EFFECT OF LOW-TEMPERATURE STORAGE ON THE BACTERIOLOGICAL QUALITY OF PASTEURIZED MARKET CREAM

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SUMMARY

Storage of commercially pasteurized cream for up to 4 days at 5–7°C caused deterioration in the bacteriological quality. This was shown by small increases in the total bacterial count, sometimes by considerable increases in the coliform count and psychrophilic count, and by decreased keeping quality as judged by bacterial count and resazurin reduction time after keeping quality storage for 24 hr at 20°C. There was also some deterioration during low-temperature storage in the quality of the same creams pasteurized again in the laboratory to destroy contaminant organisms, but these samples had better keeping quality than the corresponding samples of factory pasteurized cream.

The growth of thermoduric organisms during KQ storage was relatively slow, but practically all commercially pasteurized creams showed faster growth indicative of contamination after pasteurization, even when coliforms and psychrophiles were not detected before KQ storage.

The amount of bacterial growth during KQ storage was not directly influenced by previous storage at low temperature, but counts after KQ storage increased as initial bacterial counts increased, and these higher counts were reflected in lower resazurin reduction times.

Bacterial growth in some raw cream samples before pasteurization led to an increased thermoduric count in the laboratory-pasteurized cream, and to a reduction in keeping quality.

I. INTRODUCTION

At many factories cream is not pasteurized daily, and the pasteurized cream may be held in storage at low temperature for several days before sale. In previous experiments (Lightbody and Smythe 1962), the effect of low-temperature storage on cream pasteurized in the laboratory was investigated. In the present series of experiments the effect of storage at low temperature on the bacteriological quality of pasteurized cream with low levels of factory contamination was examined.

II. METHODS

Samples of cream were obtained from commercial factories at the time of bottling. When raw cream was examined this was taken at the factory just before the factory pasteurization was begun. Samples examined included whipping

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cream (not less than 42 per cent. butterfat, ordinary cream (not less than 35 per cent. butterfat), and dessert cream (not less than 18 per cent. butterfat).

Commercial pasteurization was carried out by flash heating in a plate heat exchanger to 82-85°C. Laboratory pasteurization was carried out as described previously (Lightbody and Smythe 1962) in erlenmeyer flasks by heating cream previously pasteurized in the factory to 73°C for 15 sec or flash heating raw cream to 83°C.

Phosphatase tests and total bacterial counts were carried out as described previously (Lightbody and Smythe 1962). Counts of coliform organisms were made using desoxycholate agar (Difco) with incubation at 32° for 24 hr. Psychrophilic counts were made on tryptone glucose extract agar (Difco) with incubation at 5°C for 14 days. Examinations for keeping quality (KQ) were made by incubating cream at 20°C for 24 hr and then testing for total bacterial count, coliform count and resazurin reduction time to white end-point.

III. RESULTS

(a) Influence of Low Temperature Storage

Seven samples of whipping cream, 6 samples of ordinary cream and 6 samples of dessert cream were stored at 4-7°C and examined daily for total bacterial count, coliform count, psychrophilic count, and resazurin reduction time and bacterial counts after KQ storage. Portions of the cream samples were pasteurized in the laboratory at 73°C on receival and these subsamples also tested in the same way. The results of these tests are summarized in Tables 1-3.

TABLE 1

EFFECT OF STORAGE AT 4–7° C ON BACTERIOLOGICAL QUALITY OF SEVEN SAMPLES OF WHIPPING CREAM

Storage Period (days)	Commercially Pasteurized Cream						After Laboratory Pasteurization		
	Total Bacterial Count (no./ml)*	Coliform Organisms (no./ml)*	Psychro-philes (no./ml)*	After KQ Incubation			Total Bacterial Count (no./ml)*	After KQ Incubation	
				Resazurin Reduction Time*	Total Bacterial Count (no./ml)*	Coliform Organisms (no./ml)*		Resazurin Reduction Time*	Total Bacterial Count (no./ml)*
0	4·34	0·45	2·47	7·0	7·14	6·06	3·84	10·7	5·17
1	4·71	1·06	2·63	5·4	7·63	6·73	4·27	7·1	5·76
2	4·83	1·34	3·00	4·3	8·04	7·22	4·39	5·6	6·14
3	5·24	1·73	3·51	2·6	8·35	7·27	4·60	4·0	6·85
4	5·51	2·30	4·06				4·83		

* Bacterial counts in logarithms. Resazurin reduction times in quarter-hour units.

TABLE 2

EFFECT OF STORAGE AT 4–7° C ON BACTERIOLOGICAL QUALITY OF SIX SAMPLES OF 35 PER CENT. CREAM

Storage Period (days)	Commercially Pasteurized Cream						After Laboratory Pasteurization		
	Total Bacterial Count (no./ml)*	Coliform Organisms (no./ml)*	Psychrophiles (no./ml)*	After KQ Incubation			Total Bacterial Count (no./ml)*	After KQ Incubation	
				Resazurin Reduction Time*	Total Bacterial Count (no./ml)*	Coliform Organisms (no./ml)*		Resazurin Reduction Time*	Total Bacterial Count (no./ml)*
0	3·38	<0	<1	11·7	6·29	3·85	2·87	13·0	4·48
1	3·51	<0	1·57	9·7	6·89		3·03	12·0	4·77
2	3·56	<0	1·67	7·3	7·51		3·29	11·0	5·41
3	3·82	<0	2·68				3·46		

* Bacterial counts in logarithms. Resazurin reduction times in quarter-hour units.

TABLE 3

EFFECT OF STORAGE AT 4–7° C ON BACTERIOLOGICAL QUALITY OF SIX SAMPLES OF DESSERT CREAM

Storage Period (days)	Commercially Pasteurized Cream						After Laboratory Pasteurization		
	Total Bacterial Count (no./ml)*	Coliform Organisms (no./ml)*	Psychrophiles (no./ml)*	After KQ Incubation			Total Bacterial Count (no./ml)*	After KQ Incubation	
				Resazurin Reduction Time*	Total Bacterial Count (no./ml)*	Coliform Organisms (no./ml)*		Resazurin Reduction Time*	Total Bacterial Count (no./ml)*
0	4·61	1·50	3·18	2·0	7·59	7·11	4·08	8·1	5·41
1	4·91	2·13	3·73	1·7	8·40	7·54	4·54	7·5	5·96
2	5·02	2·40	4·66	1·7	8·45	7·77	4·73	6·2	6·36
3	6·14	3·12	5·55	1·2	8·90	8·40	5·15	3·3	6·73
4	6·56	3·71	6·06				5·21		

* Bacterial counts in logarithms. Resazurin reduction times in quarter-hour units.

(1) *Bacterial Counts.*—The repasteurization of the cream in the laboratory, although at a lower intensity of heating than the factory pasteurization, reduced the total bacterial count considerably. The decrease in count was more than could be accounted for by destruction of coliform organisms and psychrophiles.

The total bacterial counts of the commercially pasteurized cream and of the repasteurized cream without contaminant organisms showed a gradual increase during storage. This increase, even in the laboratory-pasteurized samples, was slightly greater than found previously in similar experiments with laboratory-pasteurized cream (Lightbody and Smythe 1962). The rate of increase was similar in all creams, except for a much faster increase during the 3rd and 4th days of storage of the dessert cream. The effect of low-temperature storage on

total bacterial counts of the creams is shown in Figure 1. Although all creams contained fewer than 50,000 organisms per ml initially, it can be seen that counts of the 42 per cent. and 18 per cent. creams were well above 100,000 per ml after storage for 3 and 4 days.

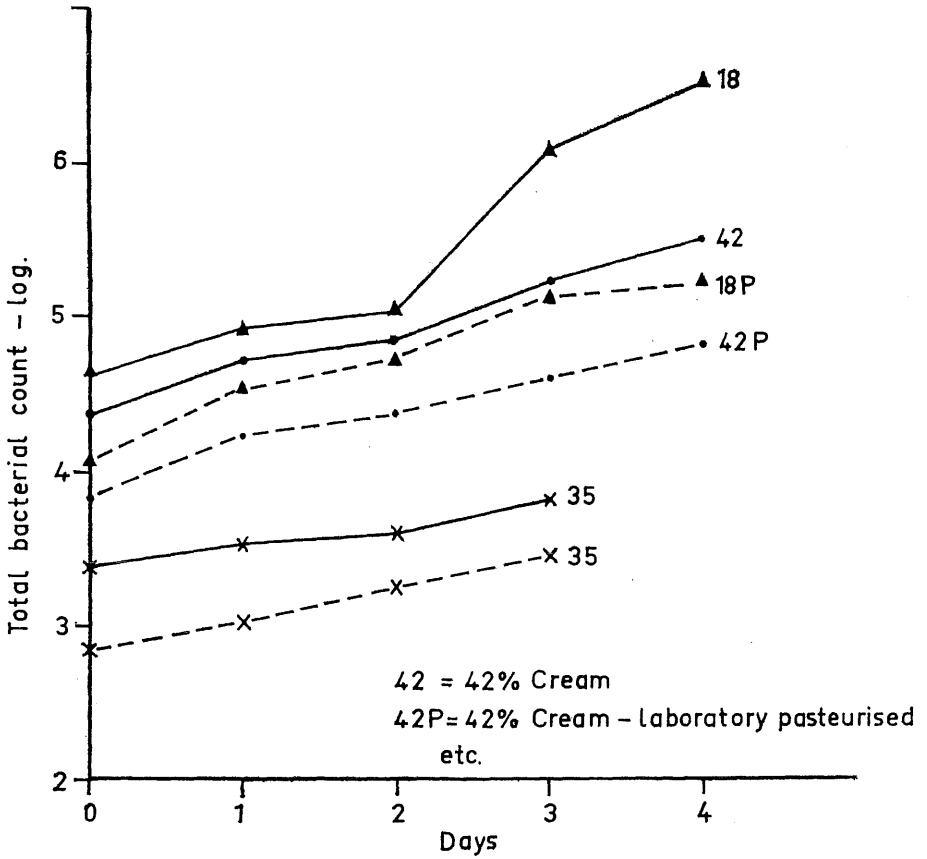

Fig. 1—Effect of low-temperature storage on total bacterial counts of pasteurized cream.

The growth of psychrophilic organisms and coliform organisms at the low storage temperature was fast and high counts of these types were found in some creams after 4 days. The samples of 35 per cent. cream were of better bacteriological quality than the samples of whipping and dessert cream received. All of these samples contained less than 1 coliform organism per ml and less than 10 psychrophiles per ml before storage. However, appreciable numbers of psychrophiles were present after 3 days at 4-7°C.

(2) *Tests for Keeping Quality.*—Total bacterial counts after KQ incubation increased with increasing duration of low-temperature storage, and resazurin reduction times decreased. The total bacterial counts after KQ incubation of the commercially pasteurized creams were very much higher than corresponding counts of the laboratory-pasteurized cream. Plates were poured to confirm the destruction of coliforms and psychrophiles in the laboratory-pasteurized cream. Coliform counts in the pasteurized cream after KQ incubation were usually high.

These results suggested a relationship between total bacterial count after KQ incubation and resazurin reduction times. They also suggested that resazurin reduction times after KQ storage could be a good indication of potential keeping quality. The reduction time of the laboratory-pasteurized cream without contamination was in every instance greater than that of the commercially pasteurized cream. However, there was a relatively lower total count after KQ storage for the same reduction time when contamination was absent than when coliform and psychrophilic organisms were present in large numbers. This finding appeared anomalous but a similar tendency can be seen in results of tests on pasteurized milk by Berger and Anderson (1949).

(3) *Increase in Total Count During KQ Incubation.*—The changes in bacterial count during KQ incubation for 24 hr at 20°C are shown in Figure 2.

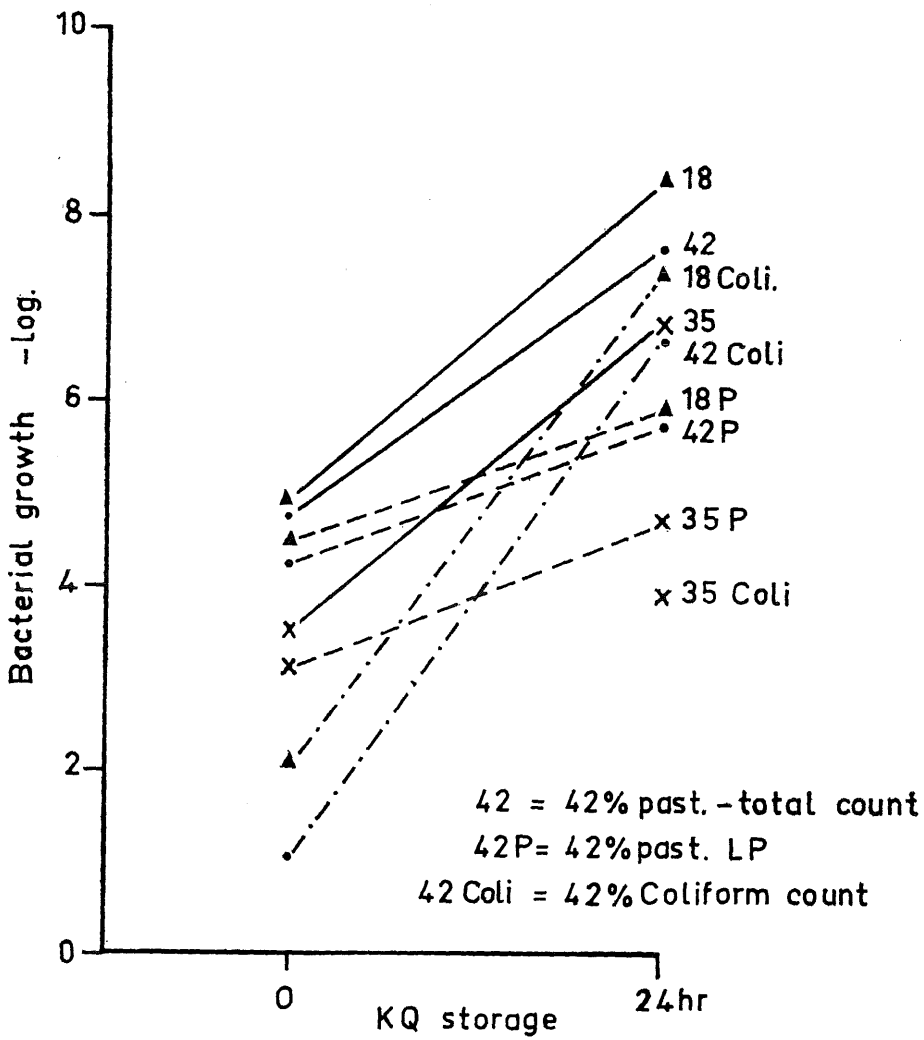

Fig. 2.—Changes in total bacterial counts and coliform counts during keeping quality storage at 20°C.

The results are those for the cream after 1 day's storage at low temperature. The coliform count of the 35 per cent. cream was less than 1 per ml before KQ storage. Similar results were obtained for the cream initially and after storage for 2 and 3 days, showing that low-temperature storage did not influence the rate of growth during KQ storage.

The changes in counts in the creams of different fat percentages were similar. The rate of growth of the thermoduric organisms in the laboratory-pasteurized creams was less than the overall growth rate of organisms present in the factory-pasteurized creams. One reason for this can be seen in the rapid rate of growth of the coliform organisms. Although the 35 per cent. cream contained very few coliform organisms, some psychrophilic contaminants were present, and these and possibly other types of contaminating organisms would have been responsible for the more rapid increase in total count in the factory-pasteurized cream than in the laboratory-pasteurized cream.

(4) *Phosphatase Tests.*—Phosphatase tests were carried out on all cream samples initially and after storage at low temperatures for 1, 2 and 3 days. There was no evidence of any reactivation of phosphatase.

(b) Effect of Raw Cream Quality

Six samples of raw 42 per cent. cream were pasteurized when received, and again after storage for 1 and 2 days at 16°C. Total bacterial counts, coliform counts and resazurin reduction times were obtained on the raw cream, and total bacterial counts and resazurin reduction times after KQ storage on the pasteurized creams. Typical results for two creams are shown in Table 4.

TABLE 4

EFFECT OF RAW CREAM QUALITY ON TOTAL BACTERIAL COUNT AND KQ TESTS OF PASTEURIZED CREAM

Cream No.	Raw			Laboratory-pasteurized		
					After KQ Storage	
	Total Bacterial Count (no./ml)*	Coliform Organisms (no./ml)*	Resazurin Reduction Time*	Total Bacterial Count (no./ml)*	Total Bacterial Count (no./ml)*	Resazurin Reduction Time*
1	4·6	1·6	8	4·1	5·1	11
	7·5	4·6	5	4·4	6·5	9
	8·8	7·3	1	4·4	6·6	8
2	5·2	2·6	18	4·0	6·6	6
	7·8	5·9	2	4·2	7·4	4
	8·9	6·4	1	5·4	7·4	1

* Bacterial counts in logarithms. Resazurin reduction times in quarter-hour units.

The deterioration in raw cream quality was shown by a sharp decrease in resazurin reduction times and an increase in bacterial counts. This deterioration was also reflected in the quality of the pasteurized cream. The growth of thermoduric organisms during holding of the raw cream can be seen by the total counts of the laboratory-pasteurized product. In both creams the resazurin reduction time after KQ storage becomes less as the quality of the raw cream decreases. The six raw creams were all of poor quality after 2 days' storage and had resazurin reduction times of ¼ or ½ hr. Three of these gave results similar to Sample 1 in Table 4, and three similar to Sample 2. The thermoduric counts of the three pasteurized creams with the low reduction times were higher than those of the other three pasteurized creams.

(c) Effect of Contamination after Pasteurization

In the previous experiments the after-pasteurization contamination was eliminated by subsequent heating in the laboratory. To avoid double heating of the cream a few experiments were made in which raw cream was pasteurized in the laboratory with approximately the same amount of heat treatment as used in the factory, and the results compared with the factory-pasteurized cream. Typical results are shown in Table 5.

The differences between the results of the laboratory-pasteurized raw cream and the factory-pasteurized cream heated again were only slight, although there was a tendency for counts to be slightly lower in the latter. The samples of cream taken from the vat immediately after pasteurization also gave results which were very little different from those obtained on the laboratory-pasteurized cream. In all instances there was the same tendency for total counts to increase, and resazurin reduction times after KQ storage to decrease, with increasing duration of low-temperature storage.

The sample of bottled cream had only slightly higher total bacterial counts than the corresponding counts in the laboratory-pasteurized cream and the cream from the vat. Coliform organisms were either absent or present only in small numbers in 1 ml. However, the organisms present grew very rapidly during KQ storage, resulting in very high bacterial counts and a resazurin reduction time of ¼ hr. The growth during KQ storage is shown in Figure 3. After low-temperature storage, psychrophilic counts in the bottled cream became high, but even before low-temperature storage the keeping quality at 20° was unsatisfactory. At this time there was no indication in the initial tests of the considerable amount of contamination which must have been present to cause the very rapid increase in bacterial count during KQ storage.

Another series of experiments was made in which small numbers of psychrophilic organisms or of coliform organisms were added to laboratory-pasteurized cream. The psychrophiles used were strains of *Pseudomonas* and the coliforms were *Aerobacter aerogenes*. Typical results are shown in Table 6. It can be seen that both the coliform organisms and the psychrophiles decreased the keeping quality, even at the very low level of initial contamination used in these experiments.

TABLE 5

EFFECT OF FACTORY CONTAMINATION ON INITIAL BACTERIOLOGICAL TESTS AND KEEPING QUALITY

Storage Period (days)	Raw—Laboratory-pasteurized			Pasteurized from Vat					Bottled Pasteurized Cream					Pasteurized from Vat—Laboratory-pasteurized		
	TC	After KQ Storage		TC	Coli	Psy.	After KQ Storage		TC	Coli	Psy.	After KQ Storage		TC	After KQ Storage	
		Res.	TC				Res.	TC				Res.	TC		Res.	TC
0	3·7	8	5·6	4·1	<0	<1	5	6·4						3·3	6	5·6
1	4·0	5	6·1	4·8	<0	<1	3	6·8						3·9	5	5·7
2	4·5	4	6·3	5·0	<0	1·7	1	7·0						4·3	3	6·0
3	4·9			5·5	<0	1·8								4·5		
0	3·3	5	6·7	3·6	<0	<1	4	6·0	4·0	<0	1·0	1	8·1	2·9	4	5·5
1	3·9	4	6·8	3·8	<0	<1	3	6·7	4·2	<0	2·5	1	8·8	3·5	3	5·8
2	4·5	3	7·1	4·4	<0	<1	2	6·8	4·7	0·5	3·0	1	8·9	4·4	2	6·0
3	4·6			4·7	<0	<1			5·1	0·6	3·4			4·5		

TC—Total bacterial count per ml in logarithms.

Res.—Resazurin reduction time in quarter-hour units.

Coli—Coliform organisms per ml in logarithms.

Psy.—Psychrophilic organisms per ml in logarithms.

TABLE 6

ADDITION OF COLIFORM AND PSYCHROPHILIC ORGANISMS TO LABORATORY–PASTEURIZED CREAM

Storage Period (days)	Raw—Laboratory-pasteurized			Laboratory-pasteurized cream + coliforms					Laboratory-pasteurized cream + psychrophiles					Laboratory-pasteurized cream + coliforms + psychrophiles				
	TC	After KQ Storage		TC	Coli	Psy.	After KQ Storage		TC	Coli	Psy.	After KQ Storage		TC	Coli	Psy.	After KQ Storage	
		Res.	TC				Res.	TC				Res.	TC				Res.	TC
0	3·3	7	6·7	3·9	1·0	<1	5	7·7	3·5	<0	<1	5	7·6	3·7	1·3	<1	5	8·6
1	3·9	6	6·8	4·2	1·6	<1	4	8·1	4·0	<0	<1	4	7·7	4·2	1·7	<1	3	9·0
2	4·5	4	7·1	4·6	1·9	<1	2	8·3	4·6	<0	1·6	3	7·9	4·7	1·9	1·3	1	9·2
3	4·6			4·6	2·1	<1			4·7	<0	2·3			5·3	2·0	2·2		

TC—Total bacterial count per ml in logarithms.

Res.—Resazurin reduction time in quarter-hour units.

Coli—Coliform organisms per ml in logarithms.

Psy.—Psychrophilic organisims per ml in logarithms.

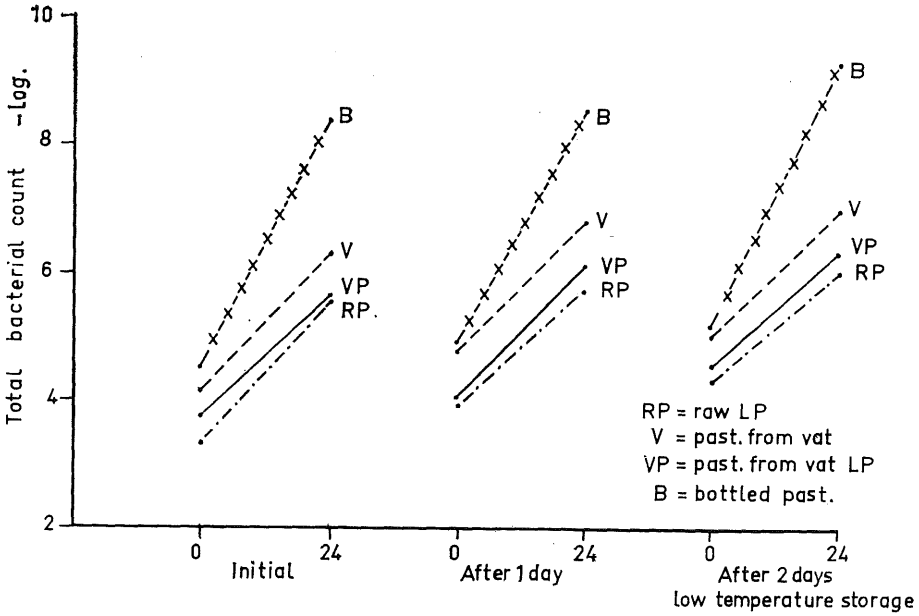

Fig. 3.—Effect of factory contamination on bacterial growth during keeping quality storage.

IV. DISCUSSION

These experiments have shown that low-temperature storage of cream can cause a serious deterioration in keeping quality, although this may not be readily predicted from bacterial counts and tests for coliform organisms. This deterioration occurred to some extent even in creams in which psychrophilic organisms were not detected before KQ storage. This may have been due to the fact that the temperature of storage of the cream was between 5° and 7°, while psychrophilic plates were incubated at a temperature not exceeding 5°. In the range 5-10°C, a small rise in temperature can cause a considerable increase in the types of organisms capable of growth.

Crossley (1948) reported the results of experiments in which pasteurized cream was stored at low temperature for several days. In these experiments there was little indication of deterioration during storage, but the cream samples examined had much lower bacterial counts than those examined in the present experiments.

Some pasteurized cream samples showed large increases in numbers of coliform organisms during low-temperature storage, and isolates from several of these were found to be psychrophilic strains of *Aerobacter aerogenes*.

The increase in bacterial count of the laboratory-pasteurized creams during KQ storage was much less than that in most samples of commercially-pasteurized cream. This is an indication of the relatively slower growth rate at 20° of

thermoduric organisms than of contaminant types. The bacterial count of most samples of commercially pasteurized cream showed a marked increase during KQ storage at 20°C, even when coliform organisms were absent in 1 ml initially and the psychrophilic count was low. The exceptions were samples of pasteurized cream taken from the holding vat straight after pasteurization, where contamination after pasteurization must be expected to be at a minimum.

These results indicated once again that some form of keeping quality test for cream is desirable. A negative coliform test alone was not sufficient indication of freedom from contamination after pasteurization. Although the use of a count of psychrophilic organisms added additional information, particularly for cream which had been stored at low temperature, there were many cream samples which contained a large number of organisms very active at 20° but in which coliforms and psychrophiles were present only in very small numbers. Olsen *et al.* (1953) in their studies on pasteurized milk similarly concluded that standard plate counts, coliform counts and psychrophilic counts on fresh milk are not good indicators of keeping quality.

Although the growth of thermoduric organisms was much slower during KQ storage than the growth of most contaminant organisms, experiments showed that an increase in thermoduric count during deterioration of raw cream caused a considerable decrease in the keeping quality of the pasteurized product.

V. ACKNOWLEDGEMENT

The author wishes to thank Mr. D. Beere for technical assistance.

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(Received for publication March 16, 1964)