture group. Also the second-grade cream showed a higher average butter score than was expected from such cream. Scores in this group ranged from 89 to 91, inclusive, while the first two series scored 90 to 92, inclusive.

Comparison of the three methods as they influence keeping quality with the same churnings is shown in Table II. The churnings are the same as in Table I. Average loss in score at three months and five months as judged by government graders is reported. Except for the first group of churnings, which was first-grade cream without culture, the cream held either in a raw or pasteurized condition 48 hours produced butter of poorer keeping quality than the same cream churned fresh. A comparison of the losses in score in held cream in the first-grade culture-butter series showed little difference between the holding methods. In the second-grade cream series, butter from cream held pasteurized lost slightly more than butter from cream held raw. The first-grade cream without added culture showed best keeping quality, as indicated by smaller losses in average score after three and five months holding.

Fig. I shows graphically the average butter scores obtained under each method of handling cream and includes the same series of trials presented in Tables I and II. Uniformity of bars in each group emphasizes that little difference in average score can be attributed to handling methods. Slight variations which exist show an advantage in the first-grade cream for holding raw rather than pasteurized for the 48-hour period. Average scores on second-grade cream butter when fresh were an exception to this, but the difference was not great. After storage the advantage in score appeared to be for butter from cream held raw 48 hours before pasteurization as compared to that held pasteurized. There is nothing in these results which would justify pasteurization of cream to be held over a 48-hour period before churning.

Factors of chemical and bacterial activity during holding were considered important in explanation of differences in results; therefore bacterial content and pH were determined on every churning. Counts were made of the total, lipolytic, and proteolytic bacteria and of yeasts and molds to study relationships of these types to butter quality resulting from each method of handling

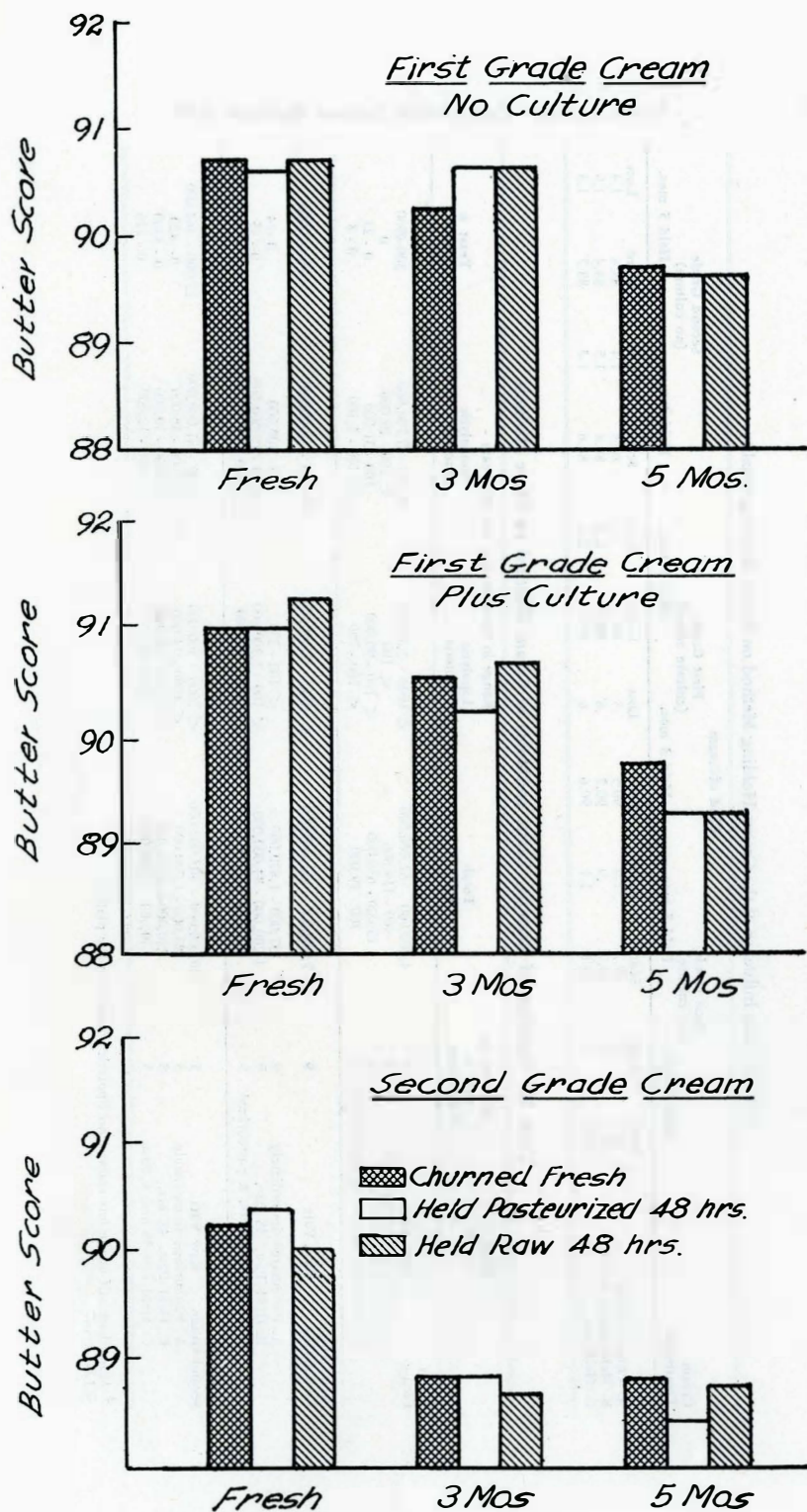


Fig. 1. The Effect of Cream Holding Methods on Butter Score When Fresh and After Storage at 32-36 Degrees F.



Table II. The Influence of the Cream Holding Method on Butter Keeping Quality.

Cream Treatment	Kind of Cream								Second Grade (no culture)			
	First Grade (no culture)		First Grade (culture added)		First Grade (no culture)		First Grade (culture added)		Second Grade (no culture)		Second Grade (no culture)	
	Held 3 mos.	Held 5 mos.	Held 3 mos.	Held 5 mos.	Held 3 mos.	Held 5 mos.	Held 3 mos.	Held 5 mos.	Held 3 mos.	Held 5 mos.	Held 3 mos.	Held 5 mos.
	Score	Loss	Score	Loss	Score	Loss	Score	Loss	Score	Loss	Score	Loss
A. Churned fresh	90.2	.5	89.7	1.0	90.5	.5	89.7	1.3	88.8	1.4	88.8	1.4
B. Held pasteurized	90.6	.0	89.7	.9	90.2	.8	89.2	1.8	88.8	1.5	88.4	1.9
C. Held raw	90.6	.1	89.6	1.1	90.6	.6	89.2	2.0	88.6	1.2	88.7	1.3

Table III. Numbers of Bacteria, Yeasts and Molds in Cream Handled by Three Methods

Kind of Cream		Number of Vats or Churnings	Total Bacteria	Range in Numbers per ml. of Cream		
				Lipolytic * Bacteria	Proteolytic Bacteria	Yeast & Molds
Series I						
First Grade	Raw Vats	9	4,000,000 - 62,000,000	< 1000 - 2,30,000	65,000 - 3,700,000	200-4900
	A. Pasteurized immediately	9	400 - 119,000	< 100	< 100 - 19,000	0
	B. Held Past. 48 hrs.	9	15,000 - 650,000	< 100 - 90,000	100 - 31,000	0 - 23
	C. Held raw 48 hrs. & pasteurized	9	200 - 49,000	< 100 - 700	< 100 - 1,100	0 - 8
Series II						
First Grade + Culture	Raw Vats	9	7,000,000 - 552,000,000	< 1000 - 4,800,000	95,000 - 1,900,000	440 - 7900
	A. Pasteurized immediately	9	37,000 - 1,820,000	< 100 - 250	300 - 300,000	0 - 14
	B. Held Past. 48 hrs.	9	1,200,000 - 84,000,000	< 100 - 1,300,000	< 1000 - 19,000,000	0 - 45
	C. Held raw 48 hrs. & pasteurized	9	13,000 - 47,000,000	< 100 - 120,000	< 1000 - 1,700,000	0 - 48
Series III						
Second Grade	Raw Vats	5	40,000,000 - 403,000,000	< 1000 - 590,000	< 1000 - 81,000,000	12,000 - 464,000
	A. Pasteurized immediately	5	80,000 - 1,700,000	< 1000 - 24,000	< 1000 - 38,000	0 - 820
	B. Held Past. 48 hrs.	5	230,000 - 3,000,000	< 1000 - 40,000	< 1000 - 30,000	0 - 3300
	C. Held raw 48 hrs. & Past.	5	130,000 - 7,500,000	< 1000 - 40,000	< 1000 - 12,000	0 - 126

\* More than half of the lots showed no lipolytic bacteria on the plates.  
 < Less than

cream. Counts on cream were made on the original mixed vat and on processed cream at churning time. Results obtained from these counts are presented in Table III. The range of counts for each group provides a comparison of the batches of cream handled by different methods.

Numbers of total bacteria in raw cream were relatively high regardless of the grade of cream. Pasteurization was effective in reducing numbers, and lowest counts were found in the first series which included the highest quality of cream. Counts in B of series II included the butter culture organisms which were added before the cream was put in storage for the 48 hours at 32 to 36 degrees. The high range of counts in this group therefore resulted from the added culture organisms. A considerable variation in pasteurization efficiency may be noted in the wide range of counts in pasteurized groups. As counts on raw cream were extremely high in both Series II and III, it is likely that heat resistant types were present in large numbers.

Lipolytic or fat-splitting bacteria ranged in numbers from a figure too low to count by the plating method to above one million per ml. Numbers were usually low, however, as indicated by the low limits in most groups, and also by the fact that more than half the cream samples failed to show lipolytic bacteria. The cream holding method apparently influenced development of these types since cream held pasteurized 48 hours gave higher counts of lipolytic bacteria and these bacteria found in a much higher percentage of churnings treated in this way.

Proteolytic bacteria were present in large numbers in raw cream in each series. After pasteurization, however, they were reduced to rather small numbers or were absent. Some tendency for these types to be present in large numbers in the cream held pasturized for 48 hours was noted. In series II involving cream with added culture, this tendency was particularly noticeable. Holding of pasteurized cream 48 hours at 32-36 degrees apparently permits growth of these types in numbers large enough to influence butter quality.

Yeasts and molds were present in all raw creams with very large numbers appearing in second-grade cream. Pasteurization usually destroyed all of these organisms, but occasionally small numbers were found in pasteurized lots. A larger number of yeasts and molds were found in pasteurized cream held 48 hours at 32-36 degrees than in the same cream when fresh. Only in second-grade cream did numbers become high enough to be significant although occasional counts of more than 50 per ml. were recorded in the butter-culture series. Although the numbers of yeast and molds were not high enough to contribute much to spoilage of butter in these trials, they indicated that some activity of microorganisms occurred, especially in the cream between pasteurization and churning. In the other methods the time between processing and churning was too short to allow much change.

Results of bacterial counts on the butter made from cream handled by the three different methods are presented in Table IV. No significant difference appears in the total bacterial counts from the three methods of handling cream. The higher counts in series II may be attributed to added butter culture while in Series III counts must be attributed to generally higher contamination in second-grade cream.

Table IV. Numbers of Bacteria, Yeasts and Molds in Butter Made From Cream Handled by Three Different Methods.

	Kind of cream churned	Number of churnings	Range in number of organisms		per ml of butter	Yeast & Mold
			Total Bacteria	Lipolytic ** Bacteria	Proteolytic Bacteria	
Series I	A First Grade Fresh, pasteurized	9	5100-95,000	<100-7300	350-11,000	0-4
	B Same Field pasteurized 48 hours	9	6800-82,000	<100-700	<100-11,000	0-2
	C Same Held raw 48 hours and pasteurized	9	3400-30,000	<100-400	200-4,800	0-3
Series II*	A First Grade Fresh, pasteurized	9	176,000-970,000	<100-20,000	450-310,000	0-165
	B Same Held pasteurized 48 hours	9	51,000-3,240,000	<100-200	<100-650,000	0-32
	C Same Held raw 48 hrs. and pasteurized	9	113,000-1,360,000	<100-400	200-140,000	0-110
Series III	A Second Grade Fresh, pasteurized	5	14,000-1,800,000	<1000-24,000	<1000-140,000	0-70
	B Same Held pasteurized 48 hours	5	160,000-1,640,000	<1000-1100	<1000-100,000	0-108
	C Same Held raw 48 hrs. and pasteurized	5	120,000-640,000	<1000-3000	3000-520,000	0-44

&lt; Less than

\* culture added to this series

\*\* more than half of the butter showed no lipolytic bacteria on the dilutions used.

Relatively small numbers of lipolytic bacteria were detected on plates made from the fresh butter and no changes were noted which could be related to cream treatment. More than half the butters examined failed to show any lipolytic bacteria. These counts agree in general with the results reported by Hammond and Collins.<sup>6</sup> They found comparatively few lipolytic bacteria in fresh, lightly salted butter. In 24 lots held at 32-50 degrees counts of lipolytic bacteria ranged from less than 1000 to 40,000 per ml.

Proteolytic bacteria were present in appreciable numbers especially in Series II, but a check of individual churnings failed to show any correlation of numbers of these types and development of protein decomposition flavors, either in butter when fresh or after storage. These types were apparently not a factor in determining the score of the fresh butter and their activity during one month at 32-36 degrees did not result in definite cheesy flavors.

Small numbers of yeasts and molds were found occasionally, but in many churnings they were absent or less than 10 per ml. Numbers, although excessive in some cases, apparently were not great enough to influence butter quality and no relation to cream holding method could be deduced. Results of numerous studies have indicated, however, that yeast and mold content should not be considered as an index of keeping quality but rather as a measure of creamery sanitation.

6. Hammer, B. W., and Collins, M. A. The numbers of lipolytic bacteria in various dairy products as determined by Nile-Blue Sulphate, Iowa Agr. Exp. Res. Bul. 169 (1934)

Table V. The pH of Butter Made From Cream Handled by Three Methods.

Cream Treatment	KIND OF CREAM							
	First Grade (no culture)		First Grade (plus culture)		Second Grade (no culture)		All churnings	
	Number of churnings	Ave. pH	Number of churnings	Ave. pH	Number of churnings	Ave. pH	Number of churnings	Ave. pH
A. Churned fresh	9	6.88	9	6.70	5	7.00	23	6.86
B. Held pasteurized	9	6.95	9	6.91	5	7.04	23	6.97
C. Held raw	9	6.92	9	6.94	5	7.26	23	7.04

The pH of the butter serum from each churning was determined and an average pH of 6.96 was found for the 69 butters. The average pH of butter in each class is presented in Table V to show the relation between cream treatment and pH of butter serum. Butter from cream held 48 hours before churning generally showed higher pH than that churned from cream when fresh. This tendency was especially noticeable in butter made from second-grade cream.

A comparison of the methods of handling cream with pH of fresh butter showed that the flavor criticism "neutralizer" was given more frequently on the churnings made from cream held raw 48 hours before pasteurizing and neutralizing. This might be due to the fact that higher acidities always developed on holding and therefore more neutralization was required. A slightly greater tendency to over-neutralize, as judged by the pH of the butter serum, was noted in the case of the high-acid second-grade cream. This was true even though the same standard of acidity was used in this series as in the higher grade creams. Hunziker and Cordes<sup>7</sup> reported similar results when they studied the pH of butter from different grades of cream. They stated that butter from unneutralized cream showed consistently higher acidities and lower pH than butter from neutralized cream when the churning acidity was the same, and a tendency for higher pH was noted as the degree of acidity reduction was increased.

### Summary and Conclusions

Sixty-nine churnings were made from 23 60-gallon vats of cream of different grades. Each vat was divided into three portions. One-third was pasteurized and churned the day the cream was received, one-third was pasteurized and held 48 hours before churning and one-third was held raw 48 hours and then pasteurized and churned. All cream was held at 32 to 36 degrees.

Butter was made in a churn of 350-pound capacity and was salted at the rate of 2 percent of the finished butter. One 20-pound tub from each churning was shipped to government graders for fresh score and score after three and five months holding at 32-36 degrees. Samples were also saved for bacterial counts and chemical analysis.

7. Hunziker, O. F., and Cordes, W. A. The hydrogen-ion concentration and titratable acidity of butter, cream and buttermilk. *Journal Dairy Science*, 18 p. 452-455 (1935)



Scores obtained on fresh butter failed to show any great difference between butter from cream held 48 hours in the raw condition as compared with butter from the same held pasteurized. After storage for five months at 32 to 36 degrees a slight advantage was indicated for cream held raw. Only a slight advantage was noted for butter from cream churned fresh. The differences in scores were not as great as was expected and one must conclude that factors other than the cream holding method influenced the results.

The plate count of bacteria, yeasts and molds were made on the raw and pasteurized cream and also on the fresh butter. Total bacterial counts varied widely in cream treated in the different ways and no correlation with cream holding method was obtained. Counts of lipolytic and proteolytic bacteria in cream at churning time tended to range higher in that pasteurized and held 48 hours than in that held raw 48 hours then pasteurized. This condition appeared in the butter also, but flavor criticisms did not indicate that any close correlation existed between numbers of bacteria and deterioration of the butter in storage. Since all butter in these trials was salted, the activity of lipolytic and proteolytic bacteria was definitely limited. The average salt content of the 69 churnings was 2.05 percent with a range of 1.7 to 2.3 percent. The pH of butter serum was determined on every churning and compared with the churning acidity and butter score. The pH was generally higher in butter from cream held 48 hours before churning. This was more marked with the second-grade cream than with the cream of higher quality. The average pH for all churnings was 6.96 with variations from 6.47 to 7.4. Neutralizer flavor in the fresh butter did not coincide with high pH to any significant degree, in fact the neutralizer flavor appeared as frequently with pH below 6.8 as it did when the pH was above 7.0.

Results of all these studies suggest that with sour cream of either first or second grade, the method of holding cream in the plant is not very important. Where holding for a 48-hour period is necessary, it appears that a slight advantage for holding raw may be expected. Apparently changes taking place in cream delivered in a slightly sour to sour condition are retarded sufficiently by air cooling at 32 to 36 degrees so that no significant reduction in butter score need be expected over a 48-hour period.