AN INVESTIGATION INTO THE MICROBIOLOGY OF MARKET CREAMS

JEAN ROBB
An Investigation into the Microbiology of Market Creams

by

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Thesis presented to the University of Edinburgh for the Degree of Master of Science

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SUMMARY

The legislation covering fresh cream production is discussed with particular reference to the absence of any microbiological control. A brief description of some processing, packaging and marketing methods to which the product may be subject to are given. Facts and figures of cream sales are included because the increase in sales and the absence of any microbiological standard have stimulated the interest of Public Health workers in fresh cream.

Samples of cream on sale to the general public were examined. Of these 250 were "pasteurised", 180 untreated, 50 bottle "sterilised" and 18 ultra heat treated (U.H.T.). Apart from the "sterilised" and U.H.T. creams which were virtually sterile the majority of the creams were of poor microbiological quality. The creams were subjected to pasteurisation in the laboratory and the results showed that the high microbiological counts and numbers of coliforms present in pasteurised creams were due to post pasteurisation contamination.

Microorganisms were isolated and identified from the creams which had been plated on various media at different temperatures. The types of microorganisms present indicated that production methods were poor and that in many cases the creams had not been kept at refrigeration temperatures. The importance of psychrotrophic organisms in creams is discussed.

A review of the position concerning the phosphatase test as applied to pasteurised cream is presented.
DEFINITIONS

Cream

The word "cream" in this thesis refers to 'Real Cream' or 'Dairy Cream'; defined in 'Emulsifiers and Stabilisers in Food Regulations, 1962' as 'that part of milk rich in fat which has been separated by skimming or otherwise', and which is intended for sale for human consumption.

Untreated cream

"Untreated cream" means cream which has not been treated by heat or in any manner likely to affect its nature and qualities and which has been derived from milk which has not been so treated.

Pasteurised cream

"Pasteurised cream" means cream which has been subjected to heat treatment so as to pasteurise it or has been produced from pasteurised milk.

Sterilised cream

"Sterilised cream" means cream which has been subjected to a process of sterilisation by heat treatment in the container in which it is to be supplied to the consumer.

Ultra heat treated cream

"Ultra heat treated cream" means cream which has been subjected in continuous flow to an appropriate heat treatment and has been packaged aseptically.
Food and Drugs

The Milk (Special Designations) (Scotland) Order 1965.

Bacteriological Standards for:-

a) "Premium" milk - Any sample of milk taken after it has been cooled (to 45°F (7.2°C)) but before delivery to the consumer shall, on being tested in accordance with the provisions of Schedule 5 to this Order, be found to contain not more than 15,000 bacteria per millilitre and
b) no coliform bacteria in one hundredth of a millilitre.

b) "Standard" milk - Any sample of milk taken after it has been cooled (to 50°F (10°C)) but before delivery to the consumer shall on being tested in accordance with the provisions of Schedule 5 to the Food and Drugs, The Milk (Special Designations) (Scotland) Order 1965, be found to contain:
   a) not more than 50,000 bacteria per millilitre,
   b) no coliform bacteria in one thousandth of a millilitre.

c) "Pasteurised" milk - Any sample of milk taken after it has been pasteurised but before delivery to the consumer, on being tested in accordance with the provisions of Schedule 5 to this Order shall:-
   a) on submission to a phosphatase test give a reading not exceeding 10 ug of p-nitrophenol/ml of milk, and
   b) be found to contain no coliform bacteria in one hundredth of a millilitre.

d) "Sterilised" milk - Any sample of the milk on being tested in accordance with the provisions of Schedule 5 to this Order, shall satisfy the turbidity test.

e)
e) "Ultra Heat Treated" milk - Any sample of milk taken after it has been treated by the ultra high temperature method but before delivery to the consumer shall, on being tested in accordance with the provisions of Schedule 5 to this Order (Amendment 1966), be found to contain not more than 1,000 bacteria per millilitre.
SECTION 1

Introduction
The last cream survey in Scotland was carried out during the winter of 1938–39 by the Dairy Bacteriology Department of the West of Scotland College of Agriculture on the keeping quality and bacteriological condition of a number of creams purchased in a large town in south west Scotland.

Smillie (1949) advised in his address to the Society of Dairy Technology on the topic 'Preparing for the cream Market' - "New regulations are advisable in the general trade and public interest and new appropriate laboratory procedures may be required for maximum control of hygienic quality." When Smillie gave this address there were no regulations covering chemical quality, heat treatment or bacteriological quality of cream. Twenty years later what is the position? There are regulations covering minimum butter fat content, i.e. Food and Drugs, Composition and Labelling, The Cream (Scotland) Regulations 1970.

Hygienic preparation of cream is covered in the Milk and Dairies (General) Regulations, 1959, and also by the Milk and Milk Products Technical Advisory Committee's 'Code of Hygienic Practice for Cream'. There are, however, no bacteriological standards laid down for cream. The Milk Special Designations (Scotland) Order 1965 which deals with the licencing and statutory tests for milk does not include cream. Therefore, the present situation is that although cream must be produced under hygienic conditions, a licence to produce cream is not required and there are no bacteriological standards to which cream must conform. This causes concern; firstly, because of the possible presence of pathogenic bacteria in cream and secondly, for problems of keeping quality. Furthermore, the absence of a satisfactory test of efficient pasteurisation of cream poses/
poses a problem of control.

The object of the work presented here was to gain information about the quality of cream on sale today, its microbiol flora, and to investigate tests and methods that might prove of value for future standards of control.

Before considering the microbiology of a product it is advisable to examine the conditions under which it is produced hence the inclusion of sections on the processing, packaging and marketing of cream.
Crossley & Rothwell (1954): "It is generally recognized that successful marketing depends upon the bacteriological quality of the raw cream, the efficiency of heat treatment, avoidance of post heating contamination, and the minimum exposure to high temperatures during distribution."
4.

PROCESSING

Appended is a copy of the "Draft Code of Hygiene Practice for Cream", recommended by the Milk Hygiene Sub-committee of the Milk and Milk Products Technical Advisory Committee. (Appendix 1)

The following paragraphs describe the methods used for cream in and around the Edinburgh area.

UNTREATED CREAM

Although the majority of creams sold are subject to some form of heat treatment, a small quantity is sold untreated. Two out of the seven sources of cream examined in this survey were untreated at the start of sampling. One producer later pasteurised the milk by the Holder method, i.e. 145°F for 30 minutes, before separating the cream.

Source A

Milk for cream production was Standard grade milk which arrived at the dairy in 10 gallon cans. The cans were placed in an electrically operated boiler where the temperature of the milk was raised to 85° - 90°F. At this point the milk was tipped into the separator and the cream was extracted at a fat percentage of 48. The cream was collected from the separator into 10 gallon cans which, once filled, were placed in a chilled water bath until the temperature of the cream had fallen to 40°F. Some cream for sale to restaurants and shops was filled into 2 or 5 gallon cans while the rest was retailed in 5 oz. or ½ pint cartons. The latter were filled by hand, using an aluminium jug. On most occasions the cream was separated in the morning, packaged and held in a cold store at 40°F until the next day when it was despatched to the retailers or to householders.

Source B/
At the beginning of the survey this dairy received milk of Standard designation in 10 gallon cans and treated it in the same manner as at Source A up to separation point. Thereafter the cream coming off the separator was filled directly from the cream spout into retail containers i.e. cartons and or cans depending on the orders. These vessels were immediately placed in a cold store at 40°F and kept there for 24-28 hours before retailing.

**HEAT TREATED CREAM**

Source C

This was the only creamery which pasteurised the separated cream. The supply of milk of Standard designation came in road tankers of 1,500-4,000 gallon capacity. On arrival at the creamery the milk was pumped from the tankers into holding tanks. When the cream processing plant was ready, the milk was drawn from the holding tank and preheated to 100°F before being clarified and then separated to give 40% or 48% butter fat cream. The cream was then pasteurised at 160°F for approximately 20 seconds in a plate pasteuriser and cooled to 40°F. From the pasteuriser the cream was piped to a stainless steel "ageing" tank where it was held at 40°F for 24 hours. When 24 hours had elapsed the cream was piped into cans or cartoned by machine. The cans and cartons were placed in cold store at 40°F until delivered to householders or retailers.

Sources D, E & F

The methods used by creameries D, E and F were similar. Milk, again of Standard designation, was pasteurised by a high temperature - short time (H.T.S.T.) process. After pasteurisation at 161°F for 15 seconds, the milk was drawn off the regeneration section of the plant at approximately/
approximately 95°F and piped to a separator.

In two creameries the cream was cooled by passing over a cascade type water cooler, to approximately 40°-45°F. Using this method in the summer has disadvantages because it is not possible to get the temperature any lower than 50°-60°F. The other creamery cooled the cream by means of a two stage cascade cooler; one half of the cooler was cooled by water, the other part by direct expansion. By this method it is possible to cool the cream all year round to approximately 40°-45°F.

After cooling, the cream was then transferred in 10 gallon cans to small holding tanks and allowed to age for 24-28 hours, then filled manually into cans or cartons as required.
PACKAGING

A survey was carried out in October 1965 by the Scottish Milk Marketing Board into the size and types of cream containers on sale. The results are shown below as percentages.

<table>
<thead>
<tr>
<th>Container size</th>
<th>Bottles</th>
<th>Cartons</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 pint</td>
<td>2.7</td>
<td>2.0</td>
<td>4.7</td>
</tr>
<tr>
<td>1/3 &quot;</td>
<td>3.1</td>
<td>8.5</td>
<td>11.6</td>
</tr>
<tr>
<td>1/2 &quot;</td>
<td>5.5</td>
<td>-</td>
<td>5.5</td>
</tr>
<tr>
<td>6 oz.</td>
<td>-</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>5 &quot;</td>
<td>4.7</td>
<td>52.9</td>
<td>57.6</td>
</tr>
<tr>
<td>4 &quot;</td>
<td>8.6</td>
<td>5.9</td>
<td>14.5</td>
</tr>
<tr>
<td>3 &quot;</td>
<td>-</td>
<td>4.7</td>
<td>4.7</td>
</tr>
<tr>
<td>2 1/2 &quot;</td>
<td>-</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2 &quot;</td>
<td>-</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

The above figures show that the 5 oz. carton is in greater demand. Whether this is due to popularity with a) the public, b) the producer, or c) the carton manufacturer one can only speculate.

In Scotland only 46% of the fresh cream produced is sold directly to the public. The remaining 54% is sold to bakers and to caterers. The cream for these sales was normally filled into 1 - 2 gallon 'sterile' aluminium tins with tight fitting lids, or into 2 - 10 gallon churns made of aluminium or a steel alloy. New containers are now (1971) being tried out. These are 'Bag and Box' type packs available in 1 - 2 gallon sizes which/
which consist of an inner twin ply 150 gauge polythene bag and a
corrugated fibre board outer box. The advantages for processor and user
are a) no return problems, b) no cleaning or can repairs and c) easier
handling and dispensing. Moreover, the packs are lighter, cleaner and
easier to handle than churns. Waterproof starch adhesive is used in the
manufacture of the outer casing in order to combat moisture effects in
storage and use. With the case packed on its side to avoid pressure on
the outer, the fluting of the corrugated board runs vertically to give
maximum crush resistance. Microbiologically these packs are expected to
be more satisfactory than churns which, if improperly cleaned, are a
potential source of contamination.

The majority of creams examined for this work were those in cartons
on sale to the housewife or those about to go on sale. The quantities
varied from 2 oz. to 1 pint and the most popular type of cartons or tubs
were made of moulded polystyrene with heat sealed foil lids. Now that
the early fears of tainting have been overcome by the provision of
specially prepared polystyrene with a low monomer content, this plastic
appears to be satisfactory for such use. Materials other than poly-
styrene such as polypropylene have been proposed, but although tougher,
more heat resistant with better moisture and other barrier properties,
they would be more expensive to produce. Other types of cream investi-
gated were 'Sterilised' and 'U.H.T.' creams. The 'Sterilised' cream
purchased was bottled; tins of cream were not investigated. 'U.H.T.'
creams were from one source only and had been aseptically filled into
Tetrapaks of a laminate of paper and polythene.

One source of deep frozen cream was discovered. In this instance
the container was a 4 oz. polythene bottle with a metal cap.
MARKETING

Processed cream is a more lucrative product per gallon of milk than either butter or cheese. The demand, however, is small in comparison. Approximately 60% of British households never buy cream. There is therefore a large potential market to be exploited.

The marketing of cream is quite different from that of milk since the day to day fluctuations in demand are extremely irregular. There is also a seasonal demand, such as at Christmas, during the soft fruit season and to a lesser extent at Easter.

Approximately 60% of the weekly production of cream is sold at the weekend. Therefore the producer is faced with the problem of marketing in good condition to the consumer, a highly perishable product with an irregular demand.

In the case of the small producer retailer the practice of ageing for 24 hours which is carried out to improve the physical state of high fat cream may be useful as a means of accumulating stocks to meet peak demands. The large scale producers are however in the position where they do not have to accumulate stock to meet trade demand, therefore ageing to them is more of a hazard (microbiologically) and an encumbrance (economically). To ease the existing marketing problems it is imperative that the cream produced be as free as is practically possible from microbial contamination if it is to reach the consumer in a palatable form.

Further problems are encountered in the retailing of cream. In many shops the creams are not necessarily put immediately into refrigerators and because of the small size of the container temperature changes are rapid. Also, there are no regulations stating that the containers must have the date of production on them and creams may be anything from 4 to 14 days/
days old when sold.

**Cream Sales**

During the war years 1940 to 1943 and up to 1953, except for a seven week period in 1951, sales of cream were prohibited. In 1953 production of cream for the liquid cream market was permitted and butter fat standards were laid down. These were:

- Double cream to be not less than 48% butter fat
- Single cream " " 18% " "
- Sterilised cream" " 23% " "

Since then cream production has risen steadily; for example, in 1954 home (U.K.) production was 14 million gallons and by 1968 it had reached 145 million gallons. Consumption of 40% butter fat cream per head of the population was 1.5 lb per annum pre-war and in 1969 3.0 lb per head per annum.

Figures for home production and imports of cream for the years 1967-1969 are given. Figures for 1938 are included for comparison.

**United Kingdom Production and Imports of Cream**
(extracted from United Kingdom Department of Fisheries and Food 1970)

<table>
<thead>
<tr>
<th>Year</th>
<th>Fresh Cream '000 tons</th>
<th>%</th>
<th>Sterilised Cream '000 tons</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969</td>
<td>Home Production</td>
<td>54.2</td>
<td>95</td>
<td>15.7</td>
</tr>
<tr>
<td></td>
<td>Net Imports</td>
<td>2.8</td>
<td>5</td>
<td>9.2</td>
</tr>
<tr>
<td>1968</td>
<td>Home</td>
<td>50.8</td>
<td>96</td>
<td>14.1</td>
</tr>
<tr>
<td></td>
<td>Imports</td>
<td>2.2</td>
<td>4</td>
<td>8.7</td>
</tr>
<tr>
<td>1967</td>
<td>Home</td>
<td>42.4</td>
<td>96</td>
<td>13.5</td>
</tr>
<tr>
<td></td>
<td>Imports</td>
<td>2.1</td>
<td>4</td>
<td>8.9</td>
</tr>
<tr>
<td>1938</td>
<td>Home</td>
<td>19.5</td>
<td>94</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>Imports</td>
<td>1.2</td>
<td>6</td>
<td>1.4</td>
</tr>
</tbody>
</table>
11.

If one classifies cream by its butter fat percentage there are four main types of cream on sale in Edinburgh.

1) Single cream  
   18% butter fat

2) Double cream  
   48% " "

3) Whipping cream 
   35-40% " "

4) Sterilised 
   23% " "

A small percentage of cream is sold untreated; the rest receives some kind of heat treatment, either pasteurisation, U.H.T. (Ultra high temperature) or 'Sterilisation'. These treatments plus the different butter fat percentages give variety to the cream market, as shown below.

<table>
<thead>
<tr>
<th>Butter Fat Percentage</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>18%</td>
<td>Untreated, Pasteurised or U.H.T.</td>
</tr>
<tr>
<td>23%</td>
<td>Sterilised</td>
</tr>
<tr>
<td>35-40%</td>
<td>Pasteurised or U.H.T.</td>
</tr>
<tr>
<td>48%</td>
<td>Untreated or Pasteurised</td>
</tr>
</tbody>
</table>

Regulations permitting the sale of whipping cream were introduced in 1970 (The Cream (Scotland) Regulations, 1970). A copy of these regulations is appended. Appendix 2.
# CREAM

## Facts & Figures

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross milk production</td>
<td>2,669</td>
<td></td>
<td>2,720</td>
<td>2,718</td>
<td>2,837</td>
</tr>
<tr>
<td>Fed to stock</td>
<td>184</td>
<td></td>
<td>185</td>
<td>185</td>
<td>189</td>
</tr>
<tr>
<td>Waste</td>
<td>5</td>
<td></td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Output for human consumption</td>
<td>2,480</td>
<td></td>
<td>2,530</td>
<td>2,528</td>
<td>2,643</td>
</tr>
<tr>
<td>Total liquid consumed</td>
<td>1,726</td>
<td></td>
<td>1,726</td>
<td>1,738</td>
<td>1,750</td>
</tr>
<tr>
<td>Cream fresh (M.M.B. sterilised)</td>
<td>102</td>
<td></td>
<td>115</td>
<td>128</td>
<td>138</td>
</tr>
<tr>
<td>Cream - on farm</td>
<td>4</td>
<td></td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

## Advertising expenditure: (£ thousand)

<table>
<thead>
<tr>
<th></th>
<th>England &amp; Wales</th>
<th>Scotland</th>
<th>Northern Ireland</th>
<th>United Kingdom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>2,164 2,043</td>
<td>103 156</td>
<td>33 38</td>
<td>2,300 2,237</td>
</tr>
<tr>
<td>Cream</td>
<td>435 440</td>
<td>20 24</td>
<td>4 5</td>
<td>459 469</td>
</tr>
<tr>
<td>Cheese</td>
<td>157 286</td>
<td>1 1</td>
<td>12</td>
<td>158 299</td>
</tr>
</tbody>
</table>

## Consumption per head: lb/head/annum.

<table>
<thead>
<tr>
<th></th>
<th>Pre-war</th>
<th>1966</th>
<th>1967</th>
<th>1968</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid milk (pints per head per annum)</td>
<td>168</td>
<td>251</td>
<td>251</td>
<td>249</td>
</tr>
<tr>
<td>Cream (at 40% B.F.)</td>
<td>1.5</td>
<td>2.5</td>
<td>2.7</td>
<td>2.8</td>
</tr>
</tbody>
</table>

0.49% of total food expenditure (out of 16.52% spent on D.P.) is spent on cream, i.e. 2.24 pence per head per week.

Total. All Foods. 454.64 pence (37/10\(\frac{3}{4}\)d).
Approx. no. of gallons of milk at 3.8% fat to produce 1 gall. cream

<table>
<thead>
<tr>
<th>Type of Cream</th>
<th>Approx. Gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double cream 48% fat</td>
<td>12.7</td>
</tr>
<tr>
<td>Single cream 18% fat</td>
<td>5.0</td>
</tr>
<tr>
<td>Sterilised cream 23% fat</td>
<td>6.3</td>
</tr>
<tr>
<td>Whipping cream 35% fat N.I.</td>
<td>9.4</td>
</tr>
</tbody>
</table>

Imports

<table>
<thead>
<tr>
<th>Country</th>
<th>Fresh Cream</th>
<th>Sterilised Cream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irish Republic</td>
<td>2,218 tons</td>
<td>250</td>
</tr>
<tr>
<td>Commonwealth</td>
<td></td>
<td>240</td>
</tr>
<tr>
<td>(other than A, C. &amp; N. Z.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>8,229</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Cream

<table>
<thead>
<tr>
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<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Home prod.</td>
<td>30.8</td>
<td>47.4</td>
<td>42.5</td>
<td>19.5</td>
<td>14.1</td>
<td>13.5</td>
<td>13.4</td>
<td>6.9</td>
</tr>
<tr>
<td>Net Imports</td>
<td>2.2</td>
<td>2.1</td>
<td>2.0</td>
<td>1.2</td>
<td>8.7</td>
<td>8.9</td>
<td>9.1</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Home production of cream has risen from 14 million gallons in 1954 to 145 million gallons in 1968. Imports risen from 2-6% (Fresh cream).

Sterilised cream H 10%-20%. Imp. 1-12%.

0.60 oz. per week per person 1966
0.58 " " " " 1965
0.38 " " " " 1960

Proportions of householders buying cream in any week has increased from 17% in 1960 to 25% in 1966. Average size of purchase per buying household has increased from 6.6 oz. to 7.5 oz.
SECTION 2

General Survey
The very word 'cream' conjures up visions of perfection; such an illusion is rapidly shattered when a microbiologist looks at cream.

In the development of heat treatment processes to prolong keeping quality and in microbiological studies, cream has lagged far behind milk (except when used in the butter making industry). Microbiologists examining cream for butter making stress the importance of a) lipolytic organisms b) coliform organisms and c) yeasts and moulds, while those working with cream for the liquid market have generally adopted the tests already in use for milk, i.e. a) colony count on milk agar b) presumptive coliform test and c) dye reduction tests, i.e. methylene blue or resazurin.

There is considerable controversy about the use of these tests for interpreting keeping and bacteriological quality of cream as it is processed and distributed at the present time. It is illuminating to note the suggestions made by various workers quoted below.

Crossley (1946) studying the significance of the presumptive coliform test in dairy products (which included cream) states that "The test is believed to be of great utility in the plant-control laboratory but of little value for public health purposes." In 1948 Crossley published the results of a 10 year survey of cream processing at a large country depot where approximately 2700 samples of cream were examined. He found that none of the usual routine control tests were satisfactory. Results from the methylene blue test were unreliable and did not correlate well with the actual keeping quality of the cream. A rapid test was devised using sterile milk and bromo-cresol purple. Crossley found this a useful test for estimating the potential keeping quality of creams for distribution. It was also noted that, although colony counts and coliform/
coliform tests were found to be of value as a check of plant hygiene, the colony count was not an index to keeping quality and failed to reveal significant qualitative differences between samples. The coliform test results were much closely related to keeping quality and revealed much finer distinctions. A disadvantage of the coliform test used at that time was the lengthy incubation period of 2 days or more at 37°C.

Smillie (1949) points out the difficulties of applying a coliform test to cream on sale in the shops because there is no control on the age of the cream and coliform organisms find cream a favourable medium even at 46°F. He suggests the use of a modified methylene blue test such as that used for ice cream in Britain. This, of course, only indicates the reducing power of the cream – presumably of organisms in the cream which can reduce methylene blue (MB). Not all do this.

More recently, 1958, a report of a Public Health Laboratory Service (PHLS) working party on the bacteriological examination and grading of retail cream in England and Wales described a modified methylene blue (MB) test for this purpose. The working party concluded that this test was a useful method of assessing the degree of bacteriological contamination and the keeping quality of fresh cream. Work of another PHLS committee was published in 1966 corroborating the previous observation and stating that there was a general correlation between the methylene blue reduction times and the numbers of bacteria, including coliform organisms. (Thomas (1970) states these claims were not supported by statistical analysis.) It is of interest to note at this point that the tests which were compared with the methylene blue test were a) colony counts on blood agar using the Miles and Misra (1938) technique and incubated/
incubated at 37°C for 48 hr. b) coliform test using McConkey's bile salt broth incubated at 37°C for 48 hr. During this investigation *Brucella abortus* was cultured from 3 samples of raw cream and the ability of pathogens to grow in cream was demonstrated. Other PHLS workers Barrow et al. (1968) also isolated *B. abortus*. This plus the fact that out of 540 samples examined, 223 reduced methylene blue by the end of the preincubation period, 90 more in ½ to 2 hr., 46 in 2½-4 hr. and 181 took over 4 hr. The poor creams had high colony counts, very often contained coliform organisms and occasionally faecal coli. One hundred and thirty seven had counts of over 1 million/g. The news caused alarm in the public health mind and interest in the dairying mind.

Some of the interest rubbed off on Davis (1969) and prompted him to carry out an investigation on the microbiological examination of cream. The creams used were "pasteurised and cartoned by good equipment in good dairies in the south of England". The samples were examined by a) methylene blue, b) colony count at 30°C and 37°C (i.e. plate count on milk agar) and c) the presumptive coliform test at 30°C and 37°C and faecal coli tests every 24 hours to follow the microbiological degradation of the samples. Davis concluded that, in general, bad methylene blue tests are well correlated with poor colony count and coliform tests although moderate and good methylene blue tests are not well correlated with the other tests. Also it cannot be assumed that a bad methylene blue test means that the sample is a bad one, whereas a bad plate count, and especially a bad coliform test, is a reliable assessment of the hygienic quality of the product. A bad methylene blue test may simply mean that the cream contains a few harmless spore-formers which grow rapidly at 20°C and are strong reducers of the dye. While being reluctant to suggest possible/
possible legal microbiological standards for cream due to lack of information, the writer suggests advisory standards using the colony count and presumptive coliform test at 30°C (standards are also given for 37°C possibly for use in medical laboratories; these standards are approximately 5 times higher than these at 30°C e.g. 10,000 organisms/gm at 37°C to 50,000 organisms/gm at 30°C.) From the health point of view Davis urges that pasteurisation is a simple way of making cream safe from such bacteria as B. abortus, Salmonella etc and that the same control at present exercised over milk should be applied to cream.

Rothwell (1969) while being aware of the findings of the various PHLS workers believed that "a considerable percentage of cream is of the highest quality." The misinterpretation of the methylene blue test is blamed for some of the cream producers problems and a suggestion is made that resazurin may be used instead of methylene blue – in the modified test – as a control test.

A review of the literature on psychrotrophic micro-organisms in market cream was published by Thomas (1970). Recommended tests and standards are given at the end of the review: no suggestions are made for legal standards but the following tests are proposed for a) creamery laboratories b) investigational or advisory purposes c) routine purposes i.e. a) violet red bile agar count at 30°C for coliform organisms and organoleptically determined keeping quality b) total count on a suitable medium such as Yeastrel with agar incubated at 25°C for 5 days, and the psychrotrophic colony count on this medium incubated at 7°C for 10 days c) incubation of plates at 30°C for 4 days would provide a sound enough estimate of the total bacterial content, while an indication of the psychrotrophic bacterial content could be quickly obtained by the micro-colony/
colony count method at 7°C.

Recently Henderson et al (1971) state that (this time supported by statistical analysis) "the methylene blue test, in spite of some anomalies, is of more use as a screening test than any of the others. As this test is cheap and easy to carry out, the working party thought it should be the test of choice. In view of the known anomalies, however, the working party recommends that the test should remain a screening or advisory test and have no penal function." From 3417 fresh creams examined Staphylococcus aureus, of animal origin, was isolated from 59 samples (54 of these were untreated cream). Other human pathogens isolated included one each of Salmonella typhimurium, Brucella abortus, Escherichia coli type 0126 and Clostridium welchii.

The above review illustrates the state of present day cream testing. In this thesis creams are examined over a period of 3 years using methods which should show whether or not these creams were produced and marketed under hygienic conditions. The effect of laboratory pasteurisation on cream is examined. The growth of lipolytic organisms at 30°C and 5°C before and after laboratory pasteurisation are studied.

Little or no work has been done on the effect of laboratory pasteurisation on the microflora of cream. A study has also been made of the numbers of lipolytic organisms in cream, their heat resistance and ability to grow at low temperatures.

A review is given at the end of the thesis on testing for efficient heat treatment of cream explaining the problems involved.
SOURCES OF UNTREATED AND PASTEURISED CREAMS

Excepting two sources, samples were bought from shops in Edinburgh. The two exceptions were:-

a) Samples from a retail producer of untreated cream who delivered samples weekly to the laboratory on his way into Edinburgh with supplies.

b) Samples from a dairy farmer who bought pasteurised cream in bulk from a creamery and cartoned it at the farm. This farmer was in the habit of delivering milk samples regularly to the laboratory for bacteriological examination.

180 untreated and 250 heat treated creams were examined.

TREATMENT OF SAMPLES

Samples if not tested immediately on arrival at the laboratory were placed in cold storage at 5°C. The period of time they were kept at 5°C was never longer than 6 hours.

Before testing the cream samples were mixed. Due to the varying viscosities of creams adequate mixing of the samples and maintenance of the original flora posed a problem. Several methods were tried as follow:-

a) Shaking sample 50 times and stirring with a sterile glass rod 25 times.

b) Shaking sample 25 times, placing in a water bath at 35°C-40°C for 10 minutes and stirring with a sterile glass rod 25 times on removal from the water bath.

c) Shaking sample 25 times, placing in a water bath at 35°C-40°C for 10 minutes and shaking 25 times on removal from the water bath. (This method/
Method showed its disadvantages almost immediately when large numbers of air bubbles became entrapped.)

d) British Standard Methods 4285:1968 Supplement No. 1 (1970). "Liquid cream varies in viscosity. Only in the case of thin cream can the first dilution be prepared by pipetting the cold sample. Thicker liquid cream, other than highly homogenised cream, may be pipetted after first warming in a water bath at 45°C for a few minutes."

Gently stir the sample with a sterile spoon or spatula and then pipette 1 ml. of cream into 9 ml. of 2% sodium citrate solution using a 1 ml. cream pipette. Before transfer remove any cream on the outside of the pipette by wiping with a sterile filter paper. After discharging the contents into the diluent, suck up and down a few times to ensure that any cream adhering to the inside of the pipette is also transferred.

e) Northern Ireland regulations - the cream sample shall be placed intact into a water bath maintained at a temperature of not less than 35°C and not more than 40°C for a period of not less than 20 minutes and of not more than 30 minutes. The sample shall be well mixed and 10 grammes shall then be weighed into a dilution flask containing not less than 89 millilitres and not more than 91 millilitres of diluent at a temperature of not less than 35°C and not more than 40°C and the contents thoroughly mixed.

Method (a) yielded satisfactory results except with extremely viscous creams. In such cases the glass rod stood perpendicularly in the cream without aid. It was also impossible to pipette such creams using this method.

Method/
Method (b) was finally selected for use in this work.

After mixing the cream the sample was split, one part for immediate testing and the other for laboratory pasteurisation at $63.0^\circ C$ for 35 minutes prior to testing.

On the first part of the sample the following tests were carried out:-

1) Total count on milk agar (M.A.) incubated at $30^\circ C$ for 3-6 days and at $5^\circ C$ for 7-10 days.

2) Count of coliform organisms on violet red - bile agar (VRBA) incubated at $30^\circ C$ for 18 hours.

3) Count of coliform organisms in MacConkey's bile salt broth incubated at $30^\circ C$ for 3 days.

4) Number of lipolytic organisms on Tributyrin agar (Oxoid) (TA) and nutrient Tributyrin agar (NTA) incubated at $30^\circ C$ for 3-6 days and also on the same media incubated at $5^\circ C$ for 7-10 days.

5) Number of yeasts and moulds on a selective medium both at $30^\circ C$ for 3-7 days and at $5^\circ C$ for 7-10 days.

6) Methylene Blue Test as used by the Public Health Laboratory Service. Dilute cream held at $20^\circ C$ for 17 hr and thereafter at $37^\circ C$ for 4 hours.

7) Resazurin Test - as for Methylene Blue Test.

8) K.Q. in Crossley's medium (1948). Milk - 0.01% bromocresol purple. One ml. cream added to 10 ml. sterile BCP milk incubated at $30^\circ C$ and inspected after 16-17 hours and again at 24-25 hours.

9) Isolation of pathogenic organisms.

a)/
a) Salmonella by enrichment in selenite broth incubated for 24 hr at 37°C followed by plating on Desoxycholate citrate medium.

b) Brucella using the World Health organisation medium.

c) Staphylococci using the Baird Parker medium.

d) Streptococci (haemolytic) by plating on blood agar.

e) *Escherichia coli* by MacConkey's broth incubated at 44°C. After laboratory pasteurisation the tests 1 to 8 were repeated using lower dilutions.

**Laboratory pasteurisation**

Approximately 15 ml. of the mixed cream sample was pipetted into a sterile test tube and, before inserting the sterile rubber bung, the cream at the top of the tube was charred in the bunsen flame to ensure that no organisms should escape pasteurisation. The tube, now stoppered, was placed in a water bath controlled at 63.0°C, first checking that the water level was well above the level of the cream in the tube, and was held for 35 minutes. The tube was then removed and immediately cooled to 40°C and tests 1 to 8 immediately carried out.

**Isolation and identification of organisms** present on milk agar and nutrient tributyrin agar incubated at 30°C and 5°C.

After incubation every colony on a suitable plate from a random selection of samples was isolated. Each colony was picked into a tube of litmus milk containing 0.25 glucose and 0.25% yeastrel and the cultures were incubated at 30°C.
Weight versus volume

In the literature some bacteriological results are given per gramme, e.g. Colenso et al. (1966), Barrow and Miller (1968), Hutchison et al. (1968) and Gerken et al. (1968), while Crossley (1948), Smillie (1949), Lightbody (1966) and Cox (1970) express their bacterial counts per millilitre. Davis (1969) in his microbial examination of cream suggests bacteriological standards per millilitre whereas Thomas (1970) in his review of psychotrophic micro-organisms in market cream recommends standards per gramme.

In the course of the work presented here the author tried both methods and decided on the volumetric method. Used in conjunction with mixing method (b) it gave consistent results. Logically there is little to choose between the methods; the deciding factor was a dislike of weighing and the extra work it entailed.

10 ml. of cream was extracted and pipetted into 90 ml. of diluent which had been warmed to 35° - 40°C. Further dilutions were also warmed. If this treatment was not carried out the fat solidified on the sides of the test tube. Dilutions ranging from $1^2$ to $10^8$, $10^1$ to $10^7$, $10^1$ to $10^4$ were used for milk agar, tributyrin-nutrient agar, yeast and mould medium and for violet red bile agar respectively. After laboratory pasteurisation dilutions ranged from 0 to $10^5$. 
TABLE 1.
Chemical composition of milk and cream

<table>
<thead>
<tr>
<th>Component</th>
<th>18% fat cream</th>
<th>45% fat cream</th>
<th>Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>74.5</td>
<td>46.78</td>
<td>87.0</td>
</tr>
<tr>
<td>Fat</td>
<td>18.0</td>
<td>48.00</td>
<td>3.9</td>
</tr>
<tr>
<td>Protein</td>
<td>2.8</td>
<td>1.98</td>
<td>3.5</td>
</tr>
<tr>
<td>Lactose</td>
<td>4.1</td>
<td>2.80</td>
<td>4.9</td>
</tr>
<tr>
<td>Ash</td>
<td>0.6</td>
<td>0.44</td>
<td>0.7</td>
</tr>
</tbody>
</table>
Medium for detection of lipolytic organisms

Because of the high concentration of butter fat in cream (see Table 1.) it was decided that a test for the enumeration of lipolytic microorganisms might prove useful.

There are several methods for assaying the production of lipolysis many of which have been developed for use with pure cultures of organisms. The use of butter fat as the substrate would appear logical when examining cream. Unfortunately only very slight reduction in opacity occurs in a butter fat plus agar medium. Various fat soluble dyes e.g. Victoria Blue have been incorporated into butter fat media and hydrolysis is shown by the colour change around the lipolytic organism. It was discovered however (El. Sadek & Richards 1955, 1957) that the dyes inhibited certain organisms. Another disadvantage was the absence of a carbohydrate in the medium. Organisms requiring such an energy source were unable to grow profusely.

In 1901 Eykman developed a double layer technique by which means the organisms are grown on a nutrient medium on top of a thin layer of tallow or lard. It is various modifications of this technique which are most popular today e.g. Tuyenburg Muys & Willems (1965), Fryer et al., (1967).

One of the fats in use with the double layer technique is tributyrin (Fryer et al., 1967) at a concentration of 0.1% v/v. Many bacteriologists found that organisms which split tributyrin appear unable to split a more complex natural triglyceride such as butter fat. (Jones & Richards, 1952; El. Sadek & Richards, 1957; Hugo & Beveridge, 1962; Brandl et al, 1962; Franklin & Sharpe, 1963; Alford & Steinle, 1966). More recently (Lawrence et al., 1967) showed that the hydrolysis of butter fat and tributyrin by a partially purified lipase preparation from Micrococcus freudenreichii/
freudenreichii and Pseudomonas fragi was due to a single enzyme in each case. The tributyrin assay, however, was 80 times more sensitive, possibly due to the solubility of dibutyrin resulting in easily distinguishable transparent zones (Sarda et al., 1961).

For this work it was decided to use tributyrin as the substrate. Various methods were tried.

Double layer technique using different concentrations of tributyrin agar (Oxoid) with

a) nutrient agar on top, dried, spread with the cream undiluted and diluted.

b) the cream or its diluted form added to the nutrient agar then poured over the tributyrin layer.

c) the nutrient agar and tributyrin agar mixed while molten and used as for pour plates, that is 1 ml. of the cream or diluent placed in the petri dish and the mixed agars poured on top, then the plate rotated to mix the contents.

The concentrations of tributyrin ranged from 0.01% to 0.1%. At the higher dilutions, i.e. 0.01%, 0.02% and 0.03%, hydrolysis of the tributyrin was extremely rapid, clearing the whole plate in some instances. 0.04%, 0.05% and 0.06% tributyrin gave clearly defined zones whereas 0.07% to 0.1% appeared to cause inhibition and clearing took much longer.

At the same concentrations of the fat, the variation in counts of the different methods was negligible. Using method (a) at low dilution and with undiluted cream butter fat, globules could be seen on the surface of the medium; this made counting difficult. Method (c) was less troublesome to prepare and had less chance of contamination than method (b) and it/
it was this method (c) which was finally decided on. The medium was prepared by mixing equal quantities of tributyrin agar (Oxoid) and nutrient agar. Once mixed the media had to be used immediately i.e. it could not be remelted because of a precipitate which appeared.

Plates are shown on page 28 illustrating growth and hydrolysis on different percentages of tributyrin.
### Milk agar (MA)

- Yeastrel: 3 g
- Peptone: 5 g
- Agar: 15 g
- Whole milk: 10 ml
- Distilled water: 1,000 ml

**pH 6.8**

### Tributyrin agar (TBA) (Oxoid)

- Peptone: 5 g
- Yeast extract: 3 g
- Tributyrin: 10 g
- Agar: 15 g
- Distilled water: 1,000 ml

**pH 7.5**

### Violet Red Bile agar (VRBA) (Oxoid)

- Yeast extract: 3 g
- Peptone: 7 g
- Sodium chloride: 5 g
- Bile salt No 3: 1.5 g
- Lactose: 10 g
- Neutral red: 0.03 g
- Crystal violet: 0.002 g
- Oxoid agar No 3: 12 g
- Distilled water: 1,000 ml

**pH 7.4**

### MacConkey's Bile salt broth

- Sodium taurocholate: 5 g
- Peptone: 20 g
- Lactose: 10 g
- Sodium chloride: 5 g
- Litmus or Andrade's indicator or 1%
Malt extract agar (Oxoid)
Malt extract 30 g
Mycological peptone 5 g
Agar 15 g
Distilled water 1,000 ml

To every 100 ml of the melted malt extract agar was added 5 ml of 10% lactic acid just before use, lowering the pH to 3.5.

Methylene Blue
One Methylene Blue (specially prepared) tablet added to 800 ml sterile glass-distilled water. The solution was stored in a cold room at 5°C and was discarded after 14 days.

Resazurin
One Resazurin tablet (specially prepared) was added to 50 ml sterile glass-distilled water. The solution was prepared freshly on the day it was required.

Crossley's milk medium
Separated milk containing 0.01% bromo cresol purple (standard 1% solution prepared by dissolving 1 g indicator in 19 ml decinormal sodium hydroxide and making up to 100 ml with distilled water). Quantities of 10 ml were filled into sterile plugged test tubes and sterilised by steaming for 20 minutes on 4 successive days.

Nutrient agar/
Nutrient agar

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lemco</td>
<td>5 g</td>
</tr>
<tr>
<td>Bacto peptone</td>
<td>2.5 g</td>
</tr>
<tr>
<td>Evans peptone</td>
<td>2.5 g</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>2.5 g</td>
</tr>
<tr>
<td>Agar</td>
<td>15 g</td>
</tr>
<tr>
<td>Distilled water</td>
<td>1,000 g</td>
</tr>
</tbody>
</table>
Media for pathogens

Selenite Broth (Oxoid CM 39)

Peptone (Oxoid L37) grams per litre 5.0
Lactose 4.0
Sodium biselenite 4.0
Sodium phosphate 10.0

pH 7.1 (approx)

Desoxycholate Citrate Agar (Oxoid CM35)

"Lab-Lanco" Beef Extract grams per litre 5.0
Peptone (Oxoid 37) 5.0
Lactose 10.0
Sodium citrate 5.0
Sodium thiosulphate 5.0
Ferric citrate 1.0
Sodium desoxycholate 2.5
Neutral red 0.025
Agar 15.0

pH 7.0 (approx)

Baird-Parker medium: (% w/v)

Bacto trytone grams per litre 10.0 (dissolved in distilled water pH 7.2.
Lab Lanco 5.0 Autoclave at 120°C for 15 minutes.
Bacto yeast extract 1.0
Lithium chloride 5.0
Agar 20.0

When cooled to 45°-50°C add Seitz filtered solutions of 20% (w/v) glycine (Hopkins & Williams) to a final concentration of 1.2% (w/v). 1.0% (w/v) potassium tellurite (B.DH) to 0.01% (w/v). 20% (w/v) sodium pyruvate (L.Light)/
(L.Light) to 1.0% (w/v) and concentrated egg yolk emulsion (Oxoid) to 5.0% (v/v).

**Blood Agar**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount (grams per litre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Lab-Lanco&quot;</td>
<td>10.0</td>
</tr>
<tr>
<td>Peptone (Oxoid L57)</td>
<td>10.0</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>5.0</td>
</tr>
<tr>
<td>Agar</td>
<td>15.0</td>
</tr>
<tr>
<td>Blood</td>
<td>100.0 ml</td>
</tr>
</tbody>
</table>

pH 7.5 (approx)

Serum dextrose agar for the cultivation of Brucella abortus.

Bacitracin: is supplied in vials containing 0.5 mega units (500,000 units.) This is diluted to give a final concentration of 2,000 units per ml. (The 0.5 mega unit is dissolved in 25 ml. of sterile distilled water; this is further diluted 1/10 to give a final concentration of 2,000 units per ml.) Storage until use should be at 4°C and the antibiotic is incorporated in the basal medium at a concentration of 25,000 units per litre (25 units/ml.)

Polymixin B: is supplied in bottles containing 0.5 mega units. This should be diluted 1/100 by dissolving 0.5 mega units in 10 ml. sterile distilled water and further diluted 1/10 to give a final concentration of 5,000 units per ml. Polymixin B should be stored at -20°C. If there is no deep freeze available the Polymixin B should be placed in the ice chamber of the refrigerator. A concentration of 6,000 units per litre (6 units/ml.) should be used.

Actidione: is supplied in 4 g bottles. The powder should be dissolved in 20 ml. acetone and diluted 1/20 with distilled water to give a final concentration of 10,000 units per ml. Storage should be in the refri-

-gerator
The antibiotic should be used at a concentration of 100,000 units per litre (100 units/ml.).

**Fungizone**: is supplied in 50 m.g. quantities. The 50 m.g. is dissolved in 10 ml. sterile distilled water to give a final concentration of 5,000 units per ml. Storage should be in a deep freeze cabinet at -20°C or in the absence of a deep freeze in the ice-chamber of a refrigerator. The antibiotic should be used at a concentration of 10,000 units per litre (10 units/ml.).

**Technique**: Forty "Oxoid" blood agar base and 5 g. Ionagar was dissolved in 1,000 ml. distilled water and then allowed to stand for 10 minutes to avoid the powder "caking". It was then gently heated until the ingredients were dissolved and then autoclaved at 15 lb. pressure for 15 minutes. The medium was then cooled to 52°C in a water bath and the following ingredients added.

- 50.0 ml. sterile inactivated horse serum
- 40.0 ml. sterile 25% solution of dextrose
- 12.5 ml. Bacitracin solution containing 2,000 U/ml.
- 1.2 ml. Polymixin B " " 5,000 U/ml.
- 10.0 ml. Actidione " " 10,000 U/ml.
- 2.0 ml. Fungizone " " 5,000 U/ml.

The ingredients must be well mixed to ensure even distribution of the antibiotics.
The Dye Reduction Tests

At the start of the investigation each sample was subjected to the methylene blue, resazurin and Crossley's bromo cresol purple tests. All three were useful in detecting creams with colony counts of over $10^5$ microorganisms per millilitre; below this figure results were variable. After 6 months it was decided to discontinue these tests for several reasons.

a) In their present form these tests do not appear to be suitable for creams kept at low temperatures and as the trend is towards more refrigeration whatever tests are used will have to accommodate this aspect.

b) Work is at present being carried out at the National Institute for Research in Dairying (Rothwell 1969) on a modified dye test.

c) When the cream arrived in 4 oz. cartons there was not sufficient cream to carry out all the tests originally planned. It was therefore decided to concentrate on the isolation of pathogenic, lipolytic and total numbers of microorganisms present before and after laboratory pasteurisation.
### Table 2
Untreated Creams

<table>
<thead>
<tr>
<th>Colony Count/ml.</th>
<th>Milk Agar 30°C for 3 days Percentage</th>
<th>Milk Agar 5°C for 7 days Percentage</th>
<th>Nutrient + Tributyrin Agar 30°C for 3 days Percentage</th>
<th>Nutrient + Tributyrin Agar 5°C for 7 days Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 10&lt;sup&gt;4&lt;/sup&gt;</td>
<td>2.2</td>
<td>35.3</td>
<td>46.5</td>
<td>46.1</td>
</tr>
<tr>
<td>10&lt;sup&gt;4&lt;/sup&gt; - 10&lt;sup&gt;5&lt;/sup&gt;</td>
<td>65.2</td>
<td>29.4</td>
<td>34.9</td>
<td>23.2</td>
</tr>
<tr>
<td>10&lt;sup&gt;5&lt;/sup&gt; - 10&lt;sup&gt;6&lt;/sup&gt;</td>
<td>10.9</td>
<td>11.8</td>
<td>9.3</td>
<td>7.5</td>
</tr>
<tr>
<td>10&lt;sup&gt;6&lt;/sup&gt; - 10&lt;sup&gt;7&lt;/sup&gt;</td>
<td>13.0</td>
<td>23.5</td>
<td>9.3</td>
<td>23.2</td>
</tr>
<tr>
<td>10&lt;sup&gt;7&lt;/sup&gt; - 10&lt;sup&gt;8&lt;/sup&gt;</td>
<td>6.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>over 10&lt;sup&gt;8&lt;/sup&gt;</td>
<td>2.2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Untreated creams

1. Comparison between untreated designated milk and untreated cream.

If the bacteriological standards for untreated milk were applied to untreated cream (i.e. Premium milk: not more than 15,000 organisms per ml. on milk agar after 3 days at 30°C and coliform organisms absent in 0.01 ml. and Standard Milk not more than 50,000 organisms per ml. on milk agar after 3 days at 30°C and coliform organisms absent in 0.001 ml.) only 7.5% and 17.1% of the untreated creams examined in this survey would have satisfied the plate count standard for Premium and Standard milk respectively. 40% would have conformed to the coliform test for Premium milk and 66% would have conformed to the coliform test for Standard milk.

Comparison between surveys

Smillie (1949) does not state whether the creams examined in his survey were untreated or pasteurised but he does compare their results with those of pasteurised milk which leads one to believe they had probably received some form of heat treatment. It is not possible therefore to compare the results of untreated creams examined here with any work done in Scotland since 1949 because there is none. In England and Wales the reports by various PHLS workers have not, until the last report by Henderson et al. (1971), separated untreated (raw) from heat treated cream colony count results in the tables presented. The 1971 report by the PHLS committee published the results of "microbiological examinations i.e. colony count (at 4, 20-22, 30, 35 & 36 ± 1°C) methylene blue, coliform and Escherichia coli I test and for pathogens. Of the 5184 cream samples examined 517 were untreated; 15% of the untreated creams had counts/
counts of \(10^3\), 42\% \(10^3 - 10^5\) and 43\% \(> 10^5\) organisms per ml.; 58\% of all untreated samples had contained coliforms in 0.1 ml. These colony counts and coliform tests were carried out at 36 ± 1°C. The report states that a number of laboratories (taking part in the survey) carried out colony counts at 4, 20-22, 30 and 35°C in addition to the customary 36 ± 1°C. Unfortunately the figures are not given for the work done at the lower temperatures i.e. 4, 20-22, 30 and 35°C although the authors state that colony counts at those temperatures "were on many occasions considerably higher than those recorded in the same samples incubated at 36 ± 1°C."

Davis (1969) in his 'suggested standards for retail cream' expects 5 x higher counts at 30°C than at 37°C. This figure is arbitrary but may be used as a guide when one compares figures given in Table with those of the PHLS reports at 37°C. The results indicate that untreated creams in this survey may have slightly lower colony counts than those examined in the PHLS survey. The general hygienic quality of untreated creams is adjudged to be poor with 97.8\% of samples having counts of \(> 10^4\) organisms per ml.

**Comparison of media and temperature**

Looking at Table 2 it is obvious that milk agar at 30°C for 3 days detects more microorganisms than the 3 other combinations. This is not surprising, 5°C for 7 days being selective for "psychrotrophic" microorganisms (i.e. microorganisms which are considered mesophilic as to their growth optimum on the one hand, but which are still able to grow well at temperatures below 10°C on the other) and tributyrin + nutrient agar being selective for lipase producing microorganisms. If, however, one adds up the percentage of counts from \(0 - 10^6\) and \(> 10^6\) in each medium/temperature combination, see Table there appears to be a better correlation between the
### Table 3.

**Untreated Creams**

<table>
<thead>
<tr>
<th>Colony Counts/ml</th>
<th>Violet Red Bile Agar 30°C for 18 hours Percentage</th>
<th>McConkey’s Bile Salt Broth 30°C for 3 days Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10^2</td>
<td>47.6</td>
<td>40.0</td>
</tr>
<tr>
<td>10^2-10^3</td>
<td>26.1</td>
<td>26.0</td>
</tr>
<tr>
<td>10^3-10^4</td>
<td>9.5</td>
<td>34.0</td>
</tr>
<tr>
<td>10^4-10^5</td>
<td>14.4</td>
<td>0.0</td>
</tr>
<tr>
<td>over 10^5</td>
<td>2.4</td>
<td>0.0</td>
</tr>
</tbody>
</table>
milk agar at 30°C for 3 days, 5°C for 7 days and the nutrient + tributyrin agar at 5°C for 7 days than with the nutrient + tributyrin agar (N.T.A.) at 30°C for 3 days and the low temperature counts. Inhibition by other non lipolytic organisms or their acid products may be the cause of the lower counts on the N.T.A. at 30°C. This theory may be strengthened by the fact that higher counts on N.T.A. occurred at higher dilutions where the plates were less crowded.

Counts on milk agar and N.T.A. at 5°C for 7 days are closely related showing that many of the microorganisms growing at that temperature were both psychrotrophic and lipolytic.

The presence of large numbers of psychrotrophic organisms is indicative of poor production methods.

**Coliform tests**

Violet red bile agar and McConkey's Bile Salt broth gave similar results, the former must be counted at 18 hours otherwise the plates became overgrown with microorganisms other than coliforms. In creamery control the violet red bile agar should prove extremely useful because of the short incubation time required.

**Laboratory pasteurisation**

All creams, no matter how high the coliform numbers were before laboratory pasteurisation, gave negative results in 1 ml. - 0.01 ml. in McConkey's bile salt broth and on violet red bile agar after laboratory pasteurisation. These results agree with those of Smillie (1949) who heated creams to 150°F (65.5°C) for 30 minutes and negative results from 1 ml. of cream inoculated into McConkey's bile salt broth.

After laboratory pasteurisation 75% and 86.6% of samples had less than/
### Table 4.4

**Untreated Creams**

Colony Counts after Laboratory Pasteurisation

<table>
<thead>
<tr>
<th>Colony Count/ml</th>
<th>Milk Agar 30°C for 3 days 5°C for 7 days Percentage</th>
<th>Nutrient + Tributyrin Agar 30°C for 3 days 5°C for 7 days Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - 100</td>
<td>22.5</td>
<td>63.3</td>
</tr>
<tr>
<td>100-500</td>
<td>52.5</td>
<td>23.3</td>
</tr>
<tr>
<td>500-1000</td>
<td>7.5</td>
<td>10.1</td>
</tr>
<tr>
<td>1000-5000</td>
<td>17.5</td>
<td>3.3</td>
</tr>
<tr>
<td>over 5000</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

41.
than 500 microorganisms per ml. on milk agar and tributyrin + nutrient agar respectively incubated at 30°C for 3 days. Colony counts at 5°C for 7 days were, on both media, under 100 microorganisms per ml. These results confirm work done by Smillie (1949) who pasteurised a number of creams with counts varying from 3,500 to 500,000 microorganisms per ml. All the creams gave under 1,000 microorganisms per ml. after heat treatment.

In the present investigation no yeasts or moulds survived pasteurisation in the creams examined.

While the figures given above support Thomas's (1970) assumption that "the psychrotrophic bacteria in cream would react in the same way as those in milk and fail to survive satisfactory pasteurisation of milk" (There is a great deal of evidence to support this e.g. Thomas & Druce (1969) and Witter (1961) have reviewed the field), there are however some organisms which survive pasteurisation and manage to grow at 5°C mainly Bacilli, Corynebacteria and Micrococci.

Pathogenic organisms

Brucella and Salmonella were not isolated, 6.5% of the coliforms gave positive results in McConkey's broth at 44°C showing faecal origin. The latter were not examined serologically. One coagulase positive staphylococcus was isolated from a 10^-1 plate (Baird Parker medium) and haemolytic streptococci were twice isolated.

Heat treated creams

1. Comparison between pasteurised milk and pasteurised cream

Because the ages of the creams examined were unknown, it would have been futile to subject them to the phosphatase test which is the official assay/
## Table 5

Bacterial Counts

Heat Treated Creams

<table>
<thead>
<tr>
<th>Counts/ml.</th>
<th>Milk Agar 30°C for 3 days</th>
<th>Milk Agar 5°C for 7 days Percentage</th>
<th>Nutrient + Tributyrin Agar 30°C for 3 days</th>
<th>Nutrient + Tributyrin Agar 5°C for 7 days Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10⁴</td>
<td>15.0</td>
<td>10.0</td>
<td>17.5</td>
<td>10.0</td>
</tr>
<tr>
<td>10⁴-10⁵</td>
<td>20.0</td>
<td>40.0</td>
<td>22.5</td>
<td>50.0</td>
</tr>
<tr>
<td>10⁵-10⁶</td>
<td>12.5</td>
<td>10.0</td>
<td>12.5</td>
<td>10.0</td>
</tr>
<tr>
<td>10⁶-10⁷</td>
<td>17.0</td>
<td>7.0</td>
<td>12.5</td>
<td>20.0</td>
</tr>
<tr>
<td>10⁷-10⁸</td>
<td>18.0</td>
<td>33.0</td>
<td>30.0</td>
<td>10.0</td>
</tr>
<tr>
<td>10⁸-10⁹</td>
<td>17.5</td>
<td>0.0</td>
<td>5.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
assay for efficiency of pasteurised milk. The anomalies of the phosphatase test when applied to cream are discussed in a later section. Suffice it to say (at the moment) that unless the phosphatase test is carried out on cream immediately after it has been pasteurised the results are unreliable in the sense that judgement of quality is not possible.

Of the pasteurised creams tested 62.8% showed the presence of coliform organisms in 0.001 ml. and only 18% had coliform organisms absent in 0.01 ml. Therefore 62.8% of pasteurised creams would have failed the standard for pasteurised milk.

2. Comparison with other surveys

Smillie (1949) examined in the winter of 1938-39 the bacteriological condition of a number of creams purchased from retailers in a large town in South-West Scotland to ascertain the general bacteriological condition of a representative cross-section of the retail cream trade. It was found that only 15% of the samples of pasteurised creams would have conformed to the bacteriological standards then in force for pasteurised milk and only 10% of the samples were free of coliforms in 1.0 ml. portions; 65% showed the presence of coliform organisms in 0.01 ml. and 20% of the cases gave positive coliform reactions in 0.001 ml. The bacterial counts of the creams "varied from 10,000 to many millions per ml., with over 50% of the samples giving counts well over the million." The incubation temperature of the samples was 98-100°F (36.7°C) and Smillie states "A lower incubation temperature has since been shown to give higher bacteriological counts in the case of creams which have been held at cold storage temperatures and as most of these purchased creams had been so treated, the actual numbers of bacteria present were probably very much higher than our numbers indicate."
In 1958 a working party of the Public Health Laboratory Service after examining 1,016 heat treated retailed cream samples, reported that with the exception of 47 creams heat treated in the bottle, most of the samples examined were of poor bacteriological quality. A large proportion of the heat-treated creams yielded coliform organisms and many contained faecal strains.

The Public Health Department, Worcestershire, (Colenso et al. 1966) realising the increase in cream sales and being concerned over the absence of any regulations governing the licencing and testing of cream, carried out a survey from January 1964 - October 1965 to examine the bacteriological condition of cream at that time. Of the 575 creams examined 34 were untreated and 541 were heat treated. In the presentation of the results of colony counts and coliform tests the authors do not differentiate between untreated and heat treated samples; 137 samples had counts of over 1 million per gm., 68 samples had counts of 200 million to 5,000 million per gm. All colony counts and coliform tests were carried out at 37°C. 346 (60.2%) samples had coliform organisms present in 0.1 gm. and 78 (13.6%) showed faecal coli in 0.1 gm.

These results showed that no improvement had taken place over the 9½ years between the two surveys. Added to this was the fact that Colenso had isolated Brucella abortus from 3 samples of raw cream. The phosphatase test was carried out on all creams and found to be satisfactory.

Barrow & Miller (1968) leading another PHLS working party discovered heat treated creams to be in the same unsatisfactory condition. Unlike Colenso they found many positive phosphatase test results and put this down to inadequate pasteurisation.

In/
In 1969 Davis published his work on "Microbiological examination of cream". This was not the same type of survey as the PHLS workers had carried out but was an effort to make 'sensible' the various tests in use by the dairy trade and the PHLS also to show the effect of efficient and inefficient handling of cream after pasteurisation. This he did by subjecting of the creams to incubation at 5°C and at 15°C, carrying out the colony count, coliform test and methylene blue test every 24 hours, and incubating plates and coliform tests at 30°C and 37°C, until the creams were unpalatable. By this means he was able to suggest which creams had been efficiently produced and marketed and those which had been contaminated after pasteurisation, relying on the fact that a) most thermoduric organisms do not grow well at 5°C, b) most organisms which grow well at 5°C must have got into the cream by post pasteurisation contamination.

This work illustrated how a "good" cream i.e. one with a low count, could fail the methylene blue test due to the majority of the organisms being Bacillus cereus or some other bacterium which are strong reducers of methylene blue (i.e. lactic acid bacteria).

The most recently published work on the hygiene and marketing of fresh cream in England and Wales took place between 1st October 1968 and 31st July 1969 and was published in 1971 (Henderson et al.). 4385 heat treated samples were examined by the methylene blue test, colony counts and presence in 0.1 ml. of coliform organisms or Escherichia coli type 1. Of the heat treated creams examined, 48.5%, 28.5% and 23% had counts of \(10^3\), \(10^3\) to \(10^5\) and \(10^5\) respectively. 25% had positive coliform tests in 0.1 ml. and 4% showed the presence of E. coli in 0.1 ml.

In the survey carried out for this thesis 65% of the heat treated samples/
samples had counts of over $10^5$ and 17.5% had counts of over $10^5$. After laboratory pasteurisation 100% of samples had counts under $10^4$, and coliforms absent in 1 ml., showing that the high counts and positive coliforms were due mainly to post pasteurisation contamination.

**Coliform tests**

As with the raw creams, good correlation is noted with the violet red bile agar and McConkey's bile salt broth. No positive coliform results were obtained in 1 ml. of cream after laboratory pasteurisation, confirming that the pasteurisation temperature used for milk was effective in this instance for cream.

**Comparison of media and temperature**

The heat treated creams showed less of a variation between the colony count on milk agar at $30^\circ C$ for 3 days and that on nutrient agar + tributyrin agar at $30^\circ C$ for 3 days than did the untreated creams. If, as suggested in the discussion on the untreated cream, acid producing microorganisms were responsible for the low numbers of lipolytic bacteria, this theory may be strengthened by the heat treated cream results because, due to pasteurisation, less of the original acid producing strains would be left in the cream. Also, if one studies the growth at $5^\circ C$ it is noticable in both types of cream that there is a greater co-relation at that temperature, suggesting possibly the absence of lactose fermenting strains which do not grow well at $5^\circ C$ although the coliform organisms should ferment at this temperature. It may be purely due to the numbers of other bacteria present on the plate which are the inhibitory factor. Also in the untreated creams a higher percentage of microorganisms would prefer $30^\circ C$ to $5^\circ C$ and many of these would be lipolytic; also only the microorganisms/
48.

**Table 6**
**Bacterial Counts**
**Heat Treated Creams**

*After Laboratory Pasteurisation*

<table>
<thead>
<tr>
<th>Counts/ml</th>
<th>Milk Agar 30°C for 3 days 5°C for 7 days Percentage</th>
<th>Nutrient + Tributyrin Agar 30°C for 3 days 5°C for 7 days Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10²</td>
<td>48.1</td>
<td>100.0</td>
</tr>
<tr>
<td>10²-10³</td>
<td>44.4</td>
<td>0.0</td>
</tr>
<tr>
<td>10³-10⁴</td>
<td>7.5</td>
<td>0.0</td>
</tr>
<tr>
<td>10⁴</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
microorganisms showing zones of hydrolysis were counted on the lipolytic medium.

Pathogenic organisms

No pathogenic microorganisms were isolated; of the coliform strains 9.3% gave positive results at 44°C showing faecal origin.

Laboratory pasteurisation

After laboratory pasteurisation 92.5% and 88.9% of heat treated creams had counts between 0 and $10^3$ on milk agar at 30°C for 3 days and nutrient + tributyrin agar at 30°C for 3 days respectively. In the range $10^3 - 10^4$ counts 11.1% were due to lipase producing strains the majority of which were aerobic spore formers. These appeared to grow better on the nutrient + tributyrin agar than on the milk agar. On both media counts at 5°C after pasteurisation were all under 100 microorganisms per ml. No coliform types, yeasts or moulds grew after laboratory pasteurisation in 1 ml. to 0.01 ml. at 30°C for 3 days or 5°C for 7 days.

Conclusions

In general the microbial quality, no matter which test is used as a guide, of untreated and heat treated creams is poor. The large numbers of psychrotrophic and coliform organisms present in both types of cream are indicative of poor production methods and subsequent handling for these organisms are not the natural flora of milk but are picked up on route from the milking machine onwards. (A later section deals with samples taken at various points during production at the creameries and these show the entrance points of contaminants.) That high counts and coliforms were due to post pasteurisation contamination in heat treated creams appears obvious because of the considerable reduction in counts after laboratory pasteurisation.

If/
If one is considering a test from the control point of view, that is at the creamery, then a coliform count on violet red bile agar seems the logical choice. It gives a quick indication (within 18 hours) of the presence of coliform organisms. If they are present then there is either a fault in pasteurisation (which can be checked at the creamery immediately after pasteurisation) or post pasteurisation contamination has taken place. If the contamination has occurred after pasteurisation there is every possibility that the organisms present will include psychrotrophic types. Unfortunately there is no rapid method for determining the presence of psychrotrophs. A colony count on tributyrin + nutrient agar at 30°C for 3 days may be used as an indicator of hygienic production and whether the cream may be subject to deterioration at low temperatures.

Examining cream from the Public Health angle poses many problems because no one test which will provide all the answers exists. If pathogens are to be looked for this means selective media and methods for each type. The "presumptive" coliform test, in use for milks, does not select out pathogenic coliforms. This has to be done by further testing at 44°C to see if the organisms are of faecal origin and, if they are serological testing must be carried out to discern whether or not they are pathogenic. The "presumptive" test for coliform types is however useful as an indication of hygienic methods of production and as such should be borne in mind for cream. To date, one of the arguments against imposing colony count and coliform test standards for cream is that the age of the cream when sampled by the Public Health Office is unknown. This, however, could be overcome by having a date on the retail container. Such a stipulation might also necessitate more efficient handling/
handling of the product. The argument for and against the use of dye reduction tests is still raging and the author has no wish to state categorically yea or nae. Suffice it to say that, when creams are of very poor hygienic quality these tests are a useful quick method of estimating the condition of the cream. On the other hand it must be remembered with modern methods of production and distribution the product is being held at low temperatures for some considerable time. Therefore to subject it to tests involving preincubation at temperatures which it would, under normal circumstances, never reach seems somewhat illogical and gives little or no indication to what the keeping quality of creams would be at 15°C and 5°C (the temperatures taken as typical of bad and good practice in the dairy distributive industry Davis 1955 and 1969).

A colony count and coliform test might at present prove useful until other more applicable tests are developed. It seems foolish to allow cream to drift "microbiologically speaking" because of the absence of a "suitable" test; the latter will probably never appear. A standard such as that for Standard milk i.e. <50,000 viable organisms per ml. at 30°C for 3 days and coliform organisms absent in 0.001 ml. might provide a useful arbitrary test with which to school the industry into line. If it were complied with the cream on sale to the Public it would have shown a marked improvement. Also, by controlling and improving methods of production and handling, one is cutting down the chances of pathogenic contamination.

Considerable attention has been focused on the presence of Brucella abortus in untreated creams (Colenso et al. 1966, Barrow & Miller 1968, Henderson 1971). Care is taken in Scotland to see that untreated creams are regularly tested i.e. monthly for the presence of Brucella abortus and/
and a move is being made to make sure that the milk supplied to the producers of this cream is from Brucella free cows.
### Table 7

#### Yeast and Mould Counts

**Untreated Creams**

<table>
<thead>
<tr>
<th>Counts/ml.</th>
<th>Malt Extract agar 30°C for 3 days Percentage</th>
<th>Malt Extract agar 5°C for 7 days Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>82.5</td>
<td>89.0</td>
</tr>
<tr>
<td>10-10²</td>
<td>12.0</td>
<td>6.0</td>
</tr>
<tr>
<td>10²-10³</td>
<td>4.5</td>
<td>5.0</td>
</tr>
<tr>
<td>10³</td>
<td>1.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

### Table 8

#### Yeast and Mould Counts

**Heat Treated Creams**

<table>
<thead>
<tr>
<th>Counts/ml.</th>
<th>Malt Extract agar 30°C for 3 days Percentage</th>
<th>Malt Extract agar 5°C for 7 days Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>98.0</td>
<td>97.0</td>
</tr>
<tr>
<td>10-10²</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>10²-10³</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>10³</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

No yeasts or moulds survived laboratory pasteurisation.
Samples taken during processing

During the survey creameries where cream was produced were occasionally visited and samples of cream and milk taken at various points during processing. It must be stressed here that the visits were few and far between and the results apply only to one batch of cream or milk on one particular day. They are in no way indicative of the day to day fluctuations. The results are however interesting in so far as they follow the increases or decreases in microbial numbers of a batch of cream or milk during processing.

Source A produced untreated cream. Source D produced cream from pasteurised milk and source C produced pasteurised cream. Both C and D creams were retailed as pasteurised.

The samples taken were of the first milk or cream through the cream manufacturing equipment that day. The idea being that the liquid would act as a rinse of the equipment pinpointing sources of contamination.

Results

The results of the samples taken at the creameries are shown in Tables 9, 10 and 11.

These show, in certain cases, variation from sample to sample which might indicate contamination in some instances e.g. in Source D there is a rise in count and coliform between samples 6 and 7 and 7 and 8 showing that the cleanliness of the vat might be questioned.

Discussion

Because of the fact that the sampling was not over a prolonged period, it is not the intention of the author to discuss the results in detail. However, such a layout of sampling might prove useful to creamery control/
SOURCE A

Results of samples taken during processing

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Source</th>
<th>Sample</th>
<th>VRBA/ml.</th>
<th>McConkey's Broth</th>
<th>Milk agar/ml.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30°C for 18 hr.</td>
<td>30°C for 3 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.01 ml.</td>
<td>0.01 ml.</td>
</tr>
<tr>
<td>1</td>
<td>8.7.67.</td>
<td>Incoming Milk</td>
<td>Milk</td>
<td>&lt;100</td>
<td>-</td>
<td>700</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supply 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Incoming Milk</td>
<td>Milk</td>
<td>&lt;100</td>
<td>+</td>
<td>1,400</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supply 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>After Separator</td>
<td>Cream</td>
<td>100</td>
<td>+</td>
<td>1,700</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cream</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>After Separator</td>
<td>Skim</td>
<td>100</td>
<td>+</td>
<td>1,600</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Skim</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>In can</td>
<td>Cream</td>
<td>450</td>
<td>+</td>
<td>28,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>In carton</td>
<td>Cream</td>
<td>600</td>
<td>+</td>
<td>34,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

V.R.B.A. = Violet Red Bile Agar

N.+ T. = Nutrient + Tributyrin
<table>
<thead>
<tr>
<th>N + T Agar/ml. 30°C for 3 days</th>
<th>Yeast &amp; Mould/ml. 30°C for 3 days</th>
<th>Milk Agar/ml. 5°C for 7 days</th>
<th>N + T Agar/ml. Yeast &amp; Mould/ml. 5°C for 7 days</th>
<th>N + T Agar/ml. Yeast &amp; Mould/ml. 5°C for 7 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>&lt; 10</td>
<td>&lt; 100</td>
<td>&lt; 100</td>
<td>&lt; 100</td>
</tr>
<tr>
<td>200</td>
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<td>&lt; 10</td>
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</tr>
<tr>
<td>5,400</td>
<td>&lt; 10</td>
<td>28,000</td>
<td>6,000</td>
<td>10</td>
</tr>
<tr>
<td>7,700</td>
<td>&lt; 10</td>
<td>29,000</td>
<td>6,000</td>
<td>30</td>
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</tbody>
</table>
## Results of samples taken during processing

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Source</th>
<th>Sample</th>
<th>VRBA/ml.</th>
<th>McConkey's Broth 30°C for 18 hr.</th>
<th>Milk agar/ml. 30°C for 3 days 0.01 ml. 0.001 ml.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.11.69. 12.30pm Bulk holding tank.</td>
<td>Milk</td>
<td>600</td>
<td>+</td>
<td>130,000</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Immediately before heating to 100°F.</td>
<td>Milk</td>
<td>900</td>
<td>+</td>
<td>90,000</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>After heating to 100°F.</td>
<td>Milk</td>
<td>900</td>
<td>+</td>
<td>110,000</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Before pasteurisation and after clarification.</td>
<td>Cream</td>
<td>100</td>
<td>+</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>After pasteurisation 180°F/2 seconds.</td>
<td>Cream</td>
<td>&lt;10</td>
<td>-</td>
<td>1,000</td>
<td></td>
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<tr>
<td>6</td>
<td>4pm In ageing tank.</td>
<td>Cream</td>
<td>&lt;10</td>
<td>-</td>
<td>1,000</td>
<td></td>
</tr>
</tbody>
</table>

*V.R.B.A.* = Violet Red Bile Agar  
*N. + T.* = Nutrient + Tributyrin  
/ml. = per millilitre
<table>
<thead>
<tr>
<th>N+T Agar/ml. 30°C for 3 days</th>
<th>Yeast &amp; Mould/ml. 30°C for 3 days</th>
<th>Milk Agar/ml. 5°C for 7 days</th>
<th>N+T Agar/ml. Yeast &amp; Mould/ml. 5°C for 7 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>130,000</td>
<td>20</td>
<td>91,000</td>
<td>36,000</td>
</tr>
<tr>
<td>60,000</td>
<td>10</td>
<td>84,000</td>
<td>80,000</td>
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<tr>
<td>28,000</td>
<td>10</td>
<td>82,000</td>
<td>47,000</td>
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<tr>
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<td>1,000</td>
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<tr>
<td>1,000</td>
<td>&lt; 10</td>
<td>1,000</td>
<td>1,000</td>
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<tr>
<td>1,000</td>
<td>&lt; 10</td>
<td>1,000</td>
<td>1,000</td>
</tr>
</tbody>
</table>
### Results of samples taken during processing

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Source</th>
<th>Sample</th>
<th>VRBA/ml.</th>
<th>McConkey's Broth</th>
<th>Milk agar/ml.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30°C for 18 hr.</td>
<td>0.01 ml.</td>
<td>0.001 ml.</td>
</tr>
<tr>
<td>1</td>
<td>16.1.67</td>
<td>Pasteurising holder tank</td>
<td>Milk</td>
<td>&lt;10</td>
<td>-</td>
<td>23,000</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Before Cooler 1.</td>
<td>Milk</td>
<td>&lt;10</td>
<td>-</td>
<td>900</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>After Cooler 1.</td>
<td>Milk</td>
<td>&lt;10</td>
<td>-</td>
<td>1,700</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>After Separation and before Cooler 2.</td>
<td>Cream</td>
<td>40</td>
<td>+</td>
<td>3,900</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>After Cooler 2.</td>
<td>Cream</td>
<td>40</td>
<td>+</td>
<td>1,000</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>In Can.</td>
<td>Cream</td>
<td>&lt;10</td>
<td>-</td>
<td>1,100</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>At vat valve.</td>
<td>Cream</td>
<td>70</td>
<td>+</td>
<td>4,800</td>
</tr>
<tr>
<td>8</td>
<td>17.1.67</td>
<td>In can after vat.</td>
<td>Cream</td>
<td>900</td>
<td>+</td>
<td>87,200</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>In carton.</td>
<td>Cream</td>
<td>700</td>
<td>+</td>
<td>117,000</td>
</tr>
</tbody>
</table>

* N.T. not tested

V.R.B.A. Violet Red Bile Agar

N. T. Nutrient Tributyrin.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>30°C for 3 days</td>
<td>30°C for 3 days</td>
<td>5°C for 7 days</td>
<td>5°C for 7 days</td>
<td>5°C for 7 days</td>
</tr>
<tr>
<td>30</td>
<td>&lt; 10</td>
<td>N.T.</td>
<td>N.T.</td>
<td>N.T.</td>
</tr>
<tr>
<td>2,450</td>
<td>&lt; 10</td>
<td>N.T.</td>
<td>N.T.</td>
<td>N.T.</td>
</tr>
<tr>
<td>550</td>
<td>&lt; 10</td>
<td>N.T.</td>
<td>N.T.</td>
<td>N.T.</td>
</tr>
<tr>
<td>20</td>
<td>&lt; 10</td>
<td>N.T.</td>
<td>N.T.</td>
<td>N.T.</td>
</tr>
<tr>
<td>&lt; 10</td>
<td>&lt; 10</td>
<td>N.T.</td>
<td>N.T.</td>
<td>N.T.</td>
</tr>
<tr>
<td>&lt; 10</td>
<td>&lt; 10</td>
<td>N.T.</td>
<td>N.T.</td>
<td>N.T.</td>
</tr>
<tr>
<td>&lt; 10</td>
<td>&lt; 10</td>
<td>N.T.</td>
<td>N.T.</td>
<td>N.T.</td>
</tr>
<tr>
<td>3,980</td>
<td>&lt; 10</td>
<td>N.T.</td>
<td>N.T.</td>
<td>N.T.</td>
</tr>
<tr>
<td>3,160</td>
<td>&lt; 10</td>
<td>N.T.</td>
<td>N.T.</td>
<td>N.T.</td>
</tr>
</tbody>
</table>
control. Samples taken at regular intervals from various parts of the dairy equipment over a period of several months might indicate the major trouble points.

From an investigational point of view the most interesting observation is the difference in colony counts between samples 3 and 4 from source C, i.e. the reduction in numbers of organisms during clarification.

Conclusions

Without the evidence of consistent sampling it would be unwise to state categorically that certain parts of equipment at sources A and D are definitely responsible for the increase in microbial numbers. It is however fairly obvious that creamery C will have fewer possible sources of contamination than creameries A and D because the cream itself is heat treated leaving the only chances of contamination to come from the ageing tank and packaging whereas source A faces hazards from the incoming milk to the carton and source D's problems will start from the point where the pasteurised milk leaves the pasteuriser to the final cream container.
SECTION 3

Microflora of Cream
Review of the Literature

on

The Microflora of Cream

Microorganisms may cause two types of undesirable effects in cream 1) on the cream itself in the form of spoilage which can be detected organoleptically and 2) on human beings from eating cream contaminated with large numbers of pathogens. In the latter case the product may be dangerously infected but appear normal to the senses of smell and taste. It is however on the microorganisms which bring about undesirable changes in cream that this section is focused.

Anderson and Hardenburg (1932) were among the first workers to study the deterioration of cream at refrigeration temperatures. The causative organism was found to be a Gram-ve rod resembling *Achromobacter* or *Alcaligenes*; the organism would not grow at 35°C or above. The deterioration, caused by lipolytic action, resulted in a bitter flavour.

McGrath & Anderson (1934) and Anderson (1958) reported their findings on several psychrotrophic microorganisms which developed bitterness in cream. *Pseudomonas fluorescens* and *Ps. viscosus* were isolated from creams which had developed bitterness after being held for prolonged periods at low temperatures (Thornton et al. 1948 and Erdman & Thornton 1951). Pont (1935) found that the *aerogenes* and intermediate coliform types grew more rapidly at 25°C and caused more serious deterioration of raw cream than did the *E.coli* types. This was confirmed by Robinton and Genung (1942) who discovered that the growth of coliforms (*aerogenes* type) was more rapid at 25°C than at 37°C and was still quite rapid at 8°C; also these organisms appeared to grow more quickly in sterile cream than in sterile milk. Smith (1944) found *Klebsiella aerogenes* to be the dominant type/
type of coliform organism to grow at 5-7°C in pasteurised cream. Crossley (1946) reported his findings on detailed studies of coliform organisms in bulk cream and clotted cream; these were, the main coliform groups in both creams were almost identical. The relative frequency of coli II and aerogenes II was even more noticable in the clotted cream than in the liquid bulk cream. It appeared that in cream there was more general distribution of all coliform strains rather than a complete predominance of coli I and aerogenes I as found in pasteurised milk examined during the same survey. (The incubation temperature for the isolation of the organisms was 37°C in McConkey's Broth followed by plating at 37°C. If no growth appeared on the plates, fresh plates were inoculated from the broth cultures and incubated at 22°C for growth of non faecal strains.) Such findings i.e. the relative frequency of coli II and aerogenes II strains, Crossley explained by the "similarity in general chemical composition of the two products and to the fact that in both manufacturing processes the major contamination was derived from packing operations." Smillie (1949) states that "Cream would seem to be a more favourable medium than milk for coliform organisms, and even in 6-12 hours storage of cream at as low as 46°F (4.5°C) these may increase very considerably. The increase is greater with aerobacter than with the true coliform type." Lightbody (1964) confirmed the findings of Smith (1944).

While the coli-aerogenes group are the most dominant of the coliform strains found in creams at low temperatures they are not the most dominant organisms of the total flora. Schutz & Olson (1960) and Dempster (1968) found Pseudomonas spp. to predominate (62.8% and 46.3% resp.), followed by coli-aerogenes (15.0%) in the case of Schutz & Olson and Achromobacter (21.9%) Dempster.
A Public Health Laboratory Report published in 1966 (Colenso et al) found that "apart from coliforms aerobic spore-bearers were the commonest organisms contaminating the samples." The incubation temperature used by those workers was 37°C so perhaps it is not surprising that the aerobic spore formers should play a major role. Davis (1969) demonstrated that Bacillus cereus often constituted a large proportion of the flora from pasteurised cream which had been held at 15°C. Cox (1970) measuring the distribution of different groups of bacteria in market creams examined after incubation at 20°C for 17 hours (the temperature/time combination used before the methylene blue test at 37°C) found B. cereus to be the most prominent species (36%), next came Streptococcus Lancefield Groups D and N (11.5%) and the Acinetobacter (11.5%). The replacement of the early flora in raw cream i.e. the acid-coagulating organisms (which at first grew rapidly) by peptonizing types was observed by Powell (1938). When the cream was heated between 68°C and 85°C, the peptonizing types showed increased survival with rising temperature and became predominant in cream heated above 74°C. It was also noted that bacterial multiplication was more rapid in raw cream held at 1.5°C than in heated cream.

No attempt was made in the present study to carry out a complete taxonomic study on the microorganisms isolated from the various creams. The aim was to group the predominant flora isolated from the different media which had been incubated at 30°C and 5°C.

The organisms were not inoculated into sterile cream to note their effect because 1) in sterilising cream no matter what method is used changes the physical and in some cases chemical composition of the cream 2) to examine organoleptically the effects of various microorganisms on cream varies considerably from person to person 3) to carry out titrations on/
the cream would add little knowledge to what is already known 4) there are so many varieties in cream fat alone (at least 60 different fatty acids) that to determine the effect of various microorganisms on these using gas chromatographic or electrophoresis would constitute a study in itself.
Isolation and identification of organisms

Suitable plates (30-100 colonies per plate. In certain cases, e.g. after laboratory pasteurisation, there were not 30 colonies on the plate.) from each time temperature combination were selected; every colony was picked into litmus milk and incubated at 28°C. After 24 hours the litmus milks were streaked onto milk agar plates which were then incubated at 28°C for 48 hours. Occasionally it was necessary to give a longer incubation period both in litmus milk and on milk agar in order to obtain growth. Single colonies were picked from the milk agar plates onto nutrient agar slopes and milk agar slopes. Both media had to be used because at the beginning of the work it was noted that several organisms did not grow well, and in some cases were lost, on nutrient agar. The continued use of nutrient agar was essential because pigmentation on this medium was important in grouping certain of the organisms.

The following tests were carried out on all isolates.

Gram stain and motility tests were carried out on young cultures preferably not more than 18 hours old. The water from the base of a nutrient agar or milk agar slope was used for testing motility by hanging drop method.

Catalase test: "Five vol." hydrogen peroxide was run down the surface of a slope culture. The production of gas indicated a positive reaction.

Gelatin liquefaction: Stab inoculations were made in nutrient gelatin. The cultures were incubated at 22°C for 30 days.

Litmus milk: The organism's reaction in litmus milk was noted.

From this point onwards it was possible to separate rods from cocci, gram+ve from gram−ve organisms, and catalase positive from catalase−ve organisms/
organisms. Further tests, considered to be necessary for identification of the organism, were then carried out and the organisms tentatively grouped as follows.

**Streptococcus**

Gram +ve coccus, forming chains short or long. Catalase negative. Litmus milk was acidified, curdled and reduced. Gelatin was not hydrolyzed.

**Bacillus** Aerobic or facultatively anaerobic. Gram +ve spore forming rods, in chains. Catalase positive. Gelatin was liquified. Some were motile, others were not.

**Corynebacterium** Aerobic to microaerophilic. Gram +ve, non spore forming banded rods pleomorphic. Catalase positive, non motile. Some were pigmented yellow, orange or pink. Liquefaction of gelatin was variable. Litmus milk was acidified by some strains and unchanged by others. Some of the isolates in this group withstood laboratory pasteurisation and perhaps should have been classified under the genus *Microbacterium*.

**Micrococcus** Aerobic to facultatively anaerobic. Gram +ve, cells, spherical, endospores were not produced. Catalase positive, non motile. Effect on gelatin varied from strain to strain; some liquified it others did not. None of the isolates were coagulase positive. Several pigmented strains were found, yellow, cream or orange. Also, several types survived pasteurisation.

**Coliform** Under this heading were placed the organisms which were Gram -ve, non sporing rods and produced acid and gas in McConkey's bile salt broth incubated at 30°C for 48 hours.

**Pseudomonas**
**Pseudomonas** Gram-ve aerobic straight rods, motile, catalase positive.

On nutrient agar these organisms produced a diffusible green-yellow pigment which was sometimes fluorescent in ultra violet light. It was necessary, in order to differentiate this group from the *Alcaligenes*, to stain for flagella. This was done using the method of Rhodes (1958). The flagella present were polar. Litmus milk was peptomized and gelatin liquified.

**Alcaligenes** Gram-ve, uniform rods, motile (peritrichous flagella). Litmus milk was made alkaline, catalase positive. Gelatin was not liquified. Glucose was not oxidised and a diffusible fluorescent pigment was not produced.

**Acinetobacter** Gram-ve, straight rods, non motile, catalase positive, aerobic. The organisms have a tendency to retain the Gram stain and may show coccal forms (Park & Holding, 1966). They did not produce a fluorescent diffusible pigment. Glucose was oxidised in Hugh & Leifson's (1953) medium. The action on litmus milk was variable.

Several Gram-ve rods and irregular forms were isolated which did not conform to the above groupings. Because they formed a very small part of the total flora it was decided not to investigate them in any great detail. However, from the tests already carried out on them it is possible that they might fall into the *Flavobacterium*, *Aeromonas* and *Arthrobacter* genera.

**Discussion**

1. **Untreated creams**

   If one looks at table 12 there are several factors which attract attention. First the high percentage of bacilli. This is due to the fact that over 80% of the untreated creams examined were from the one source /
UNTREATED CREAMS

Percentage Distribution of the Isolates from the various Media, Time, Temperature Combinations.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Milk Agar 30°C for 3 days</th>
<th>N + T Agar 30°C for 3 days</th>
<th>Milk Agar 5°C for 7 days</th>
<th>N + T Agar 5°C for 7 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacillus</td>
<td>34.4</td>
<td>49.4</td>
<td>44.7</td>
<td>37.5</td>
</tr>
<tr>
<td>Corynebacterium</td>
<td>24.0</td>
<td>17.8</td>
<td>24.4</td>
<td>25.0</td>
</tr>
<tr>
<td>Micrococcus</td>
<td>18.9</td>
<td>19.5</td>
<td>3.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Streptococcus</td>
<td>12.2</td>
<td>6.5</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Coliform</td>
<td>6.8</td>
<td>3.4</td>
<td>16.7</td>
<td>12.5</td>
</tr>
<tr>
<td>Alcaligenes</td>
<td>2.7</td>
<td>1.7</td>
<td>5.6</td>
<td>17.5</td>
</tr>
<tr>
<td>Other Gram (-)</td>
<td>1.0</td>
<td>1.7</td>
<td>5.6</td>
<td>5.0</td>
</tr>
</tbody>
</table>

* A/P = After laboratory pasteurisation

N + T Agar = Nutrient + Tributyrin Agar
Table 12

<table>
<thead>
<tr>
<th></th>
<th>A/P Milk Agar 30°C for 3 days</th>
<th>A/P N + T Agar 30°C for 3 days</th>
<th>A/P Milk Agar 5°C for 7 days</th>
<th>A/P N + T Agar 5°C for 7 days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>93.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
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<td></td>
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<tr>
<td></td>
<td>7.0</td>
<td>0.0</td>
<td>0.0</td>
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</tr>
<tr>
<td></td>
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<tr>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

In such a condition the cream may pool from either of the flats or on the top in broken particles.

The other main groups of Gram +ve organisms isolated were micrococci and corynebacteria. The micrococci isolated from the untreated cream were probably of animal origin because some unheated laboratory pasteurisation according to Abd-El-Malek & Gibson (1948). Many of these organisms were lipolytic and might play a part in the breakdown of the milk fat. The corynebacteria in the untreated cream also did not withstand laboratory pasteurisation and may also be of animal origin (Gibson & Malek, 1952). As with the micrococci several were lipolytic.
where inadequate steam sterilisation is in use. After laboratory pasteurisation bacilli and streptococci were the only viable organisms. No Gram negative organisms from the untreated creams or from the heat treated creams survived laboratory pasteurisation.

It is interesting to note that the streptococci which survived laboratory pasteurisation grew at 30°C for 3 days but not at 5°C for 7 days. This being so, they should cause no problems in pasteurised creams kept at low temperatures. If however they are present and the creams are not stored at refrigeration temperature, i.e. if they are kept at 10°C or over, then souring may occur because these organisms ferment lactose to lactic acid. The bacilli may also curdle milk producing a soft clot; with cream however possibly the most important characteristic is the ability of certain species, e.g. B. cereus to produce a lecinthinase i.e. a lecinthin splitting enzyme. Lecithin is one of the two main phospholipid components of the fat globule membrane, the other being cephalin. When lecinthin is split a condition known as "broken" or "bitty" cream may result (Stone, 1952). In such a condition the cream when poured into coffee or tea floats on the top in broken particles.

The other main groups of Gram +ve organisms isolated were micrococci and corynebacteria. The micrococci isolated from the untreated creams were probably of animal origin because none survived laboratory pasteurisation according to Abd-el-Malek & Gibson (1948). Many of these organisms were lipolytic and might play a part in the breakdown of the milk fats. The corynebacteria in the untreated creams also did not withstand laboratory pasteurisation and may also be of animal origin (Gibson & Malek, 1952). As with the micrococci several were lipolytic.

Coliform organisms were predominant among the Gram negative organisms isolated.

These/
These organisms because of their ability to rapidly ferment lactose, split fats and utilise amino acids are probably, from a keeping point of view, the most dangerous group in the untreated creams examined. Their presence is therefore undesirable.

Some strains of the genus *Alcaligenes* have been known to cause off flavours in cream at low temperatures (Anderson & Hardenburgh, 1932). Therefore their importance cannot be overlooked. However it would seem logical to suggest that due to the conditions which the untreated creams are subject and the high percentage of other organisms present it would be unlikely that the alcaligenes group would be of prime importance in the deterioration of untreated creams.

2. Heat treated creams

Apart from the effect of laboratory pasteurisation on the Gram-ve microorganisms, the pattern of the microflora in heat treated creams is different from that of the untreated creams. In the latter the Gram+ve microorganisms were the dominant flora whereas in the heat treated creams the Gram-ve microorganisms predominate with a ratio of 49.7% to 10.5% on milk agar at 30°C for 3 days and 64.0% to 27.9% on milk agar at 5°C for 7 days in heat treated to untreated creams. Similarly on the selective medium for lipolytic organisms they constitute the highest percentage of isolates from heat treated creams. In highest numbers among the Gram-ve organisms are the genus *Pseudomonas*. The members of this genus isolated were strongly lipolytic, proteolytic and grew well at 5°C.

The significance of the presence of the Acinetobacter group in cream is questionable. Although organisms grew at 5°C and some are lipolytic, it is doubtful if they could compete with the pseudomonads and coliform organisms/
### HEAT TREATED CREAMS

Percentage Distribution of the Isolates from the various Media, Time, Temperature Combinations.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Milk Agar 30°C for 3 days</th>
<th>N + T Agar 30°C for 3 days</th>
<th>Milk Agar 5°C for 7 days</th>
<th>N + T Agar 5°C for 7 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudomonas</td>
<td>23.7</td>
<td>24.2</td>
<td>28.4</td>
<td>36.7</td>
</tr>
<tr>
<td>Corynebacterium</td>
<td>24.9</td>
<td>23.2</td>
<td>22.0</td>
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*A/P = After laboratory pasteurisation  
N + T = Nutrient + Tributyrin*
Table 13

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Once again the bacteria were the dominant flora present after laboratory pasteurisation. In the heat treated cream before pasteurisation, they made up approximately 40-45% of the total flora on the various media whereas after pasteurisation they constituted 41-60% of the total flora. Streptococci were present in small numbers and none of the strains survived pasteurisation. It is possible therefore under certain conditions of storage to have lactic souring in pasteurised cream.

The previous paragraphs have discussed the types of microorganisms isolated from untreated and heat treated creams on different media incubated at 50°C and 70°C for 3 days and 7 days respectively before and after laboratory pasteurisation.
organisms as spoilage organisms at low temperatures in heat treated cream.

As with the untreated creams the coliform organisms are present in significant numbers.

Among the Gram+ve microflora the corynebacteria are the most prevalent. In heat treated creams a number of corynebacteria survived laboratory pasteurisation making up 31.0% of the total flora isolated from milk agar after incubation at 30°C for 3 days and 21.0% of the total flora from milk agar at 5°C for 7 days. Only 2.5% of the total flora on nutrient + tributyrin agar incubated at 30°C for 3 days were corynebacteria and none of those organisms appeared to be lipolytic at 5°C for 7 days.

The numbers of micrococci isolated seems to be somewhat erratic, 13.9% of the total flora on milk agar at 30°C for 3 days before pasteurisation were micrococci while only 2.1 to 3.0% were isolated from the other three combinations before pasteurisation. After laboratory pasteurisation 15.2% of the total flora on milk agar at 30°C for 3 days were micrococci while these organisms made up 37–38% of the total flora isolated from the other three combinations.

Once again the bacilli were the dominant flora present after laboratory pasteurisation. In the heat treated creams before pasteurisation they made up approximately 10–14% of the total flora on the various media whereas after pasteurisation they constituted 41–60% of the total flora.

Streptococci were present in small numbers and some strains survived pasteurisation. It is possible therefore under certain conditions to have lactic souring in pasteurised cream.

The previous paragraphs have discussed the types of microorganisms isolated from untreated and heat treated creams on different media incubated at 30°C and 5°C for 3 days and 7 days respectively before and after laboratory pasteurisation.
pasteurisation. These combinations were chosen in order to demonstrate
a) which organisms survived laboratory pasteurisation
b) the dominant microflora in the cream
c) the main types of lipolytic organisms present.

The results show the microorganisms present in the cream at the time
of analysis in the laboratory. They do not show whether or not the micro-
organisms were a) growing in the creams at 30°C or 5°C, or b) causing
deterioration. To establish a) it would be necessary to do colony counts,
isolate and identify microorganisms from creams before incubation at 30°C
and 5°C (as carried out in the experiments presented here) and colony counts
e tc. after the cream had been incubated at 30°C and 5°C for the required
periods of time, b) to determine the effect of microorganisms on cream
would be, as stated earlier, a tremendous task. While it is possible to
deduce from the known biochemical characteristics of certain microorganisms
that they may attack various chemical constituents of creams, how they
react in the actual cream, in mixed flora and under various temperatures
is an extremely complex problem to solve.

Conclusions

It is possible to conclude from the results given that, as with milk,
all Gram-ve organisms in cream are destroyed by laboratory pasteurisation
at 63°C for 35 minutes. From this it would be reasonable to deduce that
the Gram-ve organisms found in heat treated creams were there as a result
of post pasteurisation contamination.

If cream is efficiently pasteurised, and subsequently hygienically
handled the only types of organisms which should be present are the bacilli,
thermoduric strains of micrococci, corynebacteria or possibly streptococci.
The/
The types of microorganisms present in the heat treated creams examined show that the majority of creams have been produced under poor conditions.

Similarly with untreated creams, those produced under hygienic conditions should have a flora consisting mainly of micrococci and possibly corynebacteria of animal not dairy origin. The quality of untreated creams examined for this survey leave much to be desired.
Yeast and Moulds

Several yeasts and moulds were isolated during the work; none however survived laboratory pasteurisation.

Dominant among the moulds isolated both at 30°C and 5°C were **Penicillium** species. Several strains produced clearing on nutrient + tributyrin agar at both temperatures as did certain **Aspergillus** species which were also isolated. One creamery also manufactured cheese as well as cream and occasionally **Oidium** spp. were isolated from the cream from that source.
"Sterilised" creams and Ultra heat treated creams

During the survey 50 samples of bottled "sterilised" creams were examined by colony count method on milk agar and nutrient tributyrin agar at 30°C and 55°C for 7-10 days and 3 days respectively. All counts were less than 10 organisms per millilitre.

Eighteen samples of Ultra heat treated cream samples were examined. They were tested as for "sterilised" creams and all had less than 10 organisms per millilitre.

General conclusions

The results from sections 2 and 3 show that most of the problems in cream microbiological quality arise from, in the case of unheated creams poor methods during processing and in heat treated creams improper handling after heat treatment. The only way to ensure that the product arrives on the customer's table in good condition is a) to subject the cream itself to some form of heat treatment either in the bottle or ensure that the cream is packaged aseptically after heat treatment, b) to enforce cold storage of the product and c) bring in legislation to subject cream to some form of microbiological control.
SECTION 4

Testing for Heat Treatment
Testing for effective heat treatment

Without a foolproof index test for effective pasteurisation it is not possible to enforce official standards of heat treatment for cream. Such is the situation at present.

For many years the absence of the enzyme alkaline phosphatase has been used as an indication of properly pasteurised milk. Alkaline phosphatase is a native enzyme of milk which catalyses the hydrolysis of organic phosphates yielding an alcohol or a phenol and phosphoric acid. It is on the enzyme's ability to hydrolyse disodium phenyl phosphate and liberate phenol that the 'phosphatase test' suggested by Kay & Graham (1935) is based. These workers found that most pathogenic organisms, including Mycobacterium tuberculosis, were destroyed more easily than the enzyme (which was virtually destroyed under conditions of efficient pasteurisation) and hence the absence or virtual absence of alkaline phosphatase was an indication that pathogens had been killed. This test or modifications of it (e.g. Aschaffenberg & Mullen Method 1949) are in use in this and other countries for milk today.

The situation concerning pasteurised cream is different, the phosphatase test in this instance gives, for various reasons, anomalous results. Kay & Graham (1935) noted that the phosphatase enzyme was associated with fat globules in milk and, when separated, the raw cream contains a higher concentration of phosphatase than the original milk. Therefore, presuming that the thermostability of the enzyme is the same in cream as it is in milk a higher residual concentration of phosphatase is to be expected in pasteurised cream than in pasteurised milk. This appears to be true. Fay (1938) stated that more heat is required with cream than with milk to produce a negative phosphatase result (on pasteurised milk standard/
standard). This statement unfortunately led to the assumption, in certain quarters, that more heat was required to kill pathogenic organisms in cream than in milk. This is not so (Aschaffenberg et al 1956). Fay (1938) also found that the time and temperature required for phosphatase inactivation increased with the fat content. Crossley (1954) confirmed this up to a fat content of 30%; after that the temperature treatment required for inactivation tended to decrease; and that the point of maximum heating requirement did not occur at a constant fat percentage.

In 1939, Gilcreas's findings confirmed the high concentration of the enzyme in cream. Using pasteurised milk, which gave a satisfactory phosphatase test, he separated it and discovered that the resulting cream gave a 'positive' phosphatase. On the other hand, cream separated from raw milk and then pasteurised gave a negative phosphatase test.

Although the phenomenon of "reactivation" of the phosphatase enzyme in heated milk is not unknown (Wright & Tramer 1953) it occurs much more frequently in heat treated creams. Brown & Elliker (1942) obtained very variable results with high temperature flask pasteurised creams. Increased phosphatase values were most pronounced at high storage temperatures although "reactivation" also occurs as low as 4.4°C. Cream which was subject to prolonged cooling after pasteurisation showed "reactivation" tendencies. Posthumus (1952) obtained positive results after storage at 20°C for more than 3 hours in both holder and flask pasteurised creams. It was suggested by this worker that some phosphatase in the fat globules or membranes may remain intact and diffuse out when the cream is held at 20°-30°C. Ritter (1953) found "reactivation" with creams which had been pasteurised by high temperature short time treatment but not in those which/
which had been subjected to the holder method. Crossley & Rothwell (1954) did not find reactivation in holder pasteurised cream or in cream treated at 74°C for 15 secs, but a high proportion of creams heated to 82°C or higher and held at 20°C for 48 hours exhibited reactivation.

Similarly, Wright & Tramer (1953), noted with samples of 'Uperized' milk that the phosphatase was reactivated, i.e. where the milk was heated to 100°C and rapidly cooled. The optimum temperature for the development of this positive phosphatase reaction was 30°C. The phosphatase was non-microbial and appeared to be identical to natural alkaline phosphatase.

Several workers have put forward the idea that bacterial phosphatase may be the cause of creams giving a negative test after pasteurisation then giving a positive reaction after storage. Similar reactions are known in milk (Leaky et al 1939, 1940), where workers found that Gram-ve rods were able to hydrolyse disodium phenyl phosphate in buffer solutions and that some strains of Klebsiella gave a true phosphatase reaction. Such findings led them to suggest that phosphatase results on milk having colony counts >2x10^6/ml. should be interpreted with caution. Hammer & Olson (1941) found several strains of Pseudomonas, Flavobacterium, Klebsiella, Alcaligenes and Geotrichium candidum gave strong phosphatase reactions. Other workers, Barber & Frazier (1943), found that commercially pasteurised cream samples which were initially phosphatase negative became positive during the course of 3-4 days' cold storage at 4-10°C. The phosphatase producing organisms in this case were the heat resistant spore formers, Bacillus cereus and B. mesentericus. The production of a positive result could be accelerated by adding the organisms to cream and could be prevented by the addition of mercuric chloride. The bacterial phosphatase/
phosphatase was stated to withstand 76.7°C for 30 minutes.

While it is feasible that, due to the lengthy holding time of cream before distribution, microorganisms may be the cause of positive phosphatase reactions in efficiently pasteurised cream, the main causes of re-activation are non microbial.

Following the work of Wright & Tramer (1953) who stated that 'reactivated phosphatase is apparently identical with the raw phosphatase enzyme', several investigators tried various elaborate methods by which raw and reactivated alkaline phosphatase could be distinguished. Siegenthaker (1954), McFarren (1960), and Paschke (1960). Richardson & McFarren (1964) suggested that the inactivation of the enzyme after pasteurisation might be caused by the Mg ions being transferred from the enzyme into a colloidal solution. In this concept the enzyme was thought to survive heat treatment in a structurally unchanged form. It was not until Peereboom started his studies on alkaline milk phosphatase in 1966 that it was shown that the raw and reactivated phosphatase are structurally different. This was done by means of electrophoresis techniques; the latter demonstrated that the isozyme pattern is different for the raw and the reactivated enzyme. It was noted that the raw enzyme had at least three isozymes which were termed α, β and γ. In reactivated phosphatase only β-AP (alkaline phosphatase) was identified. Peereboom's (1969) theory is that "when cream is pasteurised, part of the outer layer of the fat globule membrane is dispersed into the water phase. The lipoprotein complexes which constitute this outer layer are particularly rich in β-isozyme of alkaline phosphatase. After pasteurisation these lipoprotein particles, together with the β-isozyme, go into the water phase in a denatured condition. When this water phase is added again to the native/
native membrane structure of the fat globules of raw cream, the denatured β-isozyms are re-incorporated into this structure and they recover their original enzymatically active conformation. This results in a considerable increase in β-isozyme content. This so called "β-effect" is produced by a combination of the specific conformation of the β-isozyme in the three-dimensional structure of the membrane components with a factor X which is present in the extract of pasteurised cream.

By means of Sephalex thin layer chromatography the factor X was identified as being the denatured phosphatase enzymes and denatured fragments thereof, which occur in the serum phase of pasteurised cream and milk.

As the addition of pasteurised skim milk (which contains exclusively α-x-L^4 phosphatase) to raw cream did not produce the β-effect, the factor X could be identified as the denatured β-AP isozyme.

This explanation of the β-effect can also be applied to the phenomenon of reactivation of alkaline phosphatase as occurring in practice under certain conditions."

Because of the idiosyncrasies of the phosphatase test when used for cream considerable interest has been aroused in trying to find either from the purely academic side the reason for reactivation or using the fact that the reactivated phosphatase is different from the natural phosphatase is different from the natural phosphatase to evolve a test for pasteurisation e.g. Siegenthaker (1954 & 56) discovered that 80-93% of the reactivated phosphatase was destroyed by heating to 55°C for 5 minutes whereas only 20% of the native phosphatase was destroyed. As a modification Siegenthaker (1956) suggests that the sodium p-nitro-phenolphosphate should be filtered through charcoal to free it from p-nitrophenol.

The/
The phosphatase test is not the only test for heat treatment to have made use of the fact that a natural milk enzyme is destroyed at a known temperature higher than the thermal death point of *M. tuberculosis*. It is, however, considered to be sensitive, easy to carry out and one of the least expensive. In the case of cream it may be necessary to turn to something else, e.g.

**Amylase:** Alpha-amylase is a normal constituent of cows milk and it is accepted that some milks contain β-amylase. The inactivation temperature and time for α-amylase is 55°C for 30 minutes; β-amylase however can withstand 65°C for 30 minutes without loss of activity. A method for the presence of amylase was devised in 1932 by Gould.

**Catalase:** This enzyme catalyzes the decomposition of hydrogen peroxide to water and inactive oxygen. The enzyme is completely inactivated at 65°-70°C for 30 minutes. Cream contains more catalase than milk and also it must be borne in mind that many microorganisms produce catalase.

**Xanthine oxidase:** The presence of an oxidation catalyst in milk was first observed by Schardinger in 1902 and was termed Schardinger's enzyme. The latter catalyzes the oxidation of aldehydes and is more abundant in fat and cream than in skimmed milk. Its presence can be detected by adding to the milk a mixture of a saturated solution of methylene blue in alcohol and formalin, the latter being oxidised if the enzyme is present and the change is noted by the reduction of the methylene blue.

Tests based on other ideas have also been tried e.g. The Schern-Gorli Test (1936). This is based on the fact that due to pasteurisation the fat globules lose their power of attracting fine particles in suspension. The reaction is closely associated with cream separation and while useful for milk, so long as it has not been unduly agitated, with cream/
cream it would be useless.

Atilla (1968) published his findings on the sodium ferricyanide test, which estimates the bisulphides formed from free SH groups on heating. He concluded that the test is suitable for controlling pasteurisation of milk and cream by holding at 90-95°C but has a very low sensitivity and has to be supplemented by other pasteurisation tests if an admixture of untreated cream in pasteurised cream is suspected.

**Conclusion**

Some method incorporating the knowledge put forward by Siegenthaker (1956) that 80-93% of reactivated phosphatase is destroyed by heating to 55°C for 5 minutes whereas only 20% of the native phosphatase is inactivated at that time and temperature, might prove most useful in the present situation.
ACKNOWLEDGMENTS

I wish to express my gratitude to Dr. R. Whittenbury for his advice and guidance, Mr. R. McLarty for his constructive criticisms and Miss Ann Keanie for her cheerful and good humoured assistance.
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Milk Hygiene Sub-Committee

Draft Code of Hygienic Practice for Cream

1. This Code is a guide to the practical measures for the hygienic production and handling of cream. (Attention is directed, however, to the legal requirements which are contained in the Milk and Dairies (General) Regulations 1959).

I. Selection and storage of raw milk

2. Milk for cream-making should be pure, sweet, clean and marketable. It should be free from contamination by residues of antibiotics or any other inhibitory substances.

3. When it is not used immediately it is received, milk should be cooled to, and continuously maintained at, a temperature not exceeding 45°F, until the cream-making process begins.

II. Heat treatment methods

4. It is important that cream sold for human consumption should be made safe by heating it sufficiently to destroy organisms likely to cause illness in consumers.

5. Cream which is to be subsequently filled into retail containers should, therefore, be heat-treated in one of the following ways:-

   (i) heated to a temperature of not less than 145°F. and not more than 150°F. for at least 30 minutes, and then immediately cooled to a temperature of not more than 50°F; or

   (ii) heated to a temperature of not less than 165°F. for at least 15 seconds, and immediately cooled to a temperature of not more than 50°F; or

   (iii) heated to a temperature of not less than 180°F., and immediately cooled to a temperature of not more than 50°F.

6. Cream which is heat-treated in the container in which it is to be sold should be heated as follows:-

   (a) if in cans or bottles, it should be heated to not less than 237°F. for 25 minutes or the equivalent, e.g. to not less than 225°F. for 45 minutes or 240°F. for 20 minutes. The cream should be cooled as rapidly as possible after heat treatment.

   (b) containers containing cream other than sterilised cream should be subjected to such heat treatment that the cream is retained for the appropriate period at one of the temperatures set out in sub-paragraphs 5(i), (ii) or (iii) above.
7. Precautions should be taken to prevent re-contamination after heat treatment.

III. Heat treatment plant

8. The heat treatment plant should be capable of fulfilling continuously the required time/temperature combination. The heating temperature should be continuously and automatically controlled. The plant should be provided with accurate and efficient indicating and recording thermometers which should register the temperature of the cream both during and at the completion of the heat treatment process. The accuracy of these instruments should be checked at least once a month. The records of thermometers used to record the temperatures to which the cream is raised or at which it is kept, or to which it is reduced should be retained for inspection for a period of one month from the date of heat treatment.

9. If a continuous flow heat-treatment plant is in use, the cream flow should be maintained at the required constant rate by means of either a suitable positive pump or a flow regulating device. The plant should be designed so that the holding time can be determined accurately.

10. The whole of the apparatus in which cream is heat-treated, including the cooler, should be so constructed and maintained as to ensure that the cream is protected from risk of atmospheric contamination.

11. Apparatus in which cream is to be heated to or maintained at a temperature of more than 150°F. by continuous flow method should be so arranged that the forward flow of any underheated cream is prevented.

12. The plant should be provided with adequate means for the withdrawal of samples.

13. The construction of the plant should permit effective cleansing and sterilisation.

14. After heat treatment, the cream should not be passed through pipelines or be placed in tanks or other receptacles which have held unheated milk, unless such pipelines, tanks or other receptacles have first been cleansed and sterilised.

IV. Equipment and containers-cleansing and storage

15. All plant and equipment used in cream-making should be in a good state of repair and capable of being easily cleansed and sterilised.

16. All pumps, pipelines, separators, heat treatment plants, coolers, thermometers and any other equipment which come into contact with cream in the process of cream-making should be cleansed and sterilised immediately before use and washed and effectively cleansed immediately after use. Cleansing immediately before and after use should be done for each cream-making operation even when the equipment is used for cream-making more than once in each period of 24 hours.

17. After cleansing, all equipment should be stored under conditions which avoid contamination.

18. Disposable retail containers with their lids or covers should be stored in a clean, dry place protected from the risk of contamination.
V. Retail containers—filling and sale

19. Where practicable, it is desirable that cream should be filled into retail containers at the premises at which it is prepared and as soon as possible.

20. Where it is necessary to despatch cream in bulk for filling elsewhere, it should be retained at a temperature not exceeding 50°F, and every precaution taken to prevent contamination. The person ultimately filling the cream into retail packs should take similar precautions.

21. In filling small containers from bulk cream care should be taken to ensure that hygienic conditions are observed throughout the filling operation. In particular, all articles of equipment used for dispensing and filling should be thoroughly cleansed and sterilised immediately before use and should be washed and effectively cleansed after use. Glass containers should be washed and sterilised immediately before use; others should be scrupulously clean.

22. Immediately after retail containers have been filled the lids or covers should be placed on them and the containers should be stored at a temperature of not more than 45°F. until sold.

23. Except where sold as, or as part of, a meal or refreshments, cream which has been filled into retail containers should not be sold otherwise than in those containers.

VI. Clotted Cream

24. The time/temperature combinations used in the preparation of clotted cream are such as to destroy organisms likely to cause illness in humans as well as bacteria which cause off flavours or souring. However, clotted cream is particularly susceptible to contamination after production because it frequently passes through the hands of several distributors and may also be transmitted by post before reaching the consumer. It may, therefore, be several days old before being consumed and any contamination present, would thus have an opportunity to develop. It is essential, therefore, that strict hygiene be observed during manufacture, handling, and packaging.

VII. Personal hygiene

25. Hand-washing facilities, including an adequate supply of clean water (hot and cold), soap or other suitable detergent should be provided. Nail brushes and clean towels or other suitable drying facilities should also be made available. These facilities should be used frequently.

26. All persons engaged in the preparation and handling of cream should be provided with adequate changes of protective clothing including washable head coverings.

27. Managements should make sure their staff is aware of the dangers of infections arising from human sources during the making and handling of cream; they should take all possible steps to avoid the possibility of such infections.

28. In order to prevent cross-infection, it is particularly important that no person suffering from open sores or wounds or from a heavy cold should be permitted to engage in any of the operations of cream-making or to handle any cream-making equipment.
29. Sufficient first aid equipment in the form of bandages, dressings (including waterproof dressings) and antiseptic should be readily available at all times.

VIII. Cream sold for refreshments

30. When cream is sold as, or as part of, a meal or refreshments, care should be taken to ensure that hygienic conditions are observed in the storage and handling of it. Except when in actual use the cream should be kept at a temperature not exceeding 45°F.

IX. Laboratory Control

31. Arrangements should be made for bacteriological examinations of the product and to test the effectiveness of the methods of cleansing and sterilising. (See Ministry of Agriculture, Fisheries and Food leaflet entitled "Swab Technique for Examination of Milk Plant and Equipment, B.T.21").


In exercise of the powers conferred upon me by sections 4, 7 and 56 of the Food and Drugs (Scotland) Act 1956(a), and of all other powers enabling me in that behalf, and after consultation with such organisations as appear to me to be representative of interests substantially affected by these regulations and after reference to the Scottish Food Hygiene Council under section 25 of the said Act (in so far as the regulations are made in exercise of the powers conferred by the said section 7), I hereby make the following regulations:—

Citation and commencement

1. These regulations may be cited as the Cream (Scotland) Regulations 1970, and shall come into operation on 17th August 1970.

Interpretation

2.—(1) In these regulations, unless the context otherwise requires—

“the Act” means the Food and Drugs (Scotland) Act 1956;

“appropriate designation”, in relation to food, means a name or description or a name and description sufficiently specific, in each case, to indicate to an intending purchaser the true nature of the food to which it is applied;

“clotted cream” means cream which has been produced and separated by the scalding, cooling andskimming of milk or cream;

“container” includes any form of packaging of food for sale as a single item, whether by way of wholly or partly enclosing the food or by way of attaching the food to some other article and in particular includes a wrapper or confining band;

“cream” means that part of milk rich in fat which has been separated by skimming or otherwise and which is intended for sale for human consumption;

“flavouring” includes flavouring essence and flavouring extract and means any product consisting of a flavouring agent and such other substances, if any, the use of which in food is not forbidden and which are reasonably necessary to produce a solid, a solution or an emulsion, but no other ingredient or ingredients;

“flour confectionery” means any solid or semi-solid product complete in itself and suitable for consumption without further preparation or processing.

(a) 1956 c. 30.
other than heating, of which the characteristic ingredient, apart from any
filling, is ground cereal, whether or not flavoured, coated with or containing
any carbohydrate sweetening matter, chocolate or cocoa; and includes short-
bread, sponges, pastry, pastry cases, crumpets, muffins, macaroons, ratafias,
meringues and petits fours, but does not include pharmaceutical products,
bread, biscuits or any products containing a filling which has as an ingredient
any meat or fish;
“food” means food intended for sale for human consumption and includes
drink, chewing gum and other products of a like nature and use, and articles
and substances used as ingredients in the preparation of food or drink or of
such products, but does not include—
(a) water, live animals or birds,
(b) fodder or feeding stuffs for animals, birds or fish, or
(c) articles or substances used only as drugs;
“pasteurised cream” means cream which has been subjected to heat treat-
ment so as to pasteurise it or has been produced from pasteurised milk;
“pre-packed” means made up in advance in or on a container ready for sale
by retail;
“sell” includes offer or expose for sale or have in possession for sale and
‘sale’ and ‘sold’ shall be construed accordingly;
“sell by retail” means sell to a person buying otherwise than for the purpose
of re-sale, but does not include selling to a caterer for the purposes of his
catering business or to a manufacturer for the purposes of his manufacturing
business; and ‘sale by retail’ and ‘sold by retail’ shall be construed accord-
ingly;
“sterilised cream” means cream which has been subjected to a process of
sterilisation by heat treatment in the container in which it is to be supplied
to the consumer;
“sugar” means any soluble carbohydrate sweetening matter;
“ultra heat treated cream” means cream which has been subjected in con-
tinuous flow to an appropriate heat treatment and has been packaged asepti-
cally;
“untreated cream” means cream which has not been treated by heat or in
any manner likely to affect its nature and qualities and has been derived from
milk which has not been so treated;
and other expressions have the same meaning as in the Act.
(2) The Interpretation Act 1889(a) shall apply for the interpretation of these
regulations as it applies for the interpretation of an Act of Parliament.
(3) All percentages mentioned in these regulations are percentages calculated
by weight of the cream including added ingredients, if any, permitted by regula-
tion 5, save that as respects the calculation of the milk fat content, specified in
regulation 4, of any cream which contains added sugar in accordance with the
provisions of these regulations, the percentages specified in regulation 4 are
percentages by weight of the cream excluding any such sugar.
(4) Any reference in these regulations to a label borne on a container shall
be construed as including a reference to any legible marking on the container
however effected.
(5) For the purposes of these regulations, the supply of food, otherwise than
by sale, at, in or from any place where food is supplied in the course of a business
shall be deemed to be a sale of that food, and a reference to purchasing and
purchaser shall be construed accordingly.

(a) 1889 c. 63.
(6) Any reference in these regulations to any order or other regulations shall 
be construed as a reference to such order or regulations as amended by any 
subsequent order or regulations.

(7) Any reference in these regulations to a numbered regulation shall, unless 
the reference is to a regulation of specified regulations, be construed as a reference 
to the regulation bearing that number in these regulations.

Exemptions

3. The following provisions of these regulations shall not apply in relation 
to any cream—

(a) sold, consigned or delivered for exportation to any place outside the 
United Kingdom;

(b) supplied under Government contracts for consumption by Her Majesty’s 
forces or supplied for consumption by a visiting force within the meaning 
of any of the provisions of Part I of the Visiting Forces Act 1952(a).

Description and composition of cream

4.—(1) Subject to the provisions of this regulation, any cream sold, con- 
signed or delivered shall bear one of the following descriptions and shall comply 
with such of the following compositional requirements as are specified in 
relation to that description:—

(a) “clotted cream” if the cream is clotted cream and contains not less than 
55 per cent. milk fat;

(b) “double cream” if the cream contains not less than 48 per cent. milk fat: 
Provided that, for the purposes of any sale, consignment or delivery on 
or before 29th February 1972, the word “thick” may be substituted for 
the word “double”;

(c) “whipping cream” if the cream contains not less than 35 per cent. milk 
fat;

(d) “whipped cream” if the cream contains not less than 35 per cent. milk 
fat and has been whipped;

(e) “sterilised cream” if the cream is sterilised cream and contains not less 
than 23 per cent. milk fat: 
Provided that, for the purposes of any sale, consignment or delivery on or before 29th February 1972, the word “sterilised” may be omitted;

(f) “cream” or “single cream” if the cream, not being sterilised cream con- 
tains not less than 18 per cent. milk fat;

(g) “sterilised half cream” if the cream is sterilised cream and contains not 
less than 12 per cent. milk fat;

(h) “half cream” if the cream, not being sterilised cream, contains not less 
than 12 per cent. milk fat:

Provided that the provisions of this paragraph shall not have effect as respects 
any sale, consignment or delivery before 1st March 1972 of—

(i) any clotted cream which bears the description “clotted cream” and which 
contains not less than 48 per cent. milk fat;

(ii) any sterilised cream which contains less than 23 per cent. milk fat but 
not less than 18 per cent. milk fat.

(a) 1952 c. 67.
(2) If any cream, other than cream bearing the description “clotted cream”, which is sold, consigned or delivered is pasteurised cream, ultra heat treated cream or untreated cream, the description specified in relation to that cream in paragraph (1) of this regulation shall include the expression or letters “pasteurised”, “ultra heat treated” or “U.H.T.”, or “untreated” as appropriate:

Provided that the provisions of this paragraph shall not have effect as respects any sale, consignment or delivery before 1st March 1972 of any cream (other than cream in an aerosol container) which contains not less than 18 per cent. milk fat and which bears the description “cream”, “single cream”, “double cream” or “thick cream”.

(3) In the case of cream derived from milk other than cows’ milk, each of the descriptions specified in paragraph (1) of this regulation shall include the name of the kind of animal from which the milk has been obtained.

(4) If any cream which complies with any of the compositional requirements specified in paragraph (1) of this regulation is used as an ingredient of another food, it shall be sufficient compliance with paragraphs (1) and (2) of this regulation if the description “cream” is applied to any such cream containing not less than 18 per cent. milk fat or if the description “half cream” is applied to any such cream containing not less than 12, and not more than 18 per cent. milk fat.

(5) No person shall sell, consign or deliver any cream which does not comply with this regulation.

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Permitted ingredients in cream

5.—(1) Subject to the provisions of this regulation, no cream sold, consigned or delivered shall contain any flavouring or other added ingredient whether or not that ingredient is a constituent of milk:

Provided that—

(a) clotted cream may contain nisin;

(b) cream which may bear the description “whipped cream” in pursuance of regulation 4(1) and cream in an aerosol container may contain—

(i) sodium alginate, or a mixture of sodium bicarbonate, tetrasodium pyrophosphate and alginic acid,

(ii) sodium carboxymethyl cellulose,

(iii) carrageenan,

(iv) gelatine,

so however that the percentage of any or, as the case may be, all of the ingredients specified in this sub-paragraph (b) present in the cream shall not exceed 0.3 per cent.;

(c) cream which may bear the description “whipped cream” in pursuance of regulation 4(1) and cream in an aerosol container may contain—

(i) not more than 13 per cent. of sugar,

(ii) nitrous oxide;

(d) cream in an aerosol container may contain not more than 0.5 per cent. of glyceryl monostearate;

(e) sterilised cream or ultra heat treated cream may contain—

(i) calcium chloride,

(ii) sodium or potassium salts of—

(aa) carbonic acid,

(ab) citric acid,

(ac) orthophosphoric acid,
(2) Notwithstanding the provisions of the last preceding paragraph, any cream sold, consigned or delivered to a manufacturer for the purposes of his manufacturing business or to a caterer for the purposes of his catering business may contain any or all of the following ingredients where appropriate to the circumstances or the description of cream specified in relation thereto, namely:

(a) cream intended for use in flour confectionery may contain not more than 13 per cent. of sugar;

(b) cream which may bear the description “whipping cream” in pursuance of regulation 4(1) may contain not more than 13 per cent. of sugar;

(c) cream which may bear the description “whipping cream” in pursuance of regulation 4(1) may contain—

(i) sodium alginate, or a mixture of sodium bicarbonate, tetrarsodium pyrophosphate and alginic acid,

(ii) sodium carboxymethyl cellulose,

(iii) carrageenan,

(iv) gelatine,

so however that the percentage of any or, as the case may be, all of the ingredients specified in this sub-paragraph (c) present in the cream shall not exceed 0.3 per cent.

(3) Notwithstanding the preceding provisions of this regulation, no product derived from milk and substantially similar to and resembling cream shall be deemed not to be cream solely by reason of the presence of any flavouring or other added ingredient or of any ingredient in an amount in excess of the amount permitted by this regulation.

(4) No person shall sell, consign or deliver any cream which does not comply with this regulation.

Amendment of the Emulsifiers and Stabilisers in Food (Scotland) Regulations 1962

6. The Emulsifiers and Stabilisers in Food (Scotland) Regulations 1962(a) shall be amended as follows:

(a) by adding at the end of regulation 5(1) thereof the words “save that cream may contain any such substance of a kind and to the extent permitted by regulation 5 of the Cream (Scotland) Regulations 1970.”;

(b) by deleting regulation 8 thereof.

Sales by description

7.—(1) No person shall sell any food under such a description as to lead an intending purchaser to believe that he is purchasing any kind of cream for which compositional requirements are specified in regulation 4 unless the food complies with the appropriate compositional requirements having effect in relation to that kind of cream.

(2) Where a person sells any food to a purchaser in response to a request for any kind of cream for which compositional requirements are specified in regulation 4, he shall be deemed to sell cream of that kind and under such a description as is specified in these regulations in relation to that kind of cream unless he clearly notifies the purchaser at the time of sale that the food is not that kind of cream.

(a) give with any food sold by him any label, whether attached to or borne on the container or not, or display with any food offered or exposed for sale by him any ticket, or

(b) publish, or be a party to the publication of, any advertisement for food, which bears or includes the word “cream” or any derivative thereof or any word substantially similar thereto otherwise than in accordance with provisions of the Act or any regulations made thereunder which, in either case, expressly provide for the use of that word unless—

(i) the food is cream which complies with the appropriate compositional requirements having effect in relation thereto by virtue of these regulations, or

(ii) that word is used in such a context as to indicate explicitly or by clear implication that the substance to which it relates is an ingredient of that food and unless the substance is cream which complies with such appropriate compositional requirements, or

(iii) that word is used in such a context as to indicate explicitly or by clear implication that such food is not, or does not contain, cream:

Provided that nothing in this regulation shall prohibit the use of the word “creamed” in relation to food which is not butter, milk, cream, condensed milk, evaporated milk, dried milk, cheese, skimmed milk or skimmed milk with non-milk fat.

9.—(1) No person shall sell, consign or deliver to a manufacturer for the purposes of his manufacturing business or to a caterer for the purposes of his catering business any cream which contains sugar, unless—

(a) there appears clearly and legibly on the label borne on, or securely attached to, the container of such cream and in immediate proximity to, and so prominent in height and visual emphasis as to be prominent by comparison with, the description of the cream required by regulation 4 the following statement “contains X per cent. Y”, and the statement is completed by inserting at “X” the amount of sugar in the cream expressed as a percentage of the mixture of cream and sugar and at “Y” the common or usual name or appropriate designation of the sugar, or

(b) the vendor furnishes to the purchaser not later than the time of delivery of such cream to the purchaser an invoice or other document bearing a statement as aforesaid.

(2) No person shall sell by retail any cream in an aerosol container or any cream which may bear the description “whipped cream” in pursuance of regulation 4(1), being cream which in each case contains sugar, unless there appears clearly and legibly on the label borne on, or securely attached to, the container of such cream and in immediate proximity to, and so prominent in height and visual emphasis as to be prominent by comparison with, the description of the cream required by regulation 4 the statement referred to in paragraph (1)(a) of this regulation.

10.—(1) Notwithstanding the provisions of article 5(1)(a) of, and Table C of Schedule I to, the Labelling of Food Order 1953(a), as amended (b), (whereby

(a) S.I. 1953/536 (1953 I, p. 665).

the ingredients of certain foods pre-packed for sale as such need not be specified in certain circumstances) and of regulation 6(1) of, and items 1 and 3 in Part I of Schedule 2 to, the Labelling of Food (Scotland) Regulations 1970(a) (whereby the use of certain generic, rather than specific, expressions is permitted in relation to certain food when forming an ingredient of some other food) no person shall sell by retail, pre-packed, any cream containing all or any of the substances specified in regulation 5, unless the appropriate designations of such substances appear on a label borne on the container of that cream in order of the proportion by weight in which they were used in the manufacturing process (the appropriate designation of the substance used in the greatest proportion by weight being listed first):

Provided that the provisions of this paragraph shall not have effect as respects any such sale by retail before 1st March 1972 of—

(a) any clotted cream which bears the description “clotted cream” and which contains not less than 48 per cent. milk fat;

(b) any sterilised cream which contains not less than 18 per cent. milk fat;

(c) any cream (other than cream in an aerosol container) which contains not less than 18 per cent. milk fat and which bears the description “cream”, “single cream”, “double cream” or “thick cream”.

(2) Notwithstanding the provisions of regulation 9(2) of the Labelling of Food (Scotland) Regulations 1970 (whereby the use of certain generic, rather than specific, expressions is permitted in certain circumstances in relation to certain substances contained in food for sale by retail otherwise than pre-packed), no person shall sell by retail, otherwise than pre-packed, any cream which has been dispensed from an aerosol container or any cream which may bear the description “whipped cream” in pursuance of regulation 4(1), being cream which in either case contains all or any of the substances specified in regulation 5, unless the appropriate designations of such substances in order of the proportion by weight in which they were used in the manufacturing process (the appropriate designation of the substance used in the greatest proportion by weight being listed first) appear on a ticket displayed on or in immediate proximity to such cream so as to be clearly visible to an intending purchaser:

Provided that where any such cream is so sold for immediate consumption at or near the place of sale without having been previously exposed for sale, there shall be deemed to be sufficient compliance with the provisions of this paragraph if the purchaser is clearly notified, at or before the time of delivery of the cream to him, that the cream contains all or any of the substances specified in regulation 5.

Requirements as to marking on labels on containers and on tickets

11. Any description required or permitted by regulation 4 to be borne on any cream shall appear, when the said cream is—

(a) sold, consigned or delivered in a container, on a label borne on the container of the said cream;

(b) sold by retail otherwise than in a container, on a ticket displayed on or in immediate proximity to the said cream so as to be clearly visible to an intending purchaser;

and every letter or word of such description shall be in characters of uniform colour and size, save that the initial letter of any word may be taller than any other letter in that word.

(a) S.I. 1970/1127.
Enforcement

12.—(1) The local authority of any area shall, subject to the provisions of the next following paragraph, enforce and execute the provisions of these regulations within their area.

(2) Where any part of the area of a local authority lies within the area of a port local authority such of the functions of the local authority under these regulations in relation to any food imported into that part shall, in so far as these functions fall to be exercised by the port local authority by virtue of any order made under section 172 of the Public Health (Scotland) Act 1897(a), be exercised by that port local authority.

(3) In this regulation “local authority” means the council of a county or of a large burgh within the meaning of the Local Government (Scotland) Act 1947(b); and any small burgh within the meaning of that Act shall, for the purposes of these regulations, be included in the county in which it is situated; and “port local authority” includes a joint port local authority.

Penalties

13.—(1) If any person contravenes or fails to comply with any of the foregoing provisions of these regulations he shall be guilty of an offence under these regulations.

(2) Any person who is guilty of an offence under these regulations shall be liable—

(a) on summary conviction to—

(i) a fine not exceeding £100 or to imprisonment for a term not exceeding 6 months or to both such fine and imprisonment; and

(ii) in the case of a continuing offence, to a further fine not exceeding £10 for every day during which the offence is continued; or

(b) on conviction on indictment to—

(i) a fine not exceeding £500 or to imprisonment for a term not exceeding one year or to both such fine and imprisonment; and

(ii) in the case of a continuing offence, to a further fine not exceeding £50 for every day during which the offence is continued.

Defences

14.—(1) In any proceedings for an offence against these regulations in relation to the publication of an advertisement, it shall be a defence for the accused to prove that, being a person whose business it is to publish or arrange for the publication of advertisements, he received the advertisement for publication in the ordinary course of business and did not himself make, or cause to be made, any material alteration in the substance of that advertisement.

(2) In any proceedings against the manufacturer or importer of any cream for an offence against these regulations in relation to the publication of an advertisement, it shall rest on the accused to prove that he did not publish, and was not a party to the publication of, the advertisement.

Application of various sections of the Act

15.—(1) Sections 41(2) and (5) (which relates to proceedings), 42(1), (2) and (3) (which relates to evidence of certificates of analysis), 44 (which relates to the power of a court to require analysis by the Government Chemist), 46(2) (which

(a) 1897 c. 38.

(b) 1947 c. 43.
Revocation

16.—(1) Article 10 of the Milk and Dairies (Scotland) Order 1934(a), as amended (b), and the Food Standards (Cream) Order 1951(c) are hereby revoked.

(2) Section 38 of the Interpretation Act 1889 shall apply as if these regulations were an Act of Parliament and as if the orders revoked or partially revoked by these regulations were Acts of Parliament repealed by an Act of Parliament.

Gordon Campbell,
One of Her Majesty’s Principal
Secretaries of State.

St. Andrew’s House,
Edinburgh.
5th August 1970.

EXPLANATORY NOTE

(This Note is not part of the Regulations.)

These Regulations, which apply to Scotland only, supersede the Food Standards (Cream) Order 1951 and come into operation on 17th August 1970.

The principal provisions of these Regulations—

(a) specify requirements for the description and composition of cream (Regulation 4);

(b) specify permitted added ingredients for cream, subject to specified limits (Regulation 5), and make consequential amendments to the Emulsifiers and Stabilisers in Food (Scotland) Regulations 1962 (Regulation 6);

(c) specify requirements for the labelling and advertisement of cream (Regulations 8 to 11);

(d) provide that certain requirements relating to the description and composition of cream (Regulation 4(1) and (2)) and relating to labelling (Regulation 10(1)) shall have modified effect before 1st March 1972.

The regulations do not apply to any cream intended for export or supplied for consumption by Her Majesty’s forces or a visiting force (Regulation 3(1)).

(b) S.I. 1956/2110 (1956 I, p. 1016).
(c) S.I. 1951/668 (1951 III, p. 13).
FOOD AND DRUGS

COMPOSITION AND LABELLING

The Cream (Scotland) Regulations 1970

The regulations were made under the Food and Drugs Act 1955, in the form of regulations under Section 38 of the Act. The Act received Royal Assent on 15th August 1955.

EXTRAJUDICIAL NOTE

This Note is not Part of the Regulations.

These Regulations apply to Scotland only, and supersede the Local Government (Scotland) Cream (Creaming of Milk) Regulations 1948 (S. 98) of 1948, and the Local Government (Scotland) Cream (Creaming of Milk) Regulations 1949 (S. 98) of 1949.

The regulations provide for the establishment of the Food and Drugs Department, to be known as the Food and Drugs Department, to be appointed by the Secretary of State for Scotland, and to be responsible for the enforcement of the regulations.

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