EFFECT OF HEAT TREATMENT ON BACTERIOLOGICAL QUALITY AND PHOSPHATASE ACTIVITY OF MARKET CREAM

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SUMMARY

The bacterial count of good quality cream after pasteurization did not vary greatly with increasing intensity of pasteurization until 93°C was used. In the case of poorer quality creams the total count decreased slightly with increasing temperatures of short-time heating. There was no marked relationship between counts before and after pasteurization.

For determining the end-point in keeping quality tests, reduction of methylene blue was found to be unsatisfactory, and reduction of resazurin to the bright pink stage was used. Resazurin reduction time after keeping quality storage showed a general relationship with later deterioration detected by taste and smell.

When the cream was pasteurized at the higher temperatures, the predominant organisms surviving were spore-forming bacteria which produced thickening and bitterness in keeping quality tests.

Storage at low temperatures for up to 3 days did not materially alter the bacterial count, but there was a tendency for keeping quality to be lowered slightly as storage progressed. The temperature of incubation in the keeping quality test markedly influenced the result. An incubation temperature of 22°C for 24 hr appeared to be too high to suit the purposes of the test.

With all intensities of heating, phosphatase tests were always negative immediately after pasteurization, but some samples, especially those treated at lower temperatures, showed reactivation on storage, which was apparently due to bacterial development. With these samples phosphatase activity increased as the time and temperature of storage increased.

I. INTRODUCTION

The bacteriological standards for pasteurized cream in Queensland, which are set out in the Health Acts, 1937 to 1955 (Food and Drug Regulations, 1957), require that the cream shall not contain more than 50,000 organisms per ml, and shall contain no coliform organisms in 1 ml; further that cream shall be heat-treated by an approved process, though no definite temperature requirements are prescribed.

Crossley (1954) presented a comprehensive review of the literature on market cream up to 1954. In all, little work has been published concerning the bacteriology of market cream.

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Hening and Dahlberg (1943) found that cream required slightly longer holding times than milk at temperatures from 62 to 71°C for inactivation of phosphatase and destruction of a relatively heat-resistant strain of *Escherichia coli*. Temperatures of 74 and 77°C gave similar results for both milk and cream. Aschaffenburg, Briggs, Crossley, and Rothwell (1956) determined the time/temperature requirements for the destruction of *Mycobacterium tuberculosis* and phosphatase in cream. These workers found that minimal conditions required in cream were similar to those pertaining in milk.

Although the use of milk pasteurization times and temperatures for the pasteurization of cream appears adequate for destroying coliform organisms and pathogens, flash heating at much higher temperatures is frequently used in an endeavour to produce a cream of very low bacterial count and to improve the keeping quality.

The present investigation was undertaken to obtain information on the bacteriological quality of cream after pasteurization at different time/temperature combinations, and on the effect of organisms surviving pasteurization on keeping quality. The cream in these experiments was kept under aseptic conditions after pasteurization so that there was no possibility of post-pasteurization contamination. Tests showed that coliform organisms, which have a marked influence on keeping quality of cream (Crossley 1948), were absent.

II. METHODS

(i) *Cream Samples.*—In the first series of tests, cream was obtained from the bulk supply of individual farms; in later experiments, from bulk low-acid cream received at a butter factory. The fat content of the creams ranged from 38 to 45 per cent.

The samples of farm cream were laboratory-pasteurized, using 14 different intensities of heat treatment. In the second series, creams were pasteurized at five different time/temperature combinations. Following pasteurization, samples were stored in a refrigerator at temperatures of 5 to 10°C for periods up to 3 days to simulate conditions met with in commercial practice. After low-temperature storage the creams were examined for bacterial count, keeping quality and phosphatase activity.

(ii) *Pasteurization.*—Pasteurization was carried out in 200 ml Erlenmeyer flasks. Care was taken to place the cream at the bottom of the flask without depositing any material on the neck or sides. Heating was achieved by placing the flasks in a basket in a hot-water bath. In order to obtain control of heating, a thermometer was inserted in a control flask of cream and the basket removed when the required amount of heat treatment had been obtained. As only a small amount of cream (80 ml) was heated in each flask, the come-up time was short. After heating, the cream was immediately cooled by transfer to cold running water.

(iii) *Phosphatase Tests.*—Creams were tested for phosphatase by the Aschaffenburg-Mullen test (Aschaffenburg and Mullen 1949), using the carbonate/bicarbonate buffer proposed by Aschaffenburg (1953). Readings were made after incubation for 2 hr at 37°C by comparing the colour developed with the APTW disk suggested by Tramer and Wight (1950).

(iv) *Bacteriological Tests.*—Total bacterial counts were made on tryptone/glucose/beef extract agar (Difco B2) with incubation for 3 days at 32°C. Tests for coliform organisms were made by inoculating 1 ml cream into McConkey's broth and incubating at 32°C for 3 days. Examinations for keeping quality were made by incubating cream at 18, 20 or 22°C and then testing by plate count, dye-reduction tests and organoleptic grading.

Direct counts of phosphatase-producing organisms were obtained by plating cream at suitable dilutions on tryptone/glucose/beef extract agar containing 1 ml of freshly-prepared phosphatase reagent. Colonies of phosphatase-producing organisms gave a clearly defined yellow halo on the plate.

III. RESULTS

(a) Total Bacterial Count Immediately After Pasteurization

Three samples of raw farm cream were pasteurized at 63°C for 30 min, 73, 78, 83 and 88°C for each of 5, 10 and 15 sec, and 93°C for 5 sec. These creams produced similar results, and those for one sample are shown in Table 1.

All pasteurization treatments gave cream with a negative phosphatase test before storage and with a presumptive coliform test negative in 1 ml. Time of heating of 5, 10 or 15 sec produced only slight differences in total count. Heating these creams at 63°C for 30 min, or at 73, 78, 83 or 88°C for up to 15 sec, also gave only small differences in the bacterial count of the pasteurized cream. However, heating at 93°C for 5 sec gave a somewhat lower total bacterial count. The effect of pasteurization temperature on the total bacterial count of these creams can be seen in Figure 1.

Six samples of bulk low-acid cream taken on receival at the butter factory were pasteurized by five different heat treatments: 63°C for 30 min, and 73, 78, 83 and 88°C for 15 sec. Once again coliform tests were negative in 1 ml and phosphatase tests on the freshly pasteurized cream were negative.

The initial plate counts of these raw creams were considerably higher than those of the raw farm creams. The total bacterial counts immediately after pasteurization are shown in Table 2 and in Figure 1. It can be seen that 63°C for 30 min gave a slightly lower count than 73°C for 15 sec, and that increasing the pasteurization temperature from 73 to 88°C gave progressively lower bacterial counts.

TABLE 1

EFFECT OF DIFFERENT INTENSITIES OF HEAT TREATMENT ON TOTAL BACTERIAL COUNT AND KEEPING QUALITY OF PASTEURIZED CREAM INITIALLY AND AFTER STORAGE AT 5–10° C FOR UP TO 3 DAYS*

Pasteurization Treatment	Initial		After Storage at 5–10°C for—					
			1 Day		2 Days		3 Days	
	Total Bacterial Count (log.)	Keeping Quality†	Total Bacterial Count (log.)	Keeping Quality†	Total Bacterial Count (log.)	Keeping Quality†	Total Bacterial Count (log.)	Keeping Quality†
Raw	6·01	..	..	..	..	..	..	..
63° for 30 min	4·10	5	4·19	3	4·24	5	4·31	6
73° for 5 sec	4·42	7	4·33	2	4·23	3	4·34	2
73° for 10 sec	4·35	7	4·23	4	4·36	6	4·33	4
73° for 15 sec	4·45	7	4·32	3	4·38	4	4·37	5
78° for 5 sec	4·46	7	4·41	3	4·29	2	4·39	1
78° for 10 sec	4·43	7	4·45	3	4·35	3	4·31	1
78° for 15 sec	4·46	7	4·40	3	4·44	4	4·38	2
83° for 5 sec	4·50	5	4·41	2	4·32	2	4·43	2
83° for 10 sec	4·48	5	4·36	2	4·36	2	4·30	1
83° for 15 sec	4·58	7	4·49	2	4·34	2	4·35	1
88° for 5 sec	4·28	7	4·23	2	4·13	2	4·27	1
88° for 10 sec	4·30	7	4·31	2	4·26	3	4·38	1
88° for 15 sec	4·37	7	4·42	3	4·32	3	4·30	3
93° for 5 sec	3·15	7	3·18	2	3·15	3	3·48	2

* Results of 1 sample.

† Methylene blue reduction time in ¼ hr units after incubation for 24 hr at 20°C.

TABLE 2

EFFECT OF FIVE DIFFERENT INTENSITIES OF HEAT TREATMENT ON THE TOTAL BACTERIAL COUNT OF BULK CREAM, IMMEDIATELY AFTER PASTEURIZATION AND AFTER STORAGE AT 5–10°C FOR 1, 2, AND 3 DAYS*

Treatment	Total Bacterial Count (log.)			
	After Pasteurization	After Storage for—		
		1 Day	2 Days	3 Days
63° for 30 min	5·08	5·23	5·28	5·37
73° for 15 sec	5·36	5·77	5·79	5·98
78° for 15 sec	4·78	4·82	4·99	4·91
83° for 15 sec	4·58	4·56	4·54	4·54
88° for 15 sec	3·88	3·75	3·87	3·87

* Average results for 6 samples.

TABLE 3

RELATIONSHIP BETWEEN TOTAL BACTERIAL COUNT BEFORE AND AFTER PASTEURIZATION FOR NINE INDIVIDUAL CREAMS

Pasteurization Treatment	Total Bacterial Count (log.)								
	Farm Creams			Bulk Factory Creams					
Raw	4·95	5·23	6·01	5·95	6·90	7·62	7·74	8·45	8·60
63° for 30 min ..	3·81	3·88	4·10	3·98	5·11	5·81	5·42	4·36	5·81
73° for 15 sec	3·88	4·06	4·45	3·84	5·20	6·26	6·04	4·79	6·04
78° for 15 sec	4·00	3·94	4·46	2·90	4·82	5·82	5·41	4·00	5·70
83° for 15 sec	3·95	3·99	4·58	2·78	4·72	5·42	5·06	3·90	5·52
88° for 15 sec	3·98	3·89	4·37	2·30	3·72	5·11	4·58	3·34	4·23

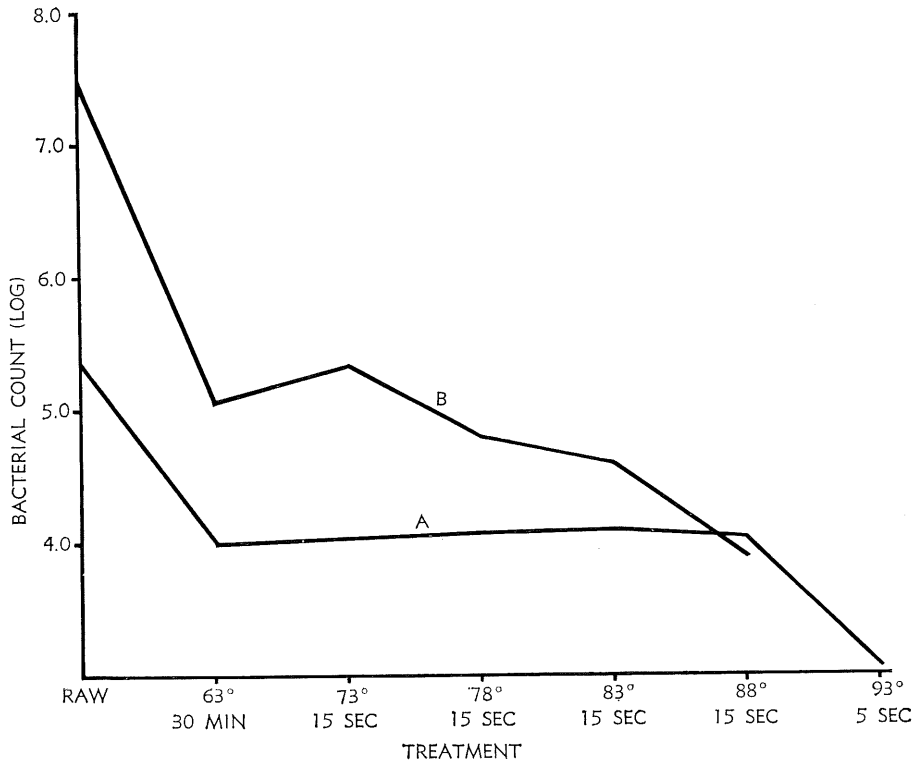

Fig. 1.—Effect of different pasteurization temperatures on total bacterial count. A, farm cream samples; B, bulk cream samples.

The bacterial counts of the individual cream samples before and after pasteurization are shown in Table 3. There was a tendency for the samples with higher counts before pasteurization to give higher counts after pasteurization. However, especially with the bulk creams, which would have a more varied flora than cream samples from individual farms, this relationship was not marked.

(b) Keeping Quality Tests

Attempts were made to use a keeping quality test for cream involving a dye-reduction test after 24 hr storage, similar to the keeping quality test for milk.

In the first series of samples the reduction time of methylene blue after 24 hr at 20°C was determined on undiluted cream. The results of these tests are included in Table 1. However, it was found that this method was not satisfactory. Difficulty was experienced in judging the end-point of the reduction test because the natural colour of the cream reduced the intensity of the methylene blue solution. Increasing the concentration of methylene blue did not overcome the difficulty because it was then noticed that the end-point was very indefinite due to poising before the completion of the change to white.

TABLE 4

RESAZURIN AND METHYLENE BLUE REDUCTION TESTS ON PASTEURIZED CREAM AND CREAM DILUTED WITH STERILIZED MILK, PASTEURIZED MILK AND STERILE TAP WATER

Vol. of Cream (ml)	Diluent	Methylene Blue Reduction Time*						Resazurin Reduction Time*					
		A1	A2	A3	B1	B2	B3	A1	A2	A3	B1	B2	B3
10	..	18	14	2	14	10	0	16	10	1	8	6	0
5	5 ml sterilized milk ..	20	16	3	16	14	3	17	12	1	10	8	1
5	5 ml pasteurized milk ..	20	16	4	16	14	3	18	14	1	10	8	0
5	5 ml water	20	16	2	15	14	2	18	14	2	12	8	0
2	8 ml sterilized milk ..	20	16	4	18	15	7	18	14	2	12	10	1
2	8 ml pasteurized milk ..	22	18	6	18	15	6	20	16	2	14	12	1
2	8 ml water	24	18	3	20	17	4	22	18	3	14	14	2
Controls	10 ml sterilized milk ..		24+			22+			24			18	
	10 ml pasteurized milk ..		24+			22+			24+			20	

* Reduction times in ¼ hr units.

In a later series of samples both methylene blue and resazurin were used as indicator dyes. Tests were made with two pasteurized creams to determine the effect of dilution of the cream sample on the reduction of methylene blue and resazurin. The diluent media tested were good quality pasteurized milk, sterilized milk and sterile tap water. The results of these tests are set out in Table 4. The pasteurized creams were stored for 24 hr at 16, 18 and 22°C in order to obtain samples of different quality within the range expected in the normal keeping quality test. In the resazurin test, readings were taken when the colour became a bright pink, corresponding to Disc 1. From Table 4 it can be seen that dilution of the cream lengthened the reduction time of methylene blue and resazurin. This effect was less marked when sterilized milk was used, and was greatest when sterile water was used.

Dilution of the cream with an equal quantity of any diluent did not improve the colour of the methylene blue test, and although a 1 in 5 dilution did produce a more easily determined colour, poising at the end-point was still very marked. With resazurin the colour was quite distinct in the undiluted cream and there did not seem to be any advantage in diluting the sample. For these reasons, it was decided in the next series to use a keeping quality test based on the reduction of resazurin after storage. This decision was strengthened by the belief that the dilution of cream by the addition of milk or water may alter the natural reducing systems present in the cream.

Samples of cream for keeping quality tests were incubated for 24 hr at each of the temperatures 18, 20 and 22°C. After this time the creams were examined for total bacterial count, taste and smell, and resazurin reduction time. The average results for six creams are shown in Table 5.

The temperature of incubation during the keeping quality test before the addition of dye was found to have a pronounced effect on the test result. This was most noticeable with regard to the resazurin reduction times but it was also apparent that total bacterial counts increased with increasing temperature of incubation. It is therefore apparent that incubation temperature in any keeping quality test must be controlled very accurately.

Organoleptic examination of cream after storage at the three incubation temperatures was made at 24 hr and 30 hr. The relationship between resazurin reduction time and deterioration detected by organoleptic grading is shown in Table 6. All samples showing deterioration had resazurin reduction times of ½ hr or less. In addition, the majority of creams with reduction times of ¼ hr or less showed deterioration in 30 hr. As no deterioration was noted within 30 hr with creams with a reduction time of more than ½ hr, it would appear that the dye reduction test could be used to assess potential deterioration some time before it could be detected by taste and smell.

TABLE 5

KEEPING QUALITY TESTS ON PASTEURIZED CREAM BEFORE AND AFTER LOW-TEMPERATURE STORAGE FOR 1 AND 2 DAYS*
Plate Counts and Resazurin Tests After Incubation at 18°, 20° and 22°C

Treatment	Low Temperature Storage (days)	Keeping Quality Incubation Temperature					
		18°		20°		22°	
		Total Bacterial Count†	Resazurin Reduction Time†	Total Bacterial Count	Resazurin Reduction Time	Total Bacterial Count	Resazurin Reduction Time
63° for 30 min	0	5·94	6·2	6·32	3·2	7·20	1·2
	1	6·45	2·2	7·10	1·2	..	..
	2	6·58	2·7	7·12	1·5	..	..
73° for 15 sec	0	6·76	3·3	7·20	1·8	7·72	0·7
	1	6·92	1·3	7·57	0·8	..	..
	2	7·20	2·2	7·62	1·3	..	..
78° for 15 sec	0	5·58	5·5	6·10	3·0	6·88	1·0
	1	6·14	2·3	6·74	1·5	..	..
	2	6·29	3·3	6·60	1·5	..	..
83° for 15 sec	0	5·05	5·3	5·84	2·7	6·81	1·2
	1	5·70	2·7	6·58	1·2	..	..
	2	5·70	2·8	6·63	1·8	..	..
88° for 15 sec	0	4·56	5·8	5·43	3·2	6·46	1·7
	1	5·29	3·7	6·07	1·5	..	..
	2	5·33	3·5	6·34	1·8	..	..

* Average results for 6 creams.
† Resazurin reduction times in ¼ hr units; bacterial counts in logarithms.

TABLE 6

RELATIONSHIP BETWEEN RESAZURIN REDUCTION TIME TO DISC 1 AND ORGANOLEPTIC GRADING AFTER KEEPING QUALITY STORAGE

Resazurin Reduction Time (hr)	Organoleptic Grading		
	No. of Samples Showing No Change in 30 hr	No. of Samples Showing Deterioration in 30 hr	No. of Samples Showing Deterioration in 24 hr
¾	11	..	..
½	20	6	..
¼	24	48	15
0	9	11	25

Examination of the types of colonies on the bacterial plates made after incubation in the keeping quality test showed that there were two main types of bacteria present: thermoduric organisms such as *Micrococcus* and *Microbacterium* which produced small pin-point colonies, and sporing bacilli. After pasteurization at lower temperatures thermoduric types predominated, but after treatment at the higher temperatures the spore-formers predominated. There were very few thermoduric types in the cream which had been pasteurized at 88°C. Creams which contained large numbers of spore-formers showed gelatinous clotting and developed pronounced bitterness.

(c) Effect of Storage at 5–10°C on Quality

The effect of storage on pasteurized farm cream is shown in Table 1. There was no appreciable change in total bacterial count of any of the pasteurized creams during storage for three days at low temperature. The results of keeping quality tests using reduction of methylene blue as the end-point were inconclusive.

The effect of low-temperature storage on the bacterial counts of pasteurized bulk creams is shown in Table 2. There was a tendency for a slight increase in bacterial counts to occur during low-temperature storage of cream pasteurized at the lower temperatures. This was not the case with one cream sample, which has a relatively low count after pasteurization. It appeared that this sample and the farm creams, which also had relatively low counts, showed no evidence of increasing bacterial count during storage.

The effect of low-temperature storage on the keeping quality tests of bulk creams is shown in Table 5. It can be seen that there is some evidence of reduction in keeping quality after low-temperature storage. Even though bacterial counts showed no increase during low-temperature storage, the bacterial counts determined after further incubation during the keeping quality test tended to increase with increasing duration of low-temperature storage. Resazurin reduction times and also the time taken for the development of bitterness or other signs of deterioration tended to decrease with increasing low-temperature storage.

(d) Phosphatase Tests

Phosphatase tests were made on pasteurized farm creams immediately after pasteurization, and then after storage at one of the following: 5–10°C for 1, 2 or 3 days, 20°C for 1, 2 or 3 days, 30°C for 1 day. A typical set of results is set out in Table 7.

All treatments produced cream with a negative phosphatase test immediately after pasteurization. When cream was stored in the refrigerator, small amounts of phosphatase were produced in some samples giving readings up to 6. When the same pasteurized creams were stored at 20 or 30°C larger amounts of phosphatase were produced, and in many samples readings above the standard of 10 were recorded. The amount of reactivation was greatest in the creams which

TABLE 7

PHOSPHATASE ACTIVITY OF PASTEURIZED CREAM IMMEDIATELY AFTER PASTEURIZATION AND AFTER STORAGE AT 5°–10°, 20° OR 30°C

APTW Disc Readings

Treatment	Immediately after Pasteurization	Storage at 5–10°C for—			Storage at 20°C for—			Storage at 30°C for 1 Day
		1 Day	2 Days	3 Days	1 Day	2 Days	3 Days	
63° for 30 min	0	0	0	0	0	0	0	0
73° for 5 sec	0	0	6	Trace	14	18	18	25
73° for 10 sec	0	6	6	Trace	14	14	14	25
73° for 15 sec	0	0	Trace	Trace	10	10	10	18
78° for 5 sec	0	0	Trace	Trace	10	18	18	25
78° for 10 sec	0	0	0	0	6	10	10	18
78° for 15 sec	0	0	0	0	6	10	10	18
83° for 5 sec	0	0	0	0	6	10	6	18
83° for 10 sec	0	0	0	0	6	6	6	18
83° for 15 sec	0	0	0	0	6	10	6	18
83° for 5 sec	0	0	0	0	0	6	6	18
88° for 10 sec	0	0	0	0	0	6	6	14
88° for 15 sec	0	0	0	0	6	6	6	18
93° fpr 5 sec	0	0	0	0	0	Trace	6	14

received the less severe H.T.S.T. treatments. The relationship between temperature of storage of the cream and phosphatase development suggested that the reactivation was of bacterial origin.

The pasteurized bulk creams were examined by the phosphatase test after storage for either 3 days at 5–10°C or 1 day at 20°C. Two samples showed slight reactivation during storage at 5–10°C, a reading of 10 being obtained after 3 days. None of the other samples showed any reactivation at low temperature. Storage at 20°C for 1 day gave slight reactivation in some samples. The results for five creams pasteurized at each of the five heat treatments are shown in Table 8. The greatest reactivation took place after H.T.S.T. treatment at the lowest temperature. At this temperature (73°C for 15 sec) three of the creams showed some reactivation and one had a disc reading of 25.

TABLE 8

PHOSPHATASE TESTS ON PASTEURIZED BULK CREAMS AFTER STORAGE AT 20° FOR 1 DAY

Pasteurization Treatment	Initially All Creams	After 1 day at 20°C Sample No.				
		1	2	3	4	5
63° for 30 min ..	0	0	6	0	0	0
73° for 15 sec ..	0	0	0	6	10	25
78° for 15 sec ..	0	0	0	0	6	6
83° for 15 sec ..	0	0	0	0	6	0
88° for 15 sec ..	0	0	0	0	0	0

TABLE 9

NUMBERS OF PHOSPHATASE-PRODUCING ORGANISMS IN CREAM SAMPLES SHOWING PHOSPHATASE REACTIVATION

Degree of Reactivation (APTW disc reading)	Phosphatase-producing Organisms (log.)
14	4·70
14	4·95
18	5·26
18	5·30
18	5·78
18	5·85
18	5·90
25	6·84
25	7·08
25	7·15
42	7·00

Eleven samples which showed reactivation after storage were plated on tryptone/glucose/beef extract agar containing p-dinitrophenylphosphate reagent to detect phosphatase-producing organisms. The results obtained are shown in

Table 9. There was a very marked relationship between the numbers of phosphatase-producing organisms present and the amount of phosphatase reactivation. These findings tend to confirm the suggestion that the phosphatase reactivation encountered in these experiments was due to growth of phosphatase-producing organisms. There was no evidence in these experiments of reactivation of a non-bacterial nature.

(e) Sensitivity of the Aschaffenburg-Mullen Phosphatase Test for Cream

Tests were made to determine the sensitivity of the phosphatase test for cream by adding various amounts of raw cream to cream pasteurized by five different temperature treatments. The results of these tests are set out in Table 10.

The presence of 0·1 per cent. raw cream was detected in most instances by the 2 hr phosphatase test, and the presence of 0·2 per cent. raw cream gave a definitely positive result. This sensitivity is of the same order as that of the phosphatase test for milk, and must be considered most satisfactory. It can also be seen from the table that variation in the intensity of pasteurization produced little difference in the test result.

IV. DISCUSSION

In these experiments cream was handled aseptically after pasteurization so that information could be obtained regarding the effect of bacteria surviving pasteurization on keeping quality. Because of the techniques employed post-pasteurization contamination did not occur in these experiments, so the influence of post-pasteurization contaminants has not been considered.

There was little change in bacterial count in the case of the better quality creams due to different intensities of heat treatment up to 88°C. However, with the creams of poorer quality higher temperatures of heating gave slightly lower counts. These results suggest that in the case of flash pasteurization a temperature somewhat above the minimum necessary to ensure destruction of pathogens and coliform organisms may be desirable to impart satisfactory bacteriological quality. However, if the temperature of heat treatment is too high, a cooked flavour frequently develops in the cream. In these experiments a cooked flavour was noticed in cream treated at 88 and 93°C. In cream treated at lower temperatures the cooked flavour was not marked.

It was also found that at higher temperatures of pasteurization there was a predominance of spore-forming organisms which caused bitterness during the storage of the keeping quality tests. Powell (1938) found that the proportions of different types of organisms surviving flash pasteurization varied at different pasteurization temperatures, and that the proportion of peptonizing types increased following higher temperatures of pasteurization. Crossley (1948) also noted that at high summer temperatures proteolytic spore-forming organisms sometimes multiplied rapidly and produced a bitter flavour. In the present experiments it was found that a bitter flavour developed more readily if higher pasteurization

TABLE 10

DETERMINATION OF THE SENSIVITY OF THE ASCHAFFENBURG–MULLEN PHOSPHATASE TEST FOR CREAM BY ADDING SMALL AMOUNTS OF RAW CREAM TO PASTEURIZED SAMPLES

Phosphatase Test	Pasteurization Treatment	APTW Disc Readings (% raw cream)							
		Nil	1	0·5	0·4	0·3	0·2	0·1	0·05
Short test (30 min) ..	63° for 30 min	0	42	18	14	14	10	6	0
	73° for 15 sec	0	42	25	18	18	14	10	6
	78° for 15 sec	0	42	25	18	14	10	6	6
	83° for 15 sec	0	42	18	18	14	10	6	0
	88° for 15 sec	0	42	18	18	14	10	6	0
Long test (2 hr)	63° for 30 min	0	42+	42	25	25	18	10	6
	73° for 15 sec	0	42+	42	42	42	25	18	10
	78° for 15 sec	0	42+	42	42	42	25	14	10
	83° for 15 sec	0	42+	42	42	25	25	14	6
	88° for 15 sec	0	42+	42	42	25	18	14	6

temperatures were used. Pasteurization temperatures in the vicinity of 78 to 83°C for short-time heating would appear to be the most satisfactory for giving good keeping quality.

An attempt was made to use dye-reduction tests after storage for estimating keeping quality. Methylene blue tests proved to be unsatisfactory. The reduction of resazurin to a pink end-point showed promise, and it was found that there was a general relationship between resazurin reduction time and subsequent deterioration detected by taste and smell. Jenkins (1940) adopted a resazurin test for pasteurized cream, but he carried out the test on the fresh cream and not after keeping quality storage. He also recommended the use of the "pink" stage as the end-point of reduction. In the present work keeping quality was determined after storage at 18, 20 and 22°C. Incubation at 22°C in the course of the keeping quality test resulted in creams showing marked deterioration, although these creams kept perfectly well in cold storage for periods up to 4 days. Thus it would appear that a temperature of 22°C was too high. Whether a keeping quality test of this nature at 18 or 20°C could be applied to commercially pasteurized creams, in which post-pasteurization contamination might occur, is a matter which could be determined only after an examination of a large number of samples.

Low-temperature storage over three days produced little effect on the bacterial count of the pasteurized creams, although there was a slight increase in count in the case of creams which possessed poorer quality in the raw state and were pasteurized at the lower temperatures. Crossley (1948) reported no changes in total bacterial count during cold storage for up to four days. He also reported that storage at low temperatures had no effect on keeping quality determined by taste and smell after incubation at 20°C. In these studies there was evidence of slight deterioration in keeping quality due to storage at low temperatures although there was no change in the total bacterial count.

Phosphatase tests were negative immediately after pasteurization at all temperatures used in these tests. However, reactivation of phosphatase occurred on some occasions after storage. Reactivation in cream has been reported previously by several workers (Wiley, Newman, and Whitehead 1941; Brown and Elliker 1942; Barber and Frazier 1943; Posthumus 1952; Ritter 1953). In the present tests it was found that as the severity of H.T.S.T. treatment increased the amount of reactivation decreased, and also that reactivation occurred more rapidly at higher temperatures of storage. These findings are similar to those obtained by Barber and Frazier (1943) and suggest that this reactivation was due to production of bacterial phosphatase. In these tests a simple method for determining a count of phosphatase-producing organisms was used. It was found that large numbers of such organisms were present in samples of cream which showed reactivation. There was no evidence of reactivation of phosphatase enzyme originally present in the cream, as has been reported by other workers. In such cases reactivation has been found to occur more readily after pasteurization at the higher temperatures.

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