# T H E S I S

# S W E E T  C R E A M  B U T T E R

by

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1908.

--THESIS--

on

Sweet Cream Butter.

Experiment stations of late years have been working upon the subject of flavor and keeping quality of butter. They have taken up the subject of the bacterial content of milk, ripening of cream by control of temperature, and control by commercial starters, but practically no work has been done with regard to producing sweet cream butter. It is for this purpose, therefore, that we intend to make a study of butter made from sweet cream, as compared with sour cream, with particular reference to the following points: keeping quality, ripening quality, and its bacteriological content.

In order to have a clear conception of what we mean when we speak of sweet or sour cream butter, it would probably be best to define just what we meant by each. By sweet cream butter is meant butter made from cream having less than .2 per cent. acidity; and by sour cream butter we mean butter made from cream having more than .2 per cent. acidity, usually .4 to .5 per cent.

A study of sweet cream butter would naturally be very closely related to the subject of natural and commercial starters. In order, therefore, to have a more definite idea concerning the relation that exists between them, we shall discuss somewhat in detail the different processes and the results sought for.

The ripening of cream has for many years been considered one of the essential factors in the production of a good butter. The object of ripening cream is to produce desirable flavors by means of growing certain species of bacteria, which act upon the milk sugar and form acid. This acid is transmitted to the butter, giving it a very palatable flavor. It also was thought that the acid destroyed the coating surrounding the fat globule, and

in that way cream could be churned more quickly. Until very recently the desirable flavor of butter was a pure acid taste. At present, however, the best trade is calling for a butter that is low in acid and characterized by a sweet nutty taste; or a butter that is characterized by the absence of any objectionable flavor.

As flavors in milk and butter are produced almost entirely by the action of bacteria upon its different parts, a control of this factor will also control the flavor. Therefore, it is the OBJECT OF THIS THESIS to make a careful study of sweet cream butter as compared with sour cream butter, in order to determine the relative keeping quality, ripening quality, and bacteriological content of each.

DISCUSSION.

Ripening of cream is a process brought about by a series of chemical changes caused by the action of micro-organisms, but little understood by chemists. A combination of these changes into one general term is called fermentation. It is definitely know that certain organisms are desirable in milk, and that certain other organisms are not desirable. It has been found by analysis that there are over one hundred species of bacteria that produce acid in milk. Obviously, it is not necessary to have all of these species present. In fact only a few of them are desirable, and just what these are is a question which is not yet settled. It also remains a doubt whether or not the same organism produces the desired acid, aroma, and flavor; but one thing is certain, when conditions are favorable for one the other also develops, showing their close relation.

# Conn claims that the bacteria which act upon the nitrogenous part of the milk are closely associated with the bacteria that produce the desirable flavor in butter. Weighman claims that the best results are obtained when a variety of species work together in the cream. Eckles came to a similar conclusion, and asserted that the flavor and aromatic

# Storr's Station, Conn

substances produced during the ripening of cream may be produced by a variety of acid producing bacteria. Storch reaches a like conclusion, and states that flavor and aromatic products are the result of a joint action of a great many species of lactic acid producing bacteria.

From the foregoing conclusions of these investigations it seems evident that no single organism produces the desirable flavor in butter and cream. It is evident, however, that the organism or organisms that produce the required flavor belong to the lactic acid group.

What composes the aromatic substances given off from butter is not known, but they undoubtedly are volatilecompounds of ether like substances produced by the action and reproduction of bacteria in the milk.

The next question which we must now deal with is the best method of controlling the growth of the bacteria in the cream, not only by inoculating it with the desired organism to begin with, but also to properly control the organisms after inoculation. In order to do this it was planned to inoculate cream while sweet with a culture of desirable lactic acid bacteria, cool and churn at once before any bacterial growth has taken place. The theory is that by churning immediately enough bacteria will be incorporated in the butter to produce any shade of variation desired in the flavor. In other words, by excluding all organisms from the cream except those which produce desirable results we have complete control of the bacteriological content of the butter, and can market the butter whenever it is found that the ripening process has reached the most desirable stage.

The method used almost universally at present, and advised by our dairy schools, is what is known as Pasteurization and Artificial Inoculation. This process consists chiefly in two separate parts: First, The cream is taken as soon as delivered and heated to about 175° F.. This kills almost all germ life present. Second, The cream is then cooled to 70° F. and inoculated with a

pure culture of lactic acid bacteria;--usually about 10% is used. The cream is then held at a temperature of about 70° F. until the desired acidity is reached. The acidity is used as an index to determine the degree to which the bacteria have developed. The starter used is kept in stock by inoculating pasteurized skim milk with a commercial starter, many kinds of which are now on the market.

The work in this experiment on Sweet Cream Butter is divided into two parts. A good grade of cream was first selected and pasteurized to 175° F., then equally divided and to #1 we added 10% starter and churned as soon as cool. No. 2 was carried out by the common creamery method, as above described.

--THESIS.--

Sweet Cream Butter

Outline #1.

A. Cream,-

1. Amount taken, 39#
2. Per cent. acidity . . . . . .19
3. Bacteriological Content . . . . . #1
4. Temperature of pasteurization . . . . 175° F.
5. Bacteriological Content . . . . #2
6. Per cent. acidity . . . . . 14
7. Starter, kind, ... Erricsson ... Per cent used, 10
8. Acidity . . . . . .5
9. Bacteriological Content . . . . . #3
10. Divide equally: Pounds each, . . . . 19
11. Churn #1, when cooled to . . . . 55° F.
12. Wash with water pasteurized to . . . . 175° F.
13. Churn #2 when .35% acidity at . . . . 54° F.
14. Wash with water pasteurized to . . . . 175° F.

B. Butter,-

1. Bacteriological Content every 10 days:
   (1) #4, sweet cream butter
   (2) #5, sour " " " "
2. Keep #1 and #2 at 50° F.

--THESIS.--

Sweet Cream Butter

Outline #2.

A. Cream,-

1. Amount taken . . . . . 38#
2. Per cent. acidity . . . . . 125
3. Bacteriological Content . . . . . 1'
4. Temperature of pasteurization . . . 175° F.
5. Bacteriological Content . . . . . #2
6. Per cent. acidity . . . . . .095
7. Starter, kind ... Erricsson ... Percent used 10
8. Bacteriological Content . . . . . #3'
9. Divide equally: Pounds each Acidity 74% 19
10. Churn #1 when cooled to . . . . . 52° F.
11. Wash with water pasteurized to . . . . 180° F.
12. Churn #2 when .4% acidity at . . . . 52° F.
13. Wash with water pasteurized to . . . 175° F.

B. Butter,-

1. Bacteriological Content every 10 days:
   (1) #4', sweet cream butter
   (2) #5', sour " "
2. Keep #1 and #2 at 50° F.

--THESIS--

Sweet Cream Butter.

Sub-outline.

Cream,-

1. Take acidity

2. Bacteriological Content.

   (a) $\frac{1}{100}$, $\frac{1}{500}$, $\frac{1}{1000}$ in duplicates, agar and gelatin, 12 plates.

   (b) Count.

   (c) Relation of liquefiers.

   (d) Take sub-cultures on agar plant.

   (e) Run sub-cultures thro:--

      1'. Glucose agar

      2'. Gelatin stab

      3'. Plain milk

      4'. Litmus milk or litmus gelatin

   (f) Microscopic examination for germs.

3. Pasteurize sample.

4. Bacteriological Content -- same as (2).

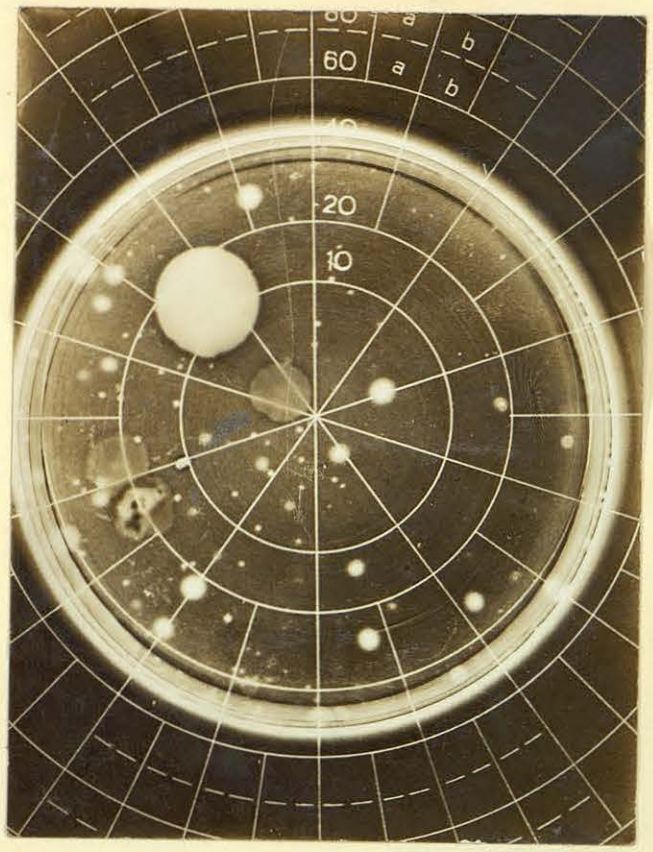
## Methods Used in the Bacteriological Study and Description.

It is thought that a few words here are needed as to the method of obtaining the data herein tabulated. The following bacteriological analyses were taken:--#1, sweet cream before pasteurization,--#2, cream after pasteurization,--#3, starter,--#4, sweet cream butter,--#5, sour, or ripened, cream butter. The history analyses were taken sixteen days from date of making.

The study of bacteria was divided into two heads,--quantitative and qualitative. The quantative was made by using plain agar and litmus gelatine. Four plates were made on each media. The dilutions used were varied according to the estimated content of the sample. In each case check plates were made, and the average of the two were computed, thus dispensing with any undue chance of error. In the qualitative analysis the following methods were used:--
The isolation of the bacteria was accomplished by making inoculations from plate cultures, usually about two days old. The inoculations were made from the plate cultures on agar slants, and plain bouillon. When the growth on either of these media was moderately abundant, sub-cultures were made on the various differential media. The following were generally used:--Litmus milk, gelatine stab, glucose agar, and plain milk.

The morphology of the organisms was determined from the bouillon cultures in most cases, although in some it was secured from fresh agar slants. The organisms were first examined under the microscope in hanging drops in order to determine the motility. No determination of spores or flagella was attempted. After this, stained preparations were made and reserved for future identifications and comparison.

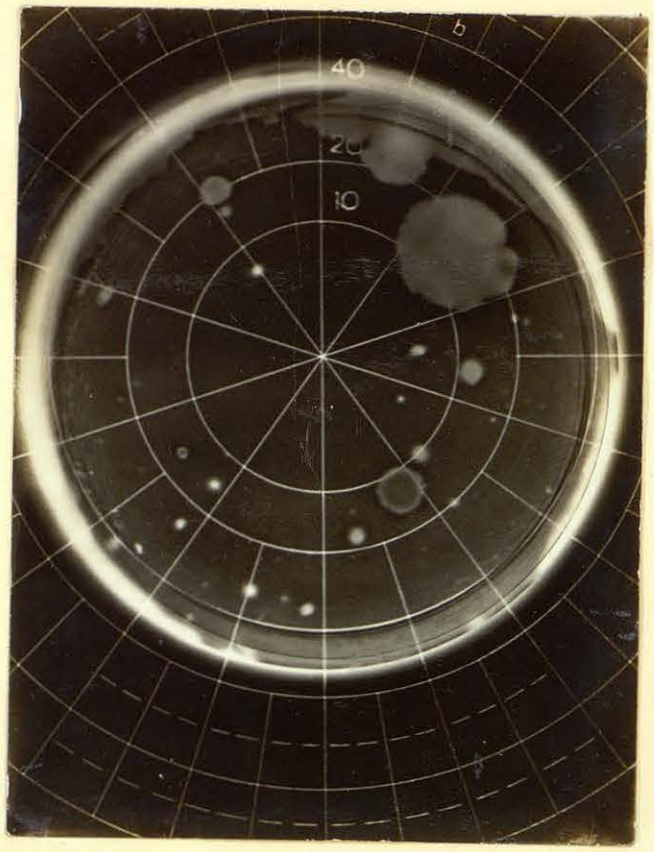
In general, in isolating and determining the species and families of bacteria we have followed the methods used by Conn.




This represents a small regular spreading colony, surface growth. Very dense. A $\frac{1}{2,000}$ dilution. Culture features found, 1 -- B -- 2.


This represents a very characteristic specimen of a large whitish, spreading colony. Surface growth; bluish floresence.

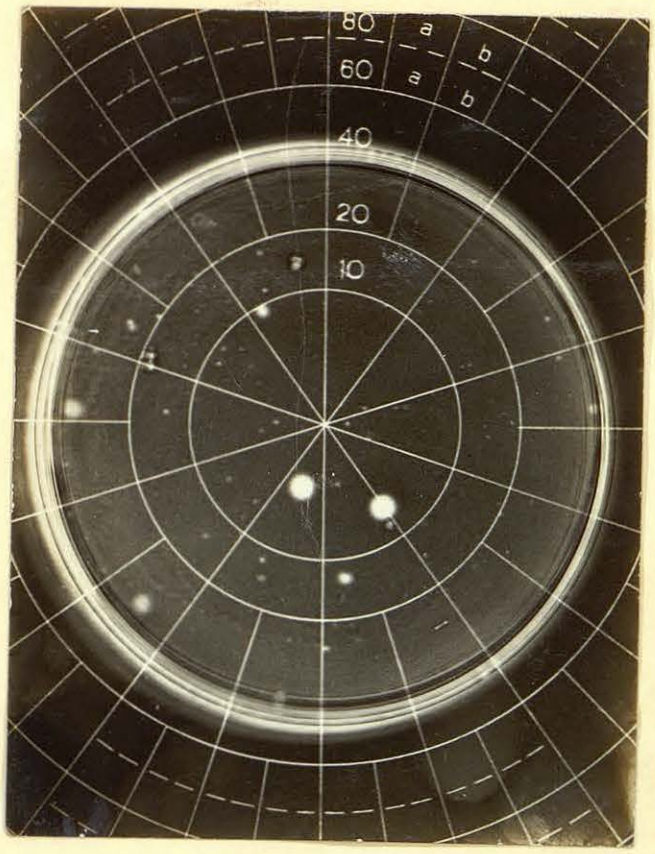
Culture features found in 3 -- B -- 1.




This represents the growth of an irregular shaped, surface growing colony. Cream, white.

A $\frac{1}{10\,000}$ dilution.

Culture features found on 4 -- B -- 2.




This represents a typical lactic acid colony.

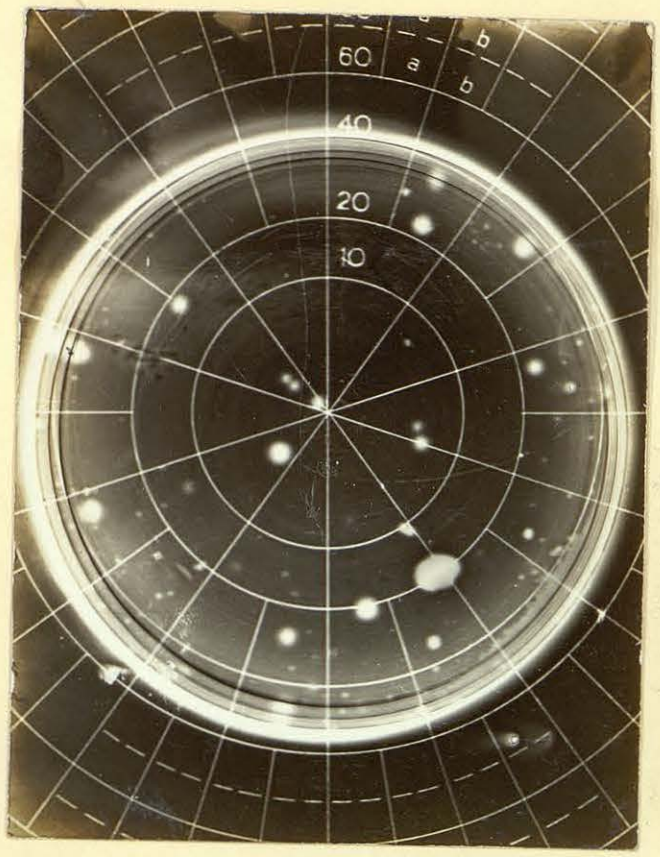
Small, oblong, grayish color. Deep and surface growth. A $\frac{1}{10\ 000}$ dilution.

Culture features found on 3 -- B -- 2.


This represents the growth of a yellow spreading colony. Very irregular, cloudy, surface growth.

A $\frac{1}{1\ 000}$ dilution.

Culture features found on 1 -- B -- 4.

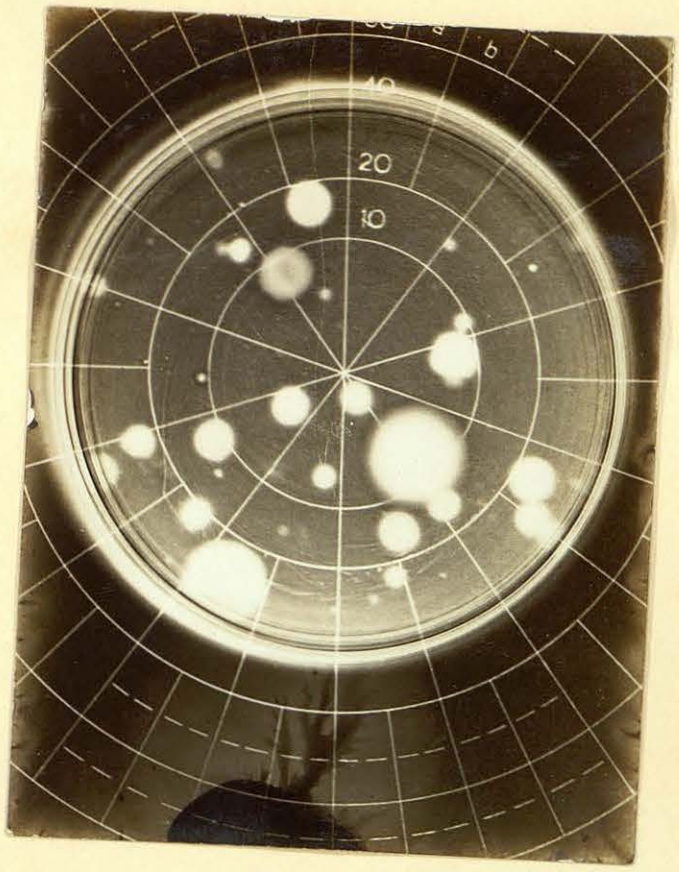



This represents a very small, regular colony.

Both surface and deep growth. Grayish white.

a $\frac{1}{2,000}$ dilution.

Culture features found on 1 -- B -- 3.




This represents a very characteristic growth of mold. The radial edge is its truest characteristic.

Qualitative Analysis.

Content #1'

No. B-1

(a) Description: ... Large white spreading colony.
Surface growth.

(b) Relative per cent.: ... Trace.

No. B-2

(a) Description: Small distinct surface colony, round and regular.

(b) Relative per cent.: 5%.

No. B-3

(a) Description: Nut shaped organism, deep and surface growth.

(b) Relative per cent.: 70.

No. B-4

(a) Description: Yellow spreading colony, surface growth.

(b) Relative per cent., 5.

No. B-5

(a) Description: Medium size, radial spreading colony, surface.

(b) Relative per cent., 1.

Quantitative Analysis.

Content #1'.

Agar Plates. -A- 24 hours.

1/200 solution 10,080,000 per c.c.

1/1000 " " 10,650,000 per c.c.

1/2000 " " 10,120,000 per c.c.

Average 10,283,000 per c.c.

Agar Plates. -B-

1/200 solution per c.c.

1/1000 " " 4,380,000 per c.c.

1/2000 " " 3,920,000 per c.c.

Average, 4,150,000 per c.c.

Final Average on Agar, 7,216,500 per c.c.

Gelatin Plates. -A- 48 hours.

1/200 solution, No growth per c.c.

" ", per c.c.

Qualitative Analysis.

Content #1.

No. B-1

(a) Description: ... Large white spreading colony.
Faintly regular, surface growth.

(b) Relative per cent. $\frac{1}{100,000}$

No. B-2

(a) Description: ... Small, distinctly white, surface colony. Very round and regular

(b) Relative per cent.: 20.

No. B-3

(a) Description: ... Very small, regular colony. Both surface and deep growth. Grayish white.

(b) Relative per cent.: 20.

No. B-4.

(a) Description: ... Yellow spreading colony. Very irregular, cloudy, surface growth.

(b) Relative per cent.: About 1 to 1,000,000.

No. B-5

(a) Description: ... Large spreading colony. Distinctly radial. Yellowish white.

(b) Relative per cent.: About 3 or 4 to 1,000,000

Quantitative Analysis,

Content #1.

Agar Plates. -A-- 24 hours.

1/100 solution, to numerous per c.c.
1/500 " " 3,460,000 per c.c.
1/1,000 " " 5,760,000 per c.c.
Average 4,610,000 per c.c.

Agar Plates. -B-

1/100 solution, to numerous,per c.c.
1/500 " " 2,540,000 per c.c.
1/1,000 " " 5,800,000 per c.c.
Average 4,176,000 per c.c.
Final Average on Agar, 4,390,000 per c.c.

Gelatin Plates. -A-- 48 hours.

1/100 solution, no growth per c.c.
1/500 " " 2,340,000 per c.c.
1/1,000 " " 2,720,000 per c.c.
Average 2,530,000 per c.c.

Gelatin Plates. -B-

1/100 solution, to numerous per c.c.
1/500 " " 2,920,000 per c.c.
1/1,000 " " 2,800,000 per c.c.
Average 2,860,000 per c.c.
Final Average of Gelatin 2,695,000 per cc.
Grand Average per c.c. 3,542,500

## Qualitative Analysis
## No. I.

| | | | 1B1 | 1B2 | 1B3 | | B1 | B2 | B3 | B4 | B5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of Plate | | | | | | | | | | | |
| No. per cc | | | | | | | | | | | |
| Morphology | | Diameter over 100 | | | | | | | | | |
| | | Chains | + | + | + | | + | + | + | + | + |
| | | Spores | | | | | | | | | |
| | | Motility | + | + | + | | + | + | + | I | I |
| | | Graham Stain | | | | | | | | | |
| Cultural Features | Broth | Turbidity | + | + | + | | + | + | + | + | + |
| | | Scum | I | I | I | | I | I | I | I | I |
| | | Sediment | I | + | I | | I | + | I | I | + |
| | Agar | Dull | I | I | I | | I | I | I | I | + |
| | | Wrinkled | + | I | I | | + | I | I | I | I |
| | | Chromogenesis | I | I | I | | I | I | I | I | I |
| | Gelatin Colony | Round-compact | + | + | I | | + | + | I | | |
| | | Proteus-like | | | | | | | | | |
| | | Rhizoid | I | I | + | | I | I | + | | |
| | | Filamentous | I | I | I | | I | I | I | | |
| | | Curled | I | I | I | | I | I | I | | |
| | Gel. Stab. | Surface growth | + | I | I | | + | I | I | I | I |
| | | Needle growth | + | + | + | | + | + | + | + | + |
| Bio-Chemical | * | Gelatin | I | I | I | | I | I | I | I | I |
| | Milk | Coagulated | + | + | + | | + | + | + | + | + |
| | | Acid | + | + | + | | + | + | + | + | + |
| | | Alkaline | I | I | I | | I | I | I | I | I |
| | | Saponified | I | I | I | | I | I | I | I | I |
| | | Peptonized | | | | | | | | | |
| | + | Gas | I | I | I | | I | I | I | I | I |
| Organism name | | | | | | | | | | | |

Analysis No. 2.

* = Liquefaction  + = Gl Sugar.

Qualitative Analysis,

Content #2'.

No. B-1

(a) Description: ... Large white surface, colony regular.

(b) Relative per cent.: Trace.

No. B-2

(a) Description: ... Single distinct surface. Colony regular.

(b) Relative per cent.: 1.

No. B-3

(a) Description: ... Small regular. Deep surface growth.

(b) Relative per cent.

No. B-4

(a) Description: ... Large dense white spreading colony. Regular.

(b) Relative per cent.: 2.

No. B-5

(a) Description: ... Small regular yellow colony, dense.

(b) Relative per cent.: Trace

Quantitative Analysis,

Content #2'.

Agar Plates. -A- 24 hours.

1/200 solution, precipitated

1/1,000 " " 240,000 per c.c.

1/2,000 " " 144,000 per c.c.

Average 192,000 per c.c.

Agar Plates: -B-

1/200 solution, plates neutralized.

Final Average on Agar 192,000 per c.c.

Gelatin Plates. -A- 48 hours.

No growth on gelatin.

Qualitative Analysis.

Content #2.

No. B-1

(a) Description: .. Large white surface growth.

(b) Relative per cent. 1.

No. B-2

(a) Description: .. Small distinct surface colony.
Regular.

(b) Relative per cent.: 3.

No. B-3

(a) Description: .. Small regular, deep surface
growth. Lactic acid.

(b) Relative per cent. 40.

No. B-4

(a) Description: ... Large white, dense surface colony.
Regular.

(b) Relative per cent. 5.

Quantitative Analysis,

Content #2.

Agar Plates. -A-

| | | | |
|---|---|---|---|
| 1/100 | solution, | 22,500 | per c.c. |
| 1/500 | " " | 31,000 | per c.c. |
| 1/1,000 | " " | 30,000 | per c.c. |
| | Average | 27,800 | per c.c. |

Agar Plates. -B-

| | | | |
|---|---|---|---|
| 1/100 | Solution | 36,000 | per c.c. |
| 1/500 | " " | 32,000 | per c.c. |
| | Average | 34,000 | per c.c. |

Final Average on Agar, 30,900 per c.c.

Gelatin Plates. -A-

| | | | |
|---|---|---|---|
| 1/100 | solution | 6,000 | per c.c. |
| 1/500 | " " | 7,500 | per c.c. |
| 1/1000 | " " | 5,000 | per c.c. |
| | Average | 6,166 | per c.c. |

Gelatin Plates. -B--

| | | | |
|---|---|---|---|
| 1/100 | solution | 6,000 | per c.c. |
| 1/500 | " " | 2,000 | per c.c. |
| 1/1,000 | " " | 6,000 | per c.c. |
| | Average | 4,666 | per c.c. |

Final Average on Gelatin 4600 per c.c.

Grand Average 17950 per C c.

## Qualitative Analyses
## No. II.

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of Plate | | | 2B1 | 2B2 | | | B1 | B2 | B3 | B4 | B5 | | | | | | | | |
| No. per cc | | | | | | | | | | | | | | | | | | | |
| Morphology | | Diameter over 100 | | | | | | | | | | | | | | | | | |
| | | Chains | * | 1 | 1 | | + | 1 | 1 | + | + | | | | | | | | |
| | | Spores | | | | | | | | | | | | | | | | | |
| | | Motility | + | 1 | + | | + | 1 | + | 1 | 1 | | | | | | | | |
| | | Graham Stain | | | | | | | | | | | | | | | | | |
| Cultural Features | Broth | Turbidity | + | + | + | | + | + | + | 1 | 1 | | | | | | | | |
| | | Scum | 1 | 1 | 1 | | 1 | 1 | 1 | + | 1 | | | | | | | | |
| | | Sediment | + | + | + | | + | + | + | + | + | | | | | | | | |
| | Agar | Dull | + | + | + | | + | + | + | + | + | | | | | | | | |
| | | Wrinkled | 1 | + | 1 | | 1 | + | 1 | + | 1 | | | | | | | | |
| | | Chromogenesis | + | 1 | 1 | | + | 1 | 1 | 1 | 1 | | | | | | | | |
| | Gelatin Colony | Round-compact | | | | | | | | | | | | | | | | | |
| | | Proteus-like | + | | | | + | | | | | | | | | | | | |
| | | Rhizoid | + | | | | + | | | | | | | | | | | | |
| | | Filamentous | + | | | | + | | | | | | | | | | | | |
| | | Curled | | | | | | | | | | | | | | | | | |
| | Gel Stab | Surface growth | + | + | 1 | | + | + | 1 | + | 1 | | | | | | | | |
| | | Needle growth | 1 | + | + | | 1 | + | + | 1 | + | | | | | | | | |
| Bio-Chemical | * | Gelatin | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | | | | | | | |
| | Milk | Coagulated | 1 | + | + | | 1 | + | + | + | + | | | | | | | | |
| | | Acid | 1 | + | + | | 1 | + | + | + | + | | | | | | | | |
| | | Alkaine | + | 1 | 1 | | + | 1 | 1 | 1 | 1 | | | | | | | | |
| | | Saponified | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | | | | | | | |
| | | Peptonized | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | | | | | | | |
| | + | Gas. | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | | | | | | | |
| Name of Organism | | | | | | Analysis No. 2. | | | | | | | | | | | | | |

* = Liquefaction  + = Gl. Sugar.

Qualitative Analysis,

Content #3'.

No. B-1

(a) Description: ... Surface spreading colony.
Blueish floresence.

(b) Relative per cent.: Trace

No. B-2

(a) Description: ... Nut shaped, deep growing colony.
Lactic acid.

(b) Relative per cent.: 80.

No. B-3

(a) Description: ... Very small white colony.
Deep and surface growths.

(b) Relative per cent.: 30.

No. B-4

(a) Description: ... None present.

No. B-5

(a) Description: ... Large radial yellow colony.
Surface growth.

(b) Relative per cent.: trace.

No. B-7

(a) Description: ... Large definitely radial white
surface growth.

(b) Relative per cent.: Trace.

No. B-8

(a) Description: ... Regular dense colony,
surface growth.

(b) Relative per cent.: 3.

Quantitative Analysis,

Content #3'.

Agar Plates. -A- 24 hours.

| | | | |
|---|---|---|---|
| 1/1,000 | solution | 75,000,000 | per c.c. |
| 1/2,0000 | " | " 15,600,000 | per c.c. |
| 1/100,000 | " | " 60,000,000 | per c.c. |
| | Average | 50,000,000 | per c.c. |

Agar Plates. -B-

| | | | |
|---|---|---|---|
| 1/1,000 | solution | 80,000,000 | per c.c. |
| 1/20,000 | " | " 98,000,000 | per c.c. |
| 1/100,000 | " | " lost | |
| | Average | 89,000,000 | per c.c. |

Final Average on Agar 69,600,000 per c.c.

Gelatin Plates. -A- 48 hours

No growth

Qualitative Analysis,

Content #3.

No. B-1

(a) Description: ... Large whitish spreading colony.
Surface growth, blueish floresence.

(b) Relative per cent.: 1 to 1,000,000

No. B-2

(a) Description: ... Small, oblong, yellow colony.
Characteristically shaped.
Irregular, deep growth.

(b) Relative per cent.: 40.

No. B-3

(a) Description: ... Very small white colony.
Round, regular, deep and surface growth

(b) Relative per cent.: 50.

No. B-4

(a) Description: ... Light blue, round colony. Dark
yellow in center, light on edges.

(b) Relative per cent.: 1-2 to 1,000,000.

No. B-5

(a) Description: ... Large radial yellow colony.
Irregular surface growth.

(b) Relative per cent.: 1-2 to 1,000,000.

No. B-6

(a) Description: ... Medium, definitely radial,
white colony.

(b) Relative per cent.: trace.

Quantitative Analysis,

Content #3.

Agar Plates. -A- 24 hours.

1/5 000 solution too numerous

1/10,000 " " 84,800,000 per c.c.

1/50,000 " " 124,000,000 per c.c.

Average104,000,000 per c.c.

Agar Plates. -B-

1/5,000 solution too numerous

1/10,000 " " 88,000,000 per c.c.

1/50,000 " " 126,000,000 per c.c.

Average 102,000,000 per c.c.

Final Average on Agar, 103,000,000 per c.c.

Gelatin Plates. -A- 48 hours.

1/5,000 solution 1,400,000 per c.c.

1/10,000 " " 1,600,000 per c.c.

1/50,000 " " 1,800,000 per c.c.

Average 1,600,000 per c.c.

Gelatin Plates. -B-

1/5,000 Solution 1,500,000 per c.c.

1/10,000 " " 1,200,000 per c.c.

1/50,000 " " 1,600,000 per c.c.

Average 1,430,000

Final Average on Gelatin 1,515,000 per c.c.

Grand Average 52,257,000 per c.c.

## Qualitative Analysis
## No. III.

| | | | 3B1 | 3B2 | 3B3 | 3B4 | 3B5 | | B1 | B2 | B3 | B4 | B5 | B7 | B8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of Plate | | | | | | | | | | | | | | | |
| No. per c c | | | | | | | | | | | | | | | |
| Morphology | | Diameter over 100 | | | | | | | | | | | | | |
| | | Chains | 1 | + | + | + | + | | 1 | + | + | | + | + | + |
| | | Spores | | | | | | | | | | | | | |
| | | Motility | + | + | 1 | + | + | | + | + | - | | + | + | 1 |
| | | Graham Stain | | | | | | | | | | | | | |
| Cultural Features | Broth | Turbidity | + | + | + | + | + | | + | + | + | | + | + | 1 |
| | | Scum | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 |
| | | Sediment | + | + | + | + | + | | + | + | + | | + | + | + |
| | Agar | Dull | + | 1 | 1 | | 1 | | + | 1 | 1 | | 1 | 1 | + |
| | | Wrinkled | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 |
| | | Chromogenesis | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 |
| | Gelatin Colony | Round-compact | | | | | | | | | | | | | |
| | | Proteus-like | | | | | | | | | | | | | |
| | | Rhizoid | | | | | | | | | | | | | |
| | | Filamentous | | | | | | | | | | | | | |
| | | Curled | | | | | | | | | | | | | |
| | Gel Stab | Surface growth | + | + | + | + | | | + | + | + | | + | 1 | + |
| | | Needle growth | 1 + | + | + | + | | | + | + | + | | + | + | 1 |
| Bio-Chemical | * | Gelatin | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | | 1 | 1 | 1 |
| | Milk | Coagulated | + | + | + | + | + | | + | + | + | | + | + | + |
| | | Acid | + | + | + | + | + | | + | + | + | | + | + | + |
| | | Alkaline | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 |
| | | Saponified | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 |
| | | Peptonized | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 |
| | + | Gas | + | + | + | + | + | | + | + | + | | + | 1 | 1 |
| Name of Organism | | | | | | | | | | | | | | | |

Analysis No. 2. None present.

* = Liquefaction  + = Gl Sugar.

Quantitative Analysis,

Content #4'.

Agar Plates. -A- 24 hours.

| | | | |
|---|---|---|---|
| 1/1,000 | slution, | 3,840,000 | per c.c. |
| 1/2,000 | " " | 4,640,000 | per c.c. |
| 1/10,000 | " " | 3,960,000 | per c.c. |
| | Average, | 4,133,300 | per c.c. |

Agar Plates. -B-

| | | | |
|---|---|---|---|
| 1/1,000 | solution, | 6,000,000 | per c.c. |
| 1/2,000 | " " | 2,880,000 | per c.c. |
| 1/10,000 | " " | 2,640,000 | per c.c. |
| | Average | 3,840,000 | per c.c. |

Final Average on Agar, 3,986,600 per c.c.

Gelatin Plates. -A-

No plates made on gelatin.

Qualitative Analysis.

Content #4.

History Analysis.

No.

(a) Description: .. Lactic acid

(b) Relative per cent.: 90.

No. B-1

(a) Description: ... Cream white, round colony.
Surface growth.

(b) Relative per cent.: 9.

No. B-2

(a) Description: ... Moulds and irregular
colonies.

(b) Relative per cent.: 1.

No. B-3

(a) Description: ... No spreading colonies.
One mould.

Quantitative Analysis,

Content #4.

History Analysis

Agar Plates. -A- 24 hours.

1/100 solution 31,000 per c.c.

1/2,000 " " 400,000 per c.c.

1/10,000 " " 610,000 per c.c.

Average 347,000 per c.c.

Agar Plates. -B-

1/1,000 solution 320,000 per c.c.

1/2,000 " " 216,000 per c.c.

1/10,000 " " 600,000 per c.c.

Average, 378,600 per c.c.

Final Average on Agar 362,800 per c.c.

Gelatin Plates. -A- 48 hours.

1/1,000 solution 720,000 per c.c.

1/2,000 " " 772,000 per c.c.

1/1,0000 " " liquefied

Average 746,000 per c.c.

Gelatin Plates. -B-

No growth on gelatin. -B-

Final Average on Gelatin 746,000 per c.c.

Grand Average 554,400 per c.c.

Qualitative Analysis.

Content #4.

No. B-1

(a) Description: ... Cream white round colony.
Surface growth.

(b) Relative per cent.: Very small.

No. B-2

(a) Description: ... Light yellow surface colony. Star
growth in center very characteristic.

(b) Relative per cent.: Very small.

No. B-3

(a) Description: ... Very small,--filimentous.
(Proved to be a mold)

(b) Relative per cent. Comparatively large.

No. B-4

(a) Description: ... Large white surface colony.
Irregular growth.

(b) Relative per cent.: 45.

No. B-5

(a) Description: ... Numerous molds present. Few
non-acidifiers.

(b) Relative per cent of acidifiers, 90.

Quantitative Analysis.

Content #4.

Agar Plates. -A- 24 hours.

| | | | |
|---|---|---|---|
| 1/1,500 | solution | 210,000 | per c.c. |
| 1/3,000 | " " | 750,000 | per c.c. |
| 1/15,000 | " " | 1,785,000 | per c.c. |
| | Average | 915,000 | per c.c. |

Agar Plates. -B-

| | | | |
|---|---|---|---|
| 1/1,500 | solution | 550,500 | per c.c. |
| 1/3,000 | " " | 288,000 | per c.c. |
| 1/15,000 | " " | 765,000 | per c.c. |
| | Average | 534,500 | per c.c. |

Final Average on Agar 724,750 per c.c.

Gelatin Plates. -A- 48 hours

| | | | |
|---|---|---|---|
| 1/500 | solution | 60,000 | per c.c. |
| 1/1,000 | "" " | 68,000 | per c.c. |
| 1/5,000 | " " | 90,000 | per c.c. |
| | Average | 72,666 | per c.c. |

Gelatin Plates. -B-

| | | | |
|---|---|---|---|
| 1/500 | solution | 59,000 | per c.c. |
| 1/1,000 | " " | 70,000 | per c.c. |
| 1/5,000 | " " | 150,000 | per c.c. |
| | Average | 93,000 | |

Final Average on Gelatin 828,333 per c.c.

Grand Average 403,742 per c.c.

## Qualitative Analysis
## No. IIII.

| | | | B1 | B2 | B3 | B4 | | B1 | B2 | B3 | B4 | | B1 | B2 | B3 | B4 | B5 | B6 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of plate | | | | | | | | | | | | | | | | | | | | |
| No. per c. c. | | | | | | | | | | | | | | | | | | | | |
| Morphology | | Diameter over 100 | | | | | | | | | | | | | | | | | | |
| | | Chains | 1 | + | | + | | 1 | + | | | | | | | + | | + | | |
| | | Spores | | | | | | | | | | | | | | | | | | |
| | | Motility | 1 | + | | + | | 1 | + | | | | | | | + | | 1 | | |
| | | Graham Stain | | | | | | | | | | | | | | | | | | |
| Cultural Features | Broth | Turbidity | + | + | | 1 | | + | + | | | | | | | 1 | | 1 | | |
| | | Scum | 1 | 1 | | + | | 1 | 1 | | | | | | | + | | 1 | | |
| | | Sediment | + | + | | 1 | | + | + | | | | | | | 1 | | + | | |
| | Agar | Dull | + | + | | 1 | | + | + | | | | | | | 1 | | 1 | | |
| | | Wrinkled | 1 | 1 | | 1 | | 1 | 1 | | | | | | | 1 | | 1 | | |
| | | Chromogenesis | 1 | 1 | | 1 | | 1 | 1 | | | | | | | 1 | | 1 | | |
| | Gelatin Colony | Round-compact | | | | | | | | | | | | | | | | | | |
| | | Proteus-like | | | | | | | | | | | | | | | | | | |
| | | Rhizoid | | | | | | | | | | | | | | | | | | |
| | | Filamentous | | | | | | | | | | | | | | | | | | |
| | | Curled | 1 | + | | | | 1 | + | | | | | | | | | | | |
| | Gel Stab | Surface growth | 1 | + | | + | | 1 | + | | | | | | | + | | + | | |
| | | Needle growth | + | 1 | | 1 | | + | + | | | | | | | 1 | | + | | |
| Bio-Chemical | * | Gelatin | 1 | 1 | | + | | 1 | 1 | | | | | | | + | | 1 | | |
| | Milk | Coagulated | 1 | 1 | | + | | 1 | 1 | | | | | | | + | | + | | |
| | | Acid | 1 | 1 | | + | | 1 | 1 | | | | | | | + | | + | | |
| | | Alkaline | 1 | 1 | | 1 | | 1 | 1 | | | | | | | 1 | | 1 | | |
| | | Saponified | 1 | 1 | | 1 | | 1 | 1 | | | | | | | 1 | | 1 | | |
| | | Peptonized | 1 | 1 | | + | | 1 | 1 | | | | | | | + | | 1 | | |
| | + | Gas. | 1 | 1 | | 1 | | 1 | 1 | | | | | | | = | | 1 | | |
| Organism name | | | | | | | | | | | | | | | | | | | | |

History Analysis of No. 1, sixteen days after first count.

None present

None present

Analysis of No. 2.

None present

None present

None present

No growth on differential

Mould

* = Liquefaction  + = Gl Sugar.

Qualitative Analysis.

Content #5.

No. B-1

(a) Description: ... Large white spreading colony.
Regular edges, surface growth.

(b) Relative per cent.: .000001.

No. B-2

(a) Description: ... Medium large yellow colony.
Very regular, dense surface growth.

(b) Relative per cent.: 2.

No. B-3

(a) Description: ... Small white deep growth colony.
Very regular, open, rather pale.

(b) Relative per cent.: 25.

No. B-4

(a) Description: ... Deep colony; very small; dense;
Nut like characteristic oblong shape.

(b) Relative per cent.: 70.

Note:-

General: No liquefaction. Very few molds.
At least 90 per cent. acidifiers.

Quantitative Analysis.

Content #5.

Agar Plates. -A- 24 hours.

| | | | |
|---|---|---|---|
| 1/2,000 | solution | 1,400,000 | per c.c. |
| 1/4,000 | " " | 1,144,000 | per c.c. |
| 1/20,000 | " " | 2,400,000 | per c.c. |
| | Average | 1,648,000 | per c.c. |

Agar Plates. -B-

| | | | |
|---|---|---|---|
| 1/2,000 | solution | 900,000 | per c.c. |
| 1/4,000 | " " | | per c.c. |
| 1/20,000 | " " | 1,500,000 | per c.c. |
| | Average | 1,200,000 | per c.c. |

Final Average on Agar 1,424,000 per c.c.

Gelatin Plates. -A- 48 hours.

| | | | |
|---|---|---|---|
| 1/2,000 | solution | 1,360,000 | per c.c. |
| 1/4,000 | " " | 3,120,000 | per c.c. |
| 1/20,000 | " " | 1,120,000 | per c.c. |
| | Average | 1,833,333 | per c.c. |

Gelatin Plates. -B-

| | | | |
|---|---|---|---|
| 1/2,000 | solution | 1,560,000 | per c.c. |
| 1/4,000 | " " | 1,000,000 | per c.c. |
| 1/20,000 | " " | 3,320,000 | per c.c. |
| | Average | 1,960,000 | per c.c. |

Final Average on Gelatin 1,896,666 per c.c.

Grand Average 1,660,333 per c.c.

Qualitative Analysis.

Content #5'.

No. B-1 None present

No. B-2 None present

No. B-3 None present

No. B-4

(a) Description: ... Lactic acid.

(b) Relative per cent.: 75.

No. B-5

(a) Description: ... Very large distinctly green surface growth.

(b) Relative per cent.: 4.

No. B-6

(a) Description: ... Radial surface growth.

(b) Trace.

Quantitative Analysis.

Content #5'.

Agar Plates. -A- 24 hours.

1/1,000 solution , too numerous
1/2,000 " " 9,480,000 per c.c.
1/10,000 " " 10,800,000 per c.c.
Average 10,320,000 per c.c.

Agar Plates. -B-

1/1,000 Solution, too numerous
1/2,000 " " 8,760,000 per c.c.
1/10,000 " " 12,000,000 per c.c.
Average 10,380,000 per c.c.

Final Average on Agar, 10,350,000 per c.c.

Gelatin Plates.

No Plates on Gelatin.

Qualitative Analysis.

Content #5.

History Analysis.

No. B-1

(a) Description: ... White, round colony, surface growth.

(b) Relative per cent.: 15 to 20.

No. B-2 None

No. B-3

(a) Description: ... Several molds, causing liquefaction of gelatin.

(b) Relative per cent.: 1.

No. B-4

(a) Description: ... Small nut shaped colonies. Very numerous and characteristic. Lactic acid.

(b) Relative per cent.: 75.

Quantitative Analysis.

Content #5.

History Analysis

Agar Plates. -A- 16 days from last count.

| | | | |
|---|---|---|---|
| 1/1,000 | solution | 180,000 | per c.c. |
| 1/2,000 | " " | 176,000 | per c.c. |
| 1/10,000 | " " | 530,000 | per c.c. |
| | Average | 295,300 | per c.c. |

Agar Plates. -B-

| | | | |
|---|---|---|---|
| 1/1,000 | solution | 280,000 | per c.c. |
| 1/2,000 | " 2 | 18,000 | per c.c. |
| 1/10,000 | " " | 170,000 | per c.c. |
| | Average | 156,000 | per c.c. |

Final Average on Agar, 225,650 per c.c.

Gelatin Plates. -A-

| | | | |
|---|---|---|---|
| 1/1,000 | solution | 249,000 | per c.c. |
| 1/2,000 | " " | 200,000 | per c.c. |
| 1/10,000 | " " | contaminated | |
| | Average | 224,500 | per c.c. |

Gelatin Plates. -B-

| | | | |
|---|---|---|---|
| 1/1,000 | solution, liquefied | | |
| 1/2,000 | " " | 466,000 | per c.c. |
| 1/10,000 | " " | 640,000 | per c.c. |
| | Average | 553,000 | per c.c. |

Final Average on Gelatin, 388,750 per c.c.

Grand Average 307,200 per c.c.

# Qualitative Analysis
## No. V.

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of Plate | | | B-1 | B2 | B3 | B4 | | B1 | B2 | B3 | B4 | | B1 | B2 | B3 | B4 | B5 | B6 | | | |
| No. per c. c. | | | | | | | | | | | | | | | | | | | | | |
| Morphology | | Diameter over 100 | | | | | History of analyses of No. 1, sixteen days after first count. | | | | | | | | | | | | | | |
| | | Chains | + | + | + | + | | + | | | + | | | | | + | + | | | | |
| | | Spores | | | | | | | | | | | | | | | | | | | |
| | | Motility | + | + | I | I | | + | | | I | | | | | I | I | | | | |
| | | Graham Stain | | | | | | | | | | | | | | | | | | | |
| Cultural Features | Broth | Turbidity | I | I | + | I | | I | | | I | | | | | I | I | | | | |
| | | Scum | I | + | I | + | | I | | | I | | | | | I | I | | | | |
| | | Sediment | + | + | + | + | | + | | | + | | | | | + | + | | | | |
| | Agar | Dull | + | + | I | I | | + | | | I | | | | | I | + | | | | |
| | | Wrinkled | I | I | I | I | | I | | | I | | | | | I | I | | | | |
| | | Chromogenesis | I | I | I | I | | I | | | I | | | | | I | I | | | | |
| | Gelatin Colony | Round-compact | | | | | | | | | | | | | | | | | | | |
| | | Proteus-like | | | | | | | | | | | | | | | | | | | |
| | | Rhizoid | | | | | | | | | | | | | | | | | | | |
| | | Filamentous | | | | | | | | | | | | | | | | | | | |
| | | Curled | | | | | | | | | | | | | | | | | | | |
| | Gel Stab. | Surface growth | I | + | I | + | | I | | | + | | | | | + | + | | | | |
| | | Needle growth | + | + | + | + | | + | | | + | | | | | + | I | | | | |
| Bio-Chemical | * | Gelatin | I | I | I | I | | I | | | I | | | | | I | + | | | | |
| | Milk | Coagulated | I | + | + | + | | I | | | + | | | | | + | + | | | | |
| | | Acid | I | + | + | + | | I | | | + | | | | | + | + | | | | |
| | | Alkaline | + | I | I | I | | + | | | I | | | | | I | I | | | | |
| | | Saponified | I | I | I | I | | I | | | I | | | | | I | I | | | | |
| | | Peptonized | I | I | I | I | | I | | | I | | | | | I | + | | | | |
| | + | Gas | I | I | I | I | | I | | | I | | | | | I | I | | | | |
| Organism name. | | | | | | | None present | None present | None present | | Analysis of No. 2. | None present | None present | None present | None present. | | | No growth on differential. | | | |

* = Liquefaction  + = Gl Sugar.

## SUMMARY.

In making a summary of this work we find it necessary to make several statements concernings its inadequacy. In the first place the work was not as extensive as it should have been in order to give conclusive results. The material and conveniences were somewhat unsatisfactory. The starters used were poor; both containing plenty of acidifiers, but they were gas producers. In spite of these undesirable features the results obtained were good, and as far as they went, fairly conclusive.

Summing up the results of the experiment we shall take up each part separately. First, in the bacteriological analysis it was found that numerous species of bacteria were present in the original cream, but after pasteurizing the cream there was an enormous decrease. In each case, however, there was a larger decrease in the lactic acid groups than in other groups, showing that the lactic acid organisms were more readily killed by heat than are some of the other species. In each case the sweet cream butter contained a smaller percentage of organisms, especially those of the lactic acid group. After the butter had been kept in cold storage (50° F.) for sixteen days it was found that the sweet cream butter had increased over 150,000 bacteria per cubic centimeter, andthat the sour cream butter had decreased over 1,000,000 bacteria per cubic centimeter. In the case of the sweet cream butter the percentage of bacteria produced, other than lactic acid, was relatively large. In the sour cream butter practically all were lactic acid organisms. From the bacteriological standpoint, therefore, the results are greatly in favor of butter churned from ripened cream.

Second, after all bacteriological analyses of the different batches were made, a careful examination of the physical features was also made. The relative conditons of each batch of butter was noted and scored by Professor Kendall, head of the Dairy Department of the College, and by Professor Wilson, State Dairy Commissioner.

The scores are as follows:--

Batch #1, Sweet cream butter, 86%.
" " #2, Sour " " " 89.75%
" " #3, Sweet " " " 90%
" " #4 Sour " " " 95.5%

The results of the scoring correspond very closely with the results obtained from the bacteriological content, as given above. From this it is evident that the butter made from churning cream ripened to .35% acidity gave much better results than that made from the cream which was not ripened at all.

As stated in the beginning, it was thought that if the cream was churned immediately after adding the starter, and before any ripening had taken place, a morecomplete control of the butter with reference to the flavor could be maintained. The results obtained, however, seem to point in the opposite direction. From the bacteriological standpoint, as has been formerly stated, the evidence is very conclusively in favor of thesour cream butter. The undesirable organisms decreased rapidly in the sour cream butter. In two weeks the total content of the sour cream butter decreased over 1,000,000 bacteria per cubic centimeter, while the sweet cream butter increased in total content. Not only this, but the results also show that the relative per cent. of undesirable organisms, gas produces, etc, in the sweet cream butter increased in relative per cent., while the undesirable organisms in the sour cream butter nearly disappeared, and the lactic acid organisms comprised nearly the entire per cent. It is thought from this, since the object in allowing organisms to grow in the butter is to impart to it a flavor that results from the presence of lactic acid, it is advisable to allow the organism to grow in the cream in order that the desirable acid producing bacteria will have abundance of milk sugar in which to develop; whereas, in the butter there is comparatively no milk sugar present in which the organism can develop. When there is an abundance of milk sugar the lactic acid organisms grow very rapidly and soon destroy all other organisms and finally produce so much acid

that they themselves are destroyed. This, then, gives the ideal butter, i.e., butter with the desired flavor and without any destructive or undesirable bacteria present.

It is our conclusion, therefore, that the best method that can be followed in making butter is to ripen the cream to a relative low per cent. acidity, viz. .35%. This amount of ripening willgive the lactic acid organisms such a start that they can soon destroy the large majority of other bacteria, and produce the desired flavor.