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# THE BOOK OF BUTTER

GUTHRIE

L. H. BAILEY
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# THE BOOK OF BUTTER

## A TEXT ON THE NATURE, MANUFACTURE AND MARKETING OF THE PRODUCT

BY

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# TABLE OF CONTENTS


CHAPTER I

PAGES

HISTORY OF BUTTER . . . . . . . . . . 1–6

Early history, 1; Creameries, 2; Developments in 1890, 3; Production, 4; Exports, 5.

CHAPTER II

COMPOSITION AND FOOD VALUE OF BUTTER . . 7–17

*The Composition of Butter:* General composition, 6; Fat, 7; Water, 8; Salt, 9; Curd, 10; *Food Value of Butter:* Comparative prices of butter and other foods, 11; Growth-promoting substances, 12; Comparison of butter and margarine, 13.

CHAPTER III

CLEANLINESS . . . . . . . . . . 18–34

*Cleaning and Care of Utensils:* Flushing off the milk, cream, and butter, 14; Preparing the washing solution, 15; Washing, 16; Rinsing and scalding, 17; Methods of applying boiling water, 18; Methods of applying steam, 19; Draining and drying, 20; Cleansing a musty churn and preparing a new churn, 21; Cleaning the test-ware, 22; *Carefulness and Neatness:* Operators, 23; Equipment, 24; Workmanship, 25; Influence of creamery surroundings, 26; Influence of creamery buildings, 27.

CHAPTER IV

CARE OF MILK AND CREAM . . . . . . 35–51

Bacteria and how carried, 28; *Methods of Keeping Bacteria out of Milk:* The air of the barn, 29; The body of the cow, 30; The utensils, 31. A

PAGES

*Method of Preventing the Growth of Bacteria:* Conditions of growth, 32; Reasons for cooling milk, 33; Methods of cooling milk, 34; Tanks, 35; Effect of stirring milk during cooling in tanks, 36; Coolers, 37; The operator, 38.

CHAPTER V

CREAM SEPARATION . . . . . . . . . 52–83

*Separation by the Force of Gravity:* Principle of separation, 39; Gravity methods, 40; Efficiency of different methods of separation, 41. *Separation by Centrifugal Force:* Intermittent separation, 42; Continuous separation, 43; When and where the first separators were made and sold, 44; Bowl devices, 45; Later separators, 46. *The Operation of the Centrifugal Separator:* Regulation of the fat in the cream, 47; The temperature of the whole milk, 48; The rate of speed, 49; Percentage of fat in whole milk, 50; Variations in the quantity of whole milk or in the amount of liquid used for flushing, 51; Slime deposit, 52. *Advantages of the Centrifugal Method of Cream Separation over the Gravity Methods:* Fewer utensils, 53; Skimmed-milk fresher and warmer, 54; Fat more easily handled; Less loss of fat, 56. *Factors to be Considered in Buying a Centrifugal Separator:* Size, 57; Supplies for repairing purposes, 58; Other factors, 59. *The Location of a Cream Separator:* In the cow stable, 60; In the kitchen, 61; In a milk-house, 62.

CHAPTER VI

GRADING MILK AND CREAM, AND NEUTRALIZING ACIDITY . . . . . . . . . 84–89

*Grading Cream and Milk:* History, 63; Practicable methods of grading, 64. *Neutralizing Acidity in Cream:* History, 65; Methods of neutralizing, 66; Advisibility of neutralizing cream, 67.

CHAPTER VII

PAGES

PASTEURIZATION . . . . . . . . . . 90–107

History, 68; Flavor improvement, 69; Killing pathogenic micro-organisms in cream, 70; Pathogenic micro-organisms in margarine, 71; Killing pathogenic micro-organisms in skimmed-milk, 72; Other effects, 73; Comparison of methods, 74; Notes, 75; Cost, 76; Summary, 77.

CHAPTER VIII

CREAM RIPENING . . . . . . . . . 108–122

When to use starter, 78. *Starter:* History, 79; Natural starter, 80; Artificial starter, 81; Apparatus, 82; Steps in propagation of mother starter, 83; How often to propagate, 84. *Ripening Cream in a Creamery:* Method, 85; Inoculation of the cream, 86. *Ripening Cream on a Farm:* Method, 87. *Ripening Temperatures:* Proper temperature, 88; Temperature and inoculation, 89. *When Cream is Ripe:* Uniform ripening, 90; How to ascertain and satisfy the demand of the trade, 91; Cooling immediately after inoculation, 92.

CHAPTER IX

FROM CHURN TO PACKAGE . . . . . . 123–159

*History of Churning:* Simple churns, 93; Large churns, 94. *Factors in the Churning Quality of Cream:* Temperature, 95; Richness of cream, 96; Ripeness of cream, 97; Condition of milk fat, 98; Size of milk-fat globules, 99; Amount of cream in churn, 100; Speed of churn, 101; Abnormal micro-organisms, 102; Steps in "from churn to package," 103; Selection of packages for storage butter, 104. *Moisture of Butter:* Variation of moisture, 105; Incorporation of moisture, 106; Control of amount of moisture, 107; Natural amount of moisture in butter, 108; Cream-

PAGES

ery-men should control moisture, 109. *Over-run:* Factors that affect over-run, 110; Over-run on the farm and in the creamery, 111. *Color:* Natural color, 112; Artificial color, 113; Mottles, 114; Faded color, 115. *Salt Blisters:* Cause, 116. *Packing Butter:* Wholesale packages, 117; Retail packages, 118; Printing, 119.

CHAPTER X

FLAVORS OF BUTTER . . . . . . . . . 160–180

Basic butter flavor, 120; Absorbed flavors, 121; Developed flavors, 122; Salted versus unsalted butter, 123; Acidity, 124; Fishy flavor, 125; Metallic flavor, 126; Rancid flavor, 127; Effect of pasteurization, 128; Effect of the individuality of the cow, 129; Effect of minor factors on storage, 130; Effect of acidity on flavor of storage butter, 131; Micro-organisms in butter, 132; Enzymes in butter, 133.

CHAPTER XI

STORAGE OF BUTTER . . . . . . . . . 181–187

Temperatures, 134; Nature of buildings and business, 135; Cost, 136; Home storage, 137; Effect of storage on price, 138.

CHAPTER XII

MARKETING . . . . . . . . . . 188–210

*Grades of Butter:* History of grading, 139. *Scoring:* Score-card, 140; Flavor, 141; Body, 142; Color, 143; Salt, 144; Package, 145. *Exchanges:* History and development, 146. *The Price:* How reported, 147; Determination of price, 148; Prices from 1840 to 1916, 149. *Inspection:* Branding inspected butter, 150; Cost of inspection, 151; Other duties of the inspector, 152.

PAGES

*Weighing Tub Butter on the Market:* Customary methods, 153; Amount of butter in tub, 154. *The Main Markets in the United States:* Leading markets, 155; Elgin market, 156. *Requirements of Different Markets:* Character of butter, 157; Wholesale packages, 158; Retail packages, 159; Parcel post, 160. *Shipping Butter:* By railroad, 161; By water, 162. *Selling Butter:* Methods of small creameries, 163; Methods of large creameries, 164; Coöperative selling, 165. *Distributors' Margins:* Wholesaler's margins, 166; Retailer's margins, 167.

CHAPTER XIII

WHEY BUTTER . . . . . . . . 211–215

Fat loss in whey, 168; Cost of manufacture, 169; Manufacture of whey butter, 170.

CHAPTER XIV

RENOVATED AND LADLED BUTTER . . . . . 216–219

Source of raw material, 171; Renovating and ladling plants, 172; Over-run, 173; Method of manufacturing renovated butter, 174; Method of manufacturing ladled butter, 175.

CHAPTER XV

MARGARINE . . . . . . . . . 220–227

History, 176; Method of making and composition, 177; Legal control, 178; Margarine test, 179; Butter and margarine, 180.

CHAPTER XVI

DEFINITION OF TERMS . . . . . . . 228–235

Butter, 181; Butter, centralizer, 182; Butter, creamery, 183; Butter, dairy, 184; Butter-

PAGES

dealer, 185; Butter, gathered cream, 186; Butter, ladled, 187; Butter, ranch, 188; Butter, renovated, or process, 189; Butter, sweet, 190; Butter, sweet cream, 191; Butter-trier, 192; Butter, whey, 193; Butter, whole-milk, 194; Buttermilk, 195; Buttermilk, artificial or commercial or cultured, 196; Dairy, 197; Cheese, 198; Cheesery or cheese factory, 199; Centralizer, 200; Cream, 201; Creamery, 202; Commission merchant, 203; Homogenized milk and cream, 204; Margarine, 205; Milk, 206; Milk-fat, 207; Milk plant, 208; Over-run, 209; Pasteurization, 210; Patron, 211; Receiver, 212; Skimmed-milk, 213; Starter, 214; Sterilization, 215; Thoroughly scalding, 216.

CHAPTER XVII

TESTING . . . . . . . . . . 236–264

Important factors in Babcock test, 217; Handling of composite samples, 218; Sampling sour milk and cream, 219; Sampling frozen milk and cream, 220; Sampling whole milk, 221; Testing whole milk, 222; Sampling cream, 223; Testing cream, 224; Sampling skimmed-milk and buttermilk, 225; Testing skimmed-milk and buttermilk, 226; Sampling butter, 227; Testing butter, 228. *Moisture-test of Butter:* Sampling, 229; Testing, 230. *Salt Test of Butter:* Sampling, 231; Testing, 232; Notes on the Chemistry of the salt test, 233. *Acidity Test of Milk or Cream:* Sampling, 234; Testing, 235; Notes on the chemistry of acidity, 236. *General Notes of Testing:* System, 237; Conveniences for testing, 238.

INDEX . . . . . . . . . . 265–270

# LIST OF ILLUSTRATIONS


FIGURE PAGE

1. An operator who is clean and does his work in an orderly manner . . . . . . . . 28
2. An operator whose suit is greasy and who is a shiftless worker . . . . . . . . . . 29
3. A well-arranged and neatly kept creamery . . . . 30
4. Floor plan of creamery shown in Fig. 3 . . . . 31
5. A poorly arranged and constructed creamery . . 32
6. A plain neat creamery, with attractive grounds . . 33
7. High-grade milk is produced in this barn by means of carefulness . . . . . . . . . 36
8. Interior view of the barn shown in Fig. 7 . . . . 38
9. An old barn with cracks filled with straw is not a sanitary place in which to milk . . . . . 39
10. Showing the decrease in bacteria-content of the milk caused by wiping the cow's udder with a damp cloth immediately before milking . . . . 40
11. A tank for cooling cream . . . . . . . 45
12. End view of tank shown in Fig. 11 . . . . . 46
13. The shallow-pan method of cream separation . . 53
14. The deep-setting method of cream separation . . 53
15. The water-dilution method of cream separation . . 54
16. A comparison of the amount of butter lost in the skimmed-milk of different methods of cream separation . . . . . . . . . . 55
17. An early cream separator experiment . . . . 56
18. A Burmeister and Wain separator . . . . . 58
19. The first Sharples factory separator . . . . 61
20. The first Sharples hand separator . . . . . 62
21. The first Sharples tubular factory separator . . 62
22. The first Sharples tubular hand separator . . . 63
23. Modern Sharples tubular turbine factory separator . 64
24. The new Sharples suction-feed hand separator . . 64
25. A simplex hand separator . . . . . . . 65

FIGURE PAGE
26. A simplex power separator . . . . . . . 66
27. The original United States separator . . . . 66
28. The modern United States separator . . . . 67
29. DeLaval power separator (large hollow bowl type) 68
30. Old and new types of DeLaval hand separator . . 69
31. Belt- and turbine-driven type of DeLaval power separators . . . . . . . . . . 69
32. The Titan-Alexandra, the largest separator made . 70
33. A comparison of the amounts of cream from one can of whole milk separated at different temperatures . 71
34. A diagram representing percentage of fat in cream as influenced by the temperature of the whole milk 73
35. A diagram representing percentage of fat in skimmed-milk as influenced by the temperature of the whole milk . . . . . . . . . 74
36. A diagram representing percentage of fat in cream as influenced by the number of revolutions of the separator crank a minute . . . . . . 75
37. A diagram representing percentage of fat in skimmed-milk as influenced by the number of revolutions of the separator crank a minute . . . . . 75
38. A diagram representing the percentage of fat in cream as influenced by the percentage of fat in whole milk . . . . . . . . . . 76
39. The barn is not a desirable location for a separator 80
40. A convenient and inexpensive building in which to make farm butter . . . . . . . 81
41. A satisfactory building in which milk may be handled in a sanitary manner and a good location for a separator and churn . . . . . . . 82
42. Interior view of the building shown in Fig. 41 . . 83
43. A few of the many types of hand churns . . . 124
44. Power churns . . . . . . . . . . 125
45. Creamery of the Fox River Butter Company . . 127
46. The churning process is not complete, for the granules are too small . . . . . . . . . 138
47. The churning process is complete. The granules are about the size of a kernel of corn . . . . 139
48. A mottled butter . . . . . . . . . 150

FIGURE PAGE
49. Butter with uniform color . . . . . . . 151
50. Acme and Lusted printer. Single pound block printers are on the shelf . . . . . . . 156
51. Friday butter-cutter . . . . . . . . 157
52. American butter-cutter . . . . . . . 158
53. Butter scales which are graduated to read to one thirty-second of an ounce . . . . . . . 158
54. Section of butter storage room in a modern fireproof cold storage warehouse . . . . . . 184
55. The first three tubs are properly finished. The last is mussy . . . . . . . . 193
56. Cutting the butter with a wire in finishing the tub 194
57. Wholesale price of butter in the United States from 1840 to 1916 . . . . . . . . 197
58. Weighing a uniform amount of butter in each tub . 202
59. Types of packages suitable for parcel post . . . 205
60. The butter counter of a large retail grocery store . 209

# THE BOOK OF BUTTER

## CHAPTER I

### *HISTORY OF BUTTER*

An understanding of butter demands a brief account of its history. It would be a fascinating adventure to explore the subject in detail, but only an outline, compiled from Hayward,[1] is possible here. Even this brief view, it is hoped, will be sufficient to stimulate the reader's interest in the development of human practices.

**1. Early history.** — Butter is one of the oldest as well as one of the most universal articles of diet. The Hindoos used it as a food 2000 to 1400 years B.C. It is known that the Scythians and Greeks used butter in 450 B.C. A little later there is a record of the Persians making and using it. In the early centuries butter was employed in many ways. The Hindoos offered it as a sacrifice in their worship. The Greeks and Romans did not eat it, but used it as a remedy for injuries to the skin. It was considered by them that the soot of burned butter was unusually good for sore eyes. The Romans also used it as an ointment for the skin and the hair. This practice was common in Macedonia, and it is

[1] Hayward, Harry, Facts Concerning the History, Commerce, and Manufacture of Butter, U. S. Dept. of Agri., B.A.I., Cir. 56, 1904. For a few of the pictures of ancient churns, see Cyclo. Amer. Agri., Vol. 3, p. 202–3.

reported that in many cold regions persons use butter as a bath. There is record of its having been employed as a remedy for wounded elephants. Not many years ago large quantities of butter were used in Scotland and in North England for smearing sheep and for lamp oil, as well as for medicine. In Spain, as late as the seventeenth century, it was found in medicine shops for external application only. In the rural districts in Germany, fresh unsalted butter has been employed as a cooling salve for burns.

In some countries the possession of butter was considered to be an indication of wealth. In both Chilas and Darel the practice of storing it in the ground still exists. Very often butter thus stored is left for many years. In order to identify the place and also to insure its not being disturbed, a tree is often planted over it. Under these conditions it turns red. The wealth of the owner is computed by the quantity of butter he has stored in this way.

In the early history, butter was used as a food by comparatively few persons. When it was eaten the general practice was to enrich cooked foods. It was stored in the melted condition and was never eaten when fresh. In fact, in comparatively recent times, strong stored butter was used as an appetizer. In Dardistan (in Asia) the peasants prized salted butter-grease that had been kept a long time. They especially valued butter that was held over one hundred years.

Not much is known concerning butter as a commercial article in ancient times. It is stated that in the first centuries it was shipped from India to ports of the Red Sea. In the twelfth century Scandinavian butter was exported. The Germans sent cargoes of wine to Bergen, Norway, and exchanged them for butter and dried fish. It seems that the Scandinavian king considered this practice injurious to his country and in 1186 stopped the exchange. Toward the latter part of the thirteenth century, among the wares of commerce that were enumerated by thirty-four countries that shipped to Belgium, Norway was the only one that included butter. In the fourteenth century butter was exported from Sweden. Probably the making of butter for food was introduced into all Europe from Scandinavia.

In 1695, John Houghton, an Englishman, when writing on dairying, speaks of the Irish rotting their butter by burying it in bogs. His report was confirmed in 1817 and later by the discovery of butter thus buried packed in firkins. This practice of burying butter in the peat bogs of Ireland may have been for the purpose of storing against a time of need, or to hide it from invaders, or to ripen it for the purpose of developing flavor.

In the United States butter has been used as food only. In the early days it was made on the farms. As time passed, some farmers assembled rather large herds of cows, and as they made more than enough butter for their own consumption they sold the surplus. The history of marketing butter is taken up in Chapter XII; suffice it to say here that it was not possible for many farmers to make and sell butter, because they were not prepared for it. Soon it was found best to band together in a suitable organization to make and sell the product. The outcome was the beginning of the creamery business.

**2. Creameries.** — Probably the first creamery [1] built in the United States was in Campbell Hall, Orange

[1] Bull, William, Letter to the author. Mr. Bull was one of the directors of the Wallkill Creamery, which was generally considered to be the first creamery in this country and which was near the creamery in Campbell Hall. In addition to his own statement, he quoted, "Portrait and Biographical Record of Orange Co.," 1895.

County, New York, in 1856. R. S. Woodhull was the owner and George George the first butter-maker. Later George became the proprietor. Soon afterward many creameries were organized, especially in the central western states.

Most of the creameries at the present time are small and they serve only the dairy-men of the immediate community. They are coöperative or stock companies. They make whole-milk butter, or gathered-cream butter, or they receive both whole milk and gathered cream. They range in size from an output of less than 50,000 pounds to approximately 1,000,000 pounds of butter per annum.

The large centralized creamery does not obtain the supply of milk-fat from one community only, but it reaches out to many states. It is interesting to know that such creameries have prospered best in regions where there is not much dairying, for in the strictly dairy districts there is enough raw product to supply a local creamery.

Among the many large centralizers, probably the Beatrice Creamery Company, the Blue Valley Creamery Company, the Fairmont Creamery Company, and the Hanford Produce Company are the most extensive. The largest makes approximately 15,000,000 to 20,000,000 pounds annually. Most of the large centralizers have several plants in which they manufacture butter. It is said that the Hanford Produce Company of Sioux City, Iowa, makes more butter in one factory than any other creamery in the world. The output of this factory is probably more than 12,000,000 pounds of butter in one year. This has been the development of the creamery industry in sixty-one years in this country.

**3. Developments in 1890.** — The beginning of the greatest period of growth of dairying in general, as well as in the butter industry, began about 1890. It was about this time that the centrifugal separator was placed on the market. The first dairy school in the United States was organized at about this year in Wisconsin, at the State University. In this same year S. M. Babcock of the University of Wisconsin gave to the world a quick and accurate method of testing milk and other dairy products for milk-fat. Starter was also placed in the hands of the butter-makers in 1890. Soon the growth of the dairy industry called for more improved methods, such as better moisture and salt control and flavor improvement. Along with better methods came improved apparatus, such as combined churns and workers, pasteurizers, starter cans, sanitary piping, milk and cream pumps, and the like.

**4. Production.** — In 1909 the total butter made in the United States was 1,619,415,263 pounds, or an increase over 1899 of 8.6 per cent. Of this amount, 994,630,610 pounds were made on the farm and 624,764,653 pounds in the creamery. There was a decrease of 7.2 per cent of dairy butter and an increase of 48.7 per cent in creamery butter. Probably at present there is more creamery than dairy butter manufactured in the United States. Table I shows the amount of butter manufactured in the leading dairy states.

**5. Exports.** — The United States is not a heavy butter exporter. In fact, the country imports about as much as it exports. Table II shows the amount of butter that leaves various countries, and the rank of the United States among the other nations as an exporter. In reading this table it should be remembered that the present war caused an abnormal condition in the butter market in 1914.

Table I — Amount of Butter Manufactured in Different States [1]

| Dairy Butter | | | Creamery Butter | | |
|---|---|---|---|---|---|
| | 1899 | 1909 | | 1899 | 1909 |
| Texas | 47,990,492 | 64,993,214 | Wisconsin | 61,813,502 | 103,884,684 |
| Ohio | 79,551,299 | 63,569,132 | Minnesota | 41,174,469 | 88,842,846 |
| Pennsylvania | 74,221,085 | 61,158,115 | Iowa | 77,233,264 | 88,582,187 |
| New York | 74,714,376 | 23,461,702 | New York | 10,693,846 | 45,897,216 |

Table II — Amount of Butter Exported by Different Nations [2]

| Nation | 1912 | 1913 | 1914 |
|---|---|---|---|
| Denmark | 187,755,000 | 200,670,000 | — |
| Russia | 160,771,000 | 172,003,000 | 116,139,000 |
| Netherlands | 86,307,000 | 81,702,000 | — |
| Australia | 67,183,000 | 76,334,000 | 56,163,000 |
| Sweden | 46,818,000 | 43,330,000 | — |
| New Zealand | 42,349,000 | 41,693,000 | — |
| France | 37,572,000 | 38,360,000 | — |
| Finland | 26,474,000 | 27,867,000 | — |
| Italy | 8,843,000 | 6,034,000 | 9,310,000 |
| Argentina | 8,106,000 | 8,342,000 | 7,676,000 |
| United States | 5,105,000 | 3,115,000 | 3,688,000 |

[1] U. S. 13th Census, abs. with supplement for New York, p. 349, 1910.

[2] Yearbook, U. S. Dept. of Agri., p. 522, 1915.

# CHAPTER II

## *COMPOSITION AND FOOD VALUE OF BUTTER*

THE composition of butter is largely fat. It may or may not contain salt. A small amount of the milk solids not fat are retained in the butter, and some moisture is incorporated in it. The food value is largely in the fat.

### THE COMPOSITION OF BUTTER

**6. General composition.** — The percentage of ingredients and constituents in butter is not constant. The various records showing the composition contain widely differing figures. Table III on page 8 shows a few analyses.

The two American analyses are the most valuable, for they are very comprehensive, being the averages of many samples. Lee and Barnhart analyzed 574 samples and Thompson, Shaw, and Norton give the results of 695 determinations of composition. It should also be noted that these analyses are recent and that the butter was not made in one factory only, but in case of Thompson, Shaw, and Norton's work, the samples were obtained from many creameries in eight states; and in case of Lee and Barnhart's study, the samples were taken from the butter markets of Elgin, Aurora, and Chicago, as well as from many creameries in Illinois.

Table III — The Analyses of Butter

| Fat | Water | Salt | Curd | Nation |
|---|---|---|---|---|
| *Per Cent* | *Per Cent* | *Per Cent* | *Per Cent* | |
| 86.85 | 11.54 | 1.02 | .59 | English (salt)[1] |
| 84.77 | 13.76 | .09 | 1.38 | French (fresh)[1] |
| 84.34 | 12.05 | 2.01 | 1.60 | French (salt)[1] |
| 85.24 | 12.24 | 1.35 | 1.17 | German (salt)[1] |
| 83.41 | 13.42 | 1.87 | 1.30 | Danish (salt)[1] |
| 82.89 | 13.75 | 2.03 | 1.33 | Swedish (salt)[1] |
| 84.62 | 12.5 | 2.00 | 0.88 | German (salt)[2] |
| 83.20 | 13.54 | 2.25 | 0.90 | American (salt)[3] |
| 82.41 | 13.90 | 2.51 | 1.18 | American (salt)[4] |

**7. Fat.** — The variation in fat according to Thompson, Shaw, and Norton[5] is between 73.49 and 87.39 per cent. The constitution of the fat is important. Below are figures taken in part from Richmond[6] which show the nature of milk-fat which so largely comprises butter.

The first three acids in Table IV are soluble in water. Caproic and lauric acids are probably partially soluble. It is thought that the characteristic flavors of butter are due largely to these soluble acids.

[1] Richmond, H. D., Dairy Chemistry, p. 246, 1899.

[2] Fleischmann, W., The Book of the Dairy, p. 194, 1896.

[3] Lee, Carl E., Barnhart, Jesse M., Composition of Market Butter, Univ. of Ill. Agri. Exp. Sta., Bul. 139, p. 440, 1909.

[4] Thompson, S. C., Shaw, R. H., and Norton, R. P., The Normal Composition of American Creamery Butter, U. S. Dept. of Agri., B. A. I., Bul. 149, p. 10, 1912.

[5] Thompson, S. C., Shaw, R. H., and Norton, R. P., The Normal Composition of American Creamery Butter, U. S. Dept. of Agri., B. A. I., Bul. 149, p. 18 and 19, 1912.

[6] Richmond, H. D., Dairy Chemistry, p. 35, 1899.

TABLE IV

COMPOSITION OF MILK-FAT

| Names of Fats | Per Cent | Yielding Fatty Acids | Formulae of Fatty Acids | Yielding Glycerol | Formulae of Glycerol |
|---|---|---|---|---|---|
| | | *Per Cent* | | *Per Cent* | |
| Butyrin, $C_3H_5(C_3H_7COO)_3$ | 3.85 | 3.73 | $C_3H_7COOH$ | 1.17 | $C_3H_5(OH)_3$ |
| Caproin, $C_3H_5(C_5H_{11}COO)_3$ | 3.60 | 3.25 | $C_5H_{11}COOH$ | .86 | $C_3H_5(OH)_3$ |
| Caprylin, $C_3H_5(C_7H_{15}COO)_3$ | .55 | .51 | $C_7H_{15}COOH$ | .10 | $C_3H_5(OH)_3$ |
| Caprin, $C_3H_5(C_9H_{19}COO_3)_3$ | 1.90 | 1.77 | $C_9H_{19}COOH$ | .31 | $C_3H_5(OH)_3$ |
| Laurin, $C_3H_5(C_{11}H_{23}COO)_3$ | 7.40 | 6.94 | $C_{11}H_{23}COOH$ | 1.07 | $C_3H_5(OH)_3$ |
| Myristin, $C_3H_5(C_{13}H_{27}COO)_3$ | 20.20 | 19.14 | $C_{13}H_{27}COOH$ | 2.53 | $C_3H_5(OH)_3$ |
| Palmitin, $C_3H_5(C_{15}H_{31}COO)_3$ | 25.70 | 24.48 | $C_{15}H_{31}COOH$ | 2.91 | $C_3H_5(OH)_3$ |
| Stearin, $C_3H_5(C_{17}H_{35}COO)_3$ | 1.80 | 1.72 | $C_{17}H_{35}COOH$ | .19 | $C_3H_5(OH)_3$ |
| Olein, $C_3H_5(C_{17}H_{33}COO)_3$ | 35.00 | 33.60 | $C_{17}H_{33}COOH$ | 3.39 | $C_3H_5(OH)_3$ |
| Total | 100.00 | 94.84 | | 12.53 | |

The fat in butter is simply a collection of milk-fat globules. They vary in diameter from .0016 to .01 mm.,[1] the average being about .0058 mm. This means that the average fat globule in milk from which butter is made is so small that it would require approximately 44,000 to extend an inch. The size of milk globules may vary under different conditions. According to Shaw and Eckles,[2] the relative size of fat globules in milk from different breeds vary between the following figures:

| Breed | Size of Small Globules | Size of Large Globules |
|---|---|---|
| Holstein . . . . . . | 42.3[a] to | 299 |
| Jersey . . . . . . | 91.6 to | 741 |

[a] Arbitrary comparative number.

These investigators [3] show that the globules of the first milk and of strippings vary in size from 139 to 215, and also that from milking to milking there is more or less variation.

The following table [4] shows the coefficients of butter:

Table V

| Specific Gravity at 15.5° C. | Melting Point | Solidifying Point | Reichert Meissl Number | Saponification Number | Iodine Number | Insoluble Fatty Acids Hehner's Number |
|---|---|---|---|---|---|---|
| .926 to .940 | 28 to 33 | 20 to 23 | 25 to 30.4 | 22.7 | 26 to 38 | 86.5 to 89.8 |

[1] Fleischmann, W., The Book of the Dairy, p. 19, 1896.

[2] Shaw, R. H., and Eckles, C. H., A Chemical and Physical Study of the Large and Small Fat Globules in Cow's Milk, U. S. Dept. Agri. B. A. I., Bul. 111, p. 15, 1909.

[3] Eckles, C. H., and Shaw, R. H., Variations in the Composition and Properties of Milk from the Individual Cow, U. S. Dept. Agri. B. A. I., Bul. 157, p. 16, 1913.

[4] Leach, A. E., Food Inspection, p. 508, 1913.

**8. Water.** — According to Thompson, Shaw, and Norton,[1] the average percentage of moisture in butter is 13.9, and the variation is 10.13 to 20.65 per cent. Usually there are very few impurities in water used for washing butter, so that the composition of it may be considered as simply $H_2O$.

**9. Salt.** — The salt-content of butter is variable. Thompson, Shaw, and Norton [1] show a variation from .68 per cent in one sample to 5.98 per cent salt in another sample. The composition of salt varies. According to Woll [2] the analyses of American salts are as follows:

TABLE VI

| | SODIUM CHLORID | CALCIUM SULFATE | CALCIUM CHLORID | MAGNESIUM CHLORID | INSOLUBLE MATTER | MOISTURE |
|---|---|---|---|---|---|---|
| Highest in sodium chlorid | 99.18 | .54 | .19 | .05 | .05 | .01 |
| Lowest in sodium chlorid | 97.79 | 1.48 | .28 | .08 | .06 | .31 |

**10. Curd.** — The curd of modern butter contains very little if any albumin, for it is taken out in the washing. The curd, therefore, is largely casein. According to Thompson, Shaw, and Norton,[3] the curd-content of the average American creamery butter is 1.18 per cent.

[1] Thompson, S. C., Shaw, R. H., and Norton, R. P., The Normal Composition of American Creamery Butter, U. S. Dept. of Agri., B. A. I., Bul. 149, pp. 10–31, 1912.

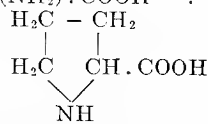
[2] Woll, F. W., A Study of Dairy Salt, Univ. of Wis. Agri. Exp. Sta., Bul. 74, p. 14, 1899.

[3] Thompson, S. C., Shaw, R. H., and Norton, R. P., The Normal Composition of American Creamery Butter, U. S. Dept. of Agri., B. A. I., Bul. 149, p. 10, 1912.

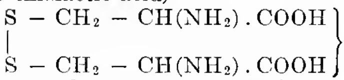
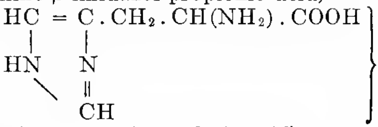
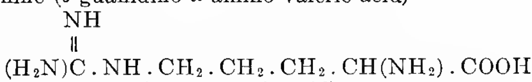
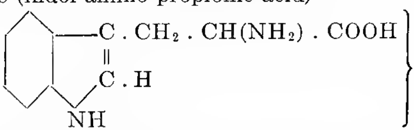
A study of the curd is essential in ascertaining some of the possible causes of certain flavors and other changes in butter. Van Slyke [1] says that the average percentages of elements found in the uncombined protein are as follows:

| | |
|---|---|
| Carbon | 53.00% |
| Oxygen | 22.70% |
| Nitrogen | 15.70% |
| Hydrogen | 7.00% |
| Phosphorus | 0.85% |
| Sulfur | 0.75% |

It is generally considered that casein is present in milk as the compound calcium casein, containing in combination about 1.5 per cent calcium oxide. Osborne and Guest, as quoted by Van Slyke, say: "Our present knowledge of the structure of any protein is stated by giving the percentages of the different amino-acids formed by hydrolysis of the protein. The products of the hydrolysis of casein have been extensively studied, and the following summary may be regarded as the most reliable up to the present time" (formulæ quoted):

| | Per Cent |
|---|---|
| Glycocoll or glycine (amino-acetic acid) $CH_2 . NH_2COOH$ | 0.00 |
| Alanine ($\alpha$-amino-propionic acid) $CH_3CHCNH_2 . COOH$ | 1.50 |
| Valine ($\alpha$-amino-isovaleric acid) $(CH_3)_2CH . CH(NH_2) . COOH$ | 7.20 |
| Leucine ($\alpha$-amino-caproic acid) $(CH_3)_2CH . CH_2 . CH(NH_2) . COOH$ | 9.35 |
| Proline (pyrrolidine-carboxylic acid)  | 6.70 |
| Phenylalanine (phenyl-a-amino propionic acid) $C_6H_5CH_2 . CH(NH_2) . COOH$ | 3.20 |

[1] Van Slyke, L. L., Proteins of Milk, Allen's Commercial Organic Analysis, p. 119, 1913.

| | Per Cent |
|---|---|
| Glutaminic acid (amino-glutaric acid) $COOH.CH_2.CH_2.CH(NH_2).COOH$ | 15.55 |
| Aspartic acid (amino-succinic acid) $COOH.CH_2.CH(NH_2).COOH$ | 1.39 |
| Cystine (amino-thialactic acid)  | . . . . |
| Serine (α-amino-β-hydroxy-propionic acid) $CH_2OH.CH(NH_2).COOH$ | 0.50 |
| Tyrusine (oxyphenyl-α-amino-propionic acid) $C_6H_4(OH)\ CH_2CH(NH_2).COOH$ | 4.50 |
| Oxyproline ($OH.C_4H_7N.COOH$) | .23 |
| Histidine (α-amino-β-imidazol-propionic acid)  | 2.50 |
| Arginine (δ-guanidino-α-amino-valeric acid)  | 3.81 |
| Lysine (α, ε, diamino-*n*-caproic acid) $CH_2(NH_2).CH_2.CH_2.CH_2.CH(NH_2).COOH$ | 5.95 |
| Tryptophane (indol-amino-propionic acid)  | 1.50 |
| Diamino-trioxy-dodecanic acid ($C_{11}H_{18}(OH)_3(NH_2)_2.COOH$ structure unknown) | .75 |
| Ammonia | 1.61 |
| Sulfur | 0.76 |
| Phosphorus | 0.85 |

Because of the presence of water and of acids, the casein may hydrolyze and consequently many of the above products are likely to be present in butter. Thus, considering the complexity of the fat and casein, the student of butter finds a large field in the flavors of this product.

FOOD VALUE OF BUTTER

The food value of butter depends on a number of factors, such as the individuality or the age of the consumer, as in cases of children or adults, and the general quality of the product which may affect the appetizing properties, and the like. In terms of calories, which is the best measures of the food value of butter, one ounce contains 208 calories of heat.[1]

**11. Comparative prices of butter and other foods.** — From the monetary viewpoint, the price of butter and the prices of other foods must be considered in food value of butter. The following table shows the comparative value of different foods when the basis of comparison is the heat unit:

TABLE VII — COST AND FOOD VALUE OF VARIOUS FOODS [2]

| | Cents per Pound | Heat Units per Pound | Cost per 1000 Units in Cents |
|---|---|---|---|
| Tenderloin steak | 28 | 1300 | 21.5 |
| Corned beef | 15 | 1395 | 10.7 |
| Fresh lean veal | 25 | 730 | 34.2 |
| Roast leg lamb | 22 | 900 | 24.4 |
| Smoked ham (52.3 per cent fat) | 22 | 2485 | 8.1 |
| Chicken (fricasseed) | 22 | 855 | 25.7 |
| Halibut steak | 20 | 565 | 35.2 |
| Bluefish | 18 | 670 | 27.0 |
| Boiled eggs | 20 | 765 | 26.1 |
| Wheat bread | 5 | 1395 | 3.7 |
| Oatmeal | 4.5 | 1860 | 2.4 |
| Whole wheat flour | 4.5 | 1675 | 2.6 |

[1] Hutchinson, Robert, Food and the Principles of Dietetics, p. 504, 1909.

[2] Troy, H. C., Composition, Food Value, and Methods of Paying for Milk, The Cornell Countryman, Vol. 13, No. 8, p. 656, 1916.

TABLE VII — *Continued*

| | Protein | Carbohydrates | Fat | Cents per Pound | Heat Units per Pound | Cost per 1000 Units in Cents |
|---|---|---|---|---|---|---|
| Milk . . . | 3.3 | 5.0 | 4.0 | 3.5 | 325 | 10.7 |
| Cheese . . . | 25.0 | | 33.7 | 20.0 | 1950 | 10.2 |
| Butter . . . | | | | 35.0 | 3605 | 9.7 |
| Boiled potatoes at $.75 a bu. | | | | 1.25 | 440 | 2.8 |
| Dried beans at $3.00 a bu. . | | | | 5.50 | 1605 | 3.4 |

The above table shows that butter is one of the cheapest foods at 35 cents a pound, and that it cannot be considered a luxury at 45 or 50 cents a pound.

**12. Growth-promoting substances.** — Another feature in relation to food value of butter that has recently been discovered is of extreme importance in nutrition. It has been known for many years that certain foods, such as milk, cod-liver oil and eggs, are of special value to the growth of animals. The exact source of this growth-producing power has attracted the attention of biochemists, and as a result there have been important findings. According to Osborne and Mendel,[1] the growth-promoting substance of milk is found in the butter-fat. This is substantiated by McCollum and Davis.[2] It seems that a few other animal fats, such as egg-yolk-fat,[1 and 3] kidney-fat,[3]

[1] Osborne, T. B., and Mendel, L. B., Influence of Butter-fat on Growth, The Jour. Biol. Chem., Vol. 16, pp. 423–432, 1913.

[2] McCollum, E. V., and Davis, Marguerite, Observations on the Isolation of the Substance in Butter-Fat Which Exerts a Stimulating Influence on Growth, The Jour. Biol. Chem., Vol. 19, p. 248, 1914.

[3] McCollum, E. V., and Davis, Marguerite, The Influence of Certain Vegetable Fats on Growth, The Jour. Biol. Chem., Vol. 21, p. 179, 1915.

cod-liver oil [1] and the liquid part of beef-fat,[2] contain this "accessory substance." Several vegetable fats have been studied. Of these the substance vital to the growth of animals has been found only in the embryo of wheat seeds, but in quantities too small to serve in the normal growth of any animal.

The proper name for this growth-producing substance has been a puzzling problem. McCollum and Kennedy [3] state that Funk proposed the name "vitamine" for this type of substance. McCollum and Kennedy, however, do not like this term. In fact, they consider it erroneous. They suggested the terms "fat-soluble A" and "water-soluble B" for the two classes of unknown substances concerned in inducing growth. They contend that these terms have the merit of not attributing extravagant values to these bodies, and they differentiate between the substances or groups of substances only with respect to their solubility relations, which is the only basis of differentiation known at present.

This growth-producing fat-soluble factor does not deteriorate when the butter is held in storage [4] nor when it is heated with live steam for two and one-half hours,[5] which

[1] Osborne, T. B., and Mendel, L. B., The Influence of Cod-liver Oil and Some Other Fats on Growth, The Jour. Biol. Chem., Vol. 17, p. 401, 1914.

[2] McCollum, E. V., and Davis, Marguerite, The Influence of Certain Vegetable Fats on Growth, The Jour. Biol. Chem., Vol. 21, p. 179, 1915.

[3] McCollum, E. V., and Kennedy, C., The Dietary Factors Operating in the Production of Polyneurites, The Jour. Biol. Chem., Vol. 24, No. 4, p. 491, 1916.

[4] Osborne, T. B., and Mendel, L. B., The Stability of the Growth-Promoting Substance in Butter Fat, The Jour. Biol. Chem., Vol. 24, No. 1, p. 38, 1915.

[5] Osborne, T. B., and Mendel, L. B., Further Observations of the Influence of Natural Fats upon Growth, The Jour. Biol. Chem., Vol. 20, pp. 37 and 384, 1915.

is a higher temperature and more prolonged period of heating than the milk-fat is subjected to during the process of manufacture into butter. The growth-promoting substance seems to be in greatest quantity in milk-fat. In comparison with beef-fat, the growth produced by milk-fat was more marked and more prolonged.[1] In both, the factor efficient in facilitating growth is found in the fats with low melting points.[1]

**13. Comparison of butter and margarine.** — As a food for growth, butter is superior to the best grades of margarine that contain some beef and to the margarine that contains no beef; for there is no fat-soluble A and water-soluble B in the margarine that contains no milk-fat nor beef-fat. Even in the margarine that contains milk-fat or beef-fat, the growth-promoting substance is so small that its value cannot be compared with that of butter. McCollum [2] says: "Experiments which we conducted a year ago show that 3 per cent of butter-fat furnishes the minimum supply of this factor for normal growth in young rats. In comparable experiments 10 per cent oleo was the minimum which would serve this purpose." The factor to which McCollum refers is "fat-soluble A substance." This shows that butter contains more than three times the quantity of this vital substance than is found in margarine.

[1] Osborne, T. B., and Mendel, L. B., Further Observations of the Influence of Natural Fats upon Growth, The Jour. Biol. Chem., Vol. 20, pp. 37 and 384, 1915.

[2] McCollum, E. V., The Relative Nutritive Value of Oleomargarine and Butter, Univ. Wis., Jour. Home Econ., p. 229, 1917.

# CHAPTER III

## *CLEANLINESS*

CLEANLINESS is a habit. It is not merely the following of certain set practices. It rests on a rational procedure, comprised in a knowledge of the nature of germs as well as an antipathy to what is called dirt. It is much more than washing and scrubbing.

### CLEANING AND CARE OF UTENSILS

The proper cleaning of dairy utensils, floors, walls, drains, and the like, is essential to profitable dairying. The operations of cleaning are simple, but they must be accompanied by a high degree of thoroughness and good judgment. Methods of cleaning are discussed in the following paragraphs. The details must all be given close attention.

**14. Flushing off the milk, cream, and butter.** — The purpose of the flushing is to discard as much of the dross as possible before the utensils are put into the washing solution. It is expensive to remove this first dirt with washing solution. Also, if the flushing is not done, the washing solution is very likely to become too greasy and sloppy for efficient work. Cold or lukewarm water should be employed when milk has been in the apparatus, for the heat of the hot water precipitates the casein of the milk that adheres to the utensils. Hot water may be used to flush off butter and cream because it melts the milk-fat, in which condition it is easily removed.

**15. Preparing the washing solution.** — The water should be as warm as the hands can stand. Into this water should be put just enough washing-powder to cut the grease. Experience must be the guide in determining the amount of washing-powder necessary. Usually for ordinary dairy utensils the ratio should be about one-half ounce of washing-powder to one gallon of water. The mistake of using too much water is common. When this is done an excess of powder is likely to be used. This is equally true of the soap powders and of the carbonates, as Wyandotte cleaner, Dominion cleanser, and others.

**16. Washing.** — A brush is more satisfactory for washing than a cloth. In the first place, on account of the handle of the brush, it is possible to work in warmer water than with a cloth. It is especially important to use hot water if the utensils are greasy. Secondly, because of the bristles of the brush, it is possible to reach into the corners and crevices of the utensils; whereas, if a cloth is employed, it passes over these places, and the particles of dirt are not dislodged. Thirdly, the brushes are more easily kept clean than the cloths, largely because when not in use the air passes through them more freely.

When cleaning the interior of a churn, care should be taken to remove all the butter. Sometimes it is necessary to put cold water into the churn and revolve a few times to remove the butter from behind the workers. Eight or ten gallons of boiling water should be put into the churn when the capacity is three or four hundred pounds of butter, then about two or three ounces of washing-powder should be added. Now turn the churn twelve or fifteen revolutions at high speed. This speed causes greater agitation than low speed, and consequently the washing is more thorough. The gate should be partly open to permit escape of steam, for the pressure is likely to blow out some of the cork packing. After washing, the churn should be rinsed with boiling water.

When washing a pasteurizer, a starter-can, or a milk-heater, it is usually necessary to allow the casein that has been precipitated on the sides, bottoms, and coils or drum, to soak for a time in the solution. In order that the soaking may be effective, it is necessary to prepare more solution than would otherwise be used. For proper soaking of the casein, a combined pasteurizer and ripener should be about one-fourth to one-third full of washing solution.

The floor should be washed with a fairly strong washing solution. This compound may be made in a vat and then carried in pails and from them distributed on the floor. There is a tendency to waste floor-washing solution. It should be poured on the floor only as fast as the man or men are able to scrub. Only lazy operators attempt to clean without the application of friction with a scrubbing brush. All the washing solution should never be thrown on the floor before the scrubbing process is started, for most of it goes down the drain and thus is wasted. It is advisable to begin scrubbing at the highest point of the floor, and as the solution runs toward the drain the scrubbing may be continued in that direction.

Painted surfaces, such as the outside of the churns, vats, and separators, should not be cleansed with a washing solution on account of removing the paint. On painted surfaces where there is only a little grease, scrubbing with a soft-bristled brush and boiling water is sufficient. If there is too much dirt to wash off in clear boiling water, ivory or a similar soap may be applied with a soft cloth, using care not to loosen too much paint.

**17. Rinsing and scalding.** — If the utensils are put into a vat of boiling water, the washing solution is rinsed off. If boiling water is applied through a hose, as in case of a vat or a pasteurizer, the same result is obtained. In case steam is employed to scald, the utensils should be thoroughly rinsed before scalding, otherwise white streaks of the powder will remain on the utensils.

In this step in the process of cleaning, the most important factor is the killing of bacteria. Thorough scalding of utensils is a practice of good dairying. The value of complete scalding is well known in all industries where the presence or absence of bacterial life is important. A mistake is often made in utilizing water that is not sufficiently hot to kill bacteria. A short experiment was made on the effect of warm water versus hot water for killing bacteria. Two buttermilk pails were cleaned in the same way. One was held in a tub of water for one minute at a temperature of 130° F. The temperature of the water in the tub was then raised to 180° F. and the other pail was submerged for one minute. A bacteriological study was made later. It was found that over two hundred times as many organisms were left alive in the first pail as in the second. A temperature of 130° F., or a few degrees above, is not sufficient to destroy bacteria. The presence of steam, which may appear at this time, is not a certain indication of the scalding temperature.

The question often arises, "What is the best temperature for thorough scalding, and how long should a dairy utensil be exposed to a given temperature?" Data are found in Table VIII which show that there is very little difference in the number of bacteria killed, on the one hand, at temperatures ranging from 160° F. to 200° F., and in time of exposure to these temperatures ranging from fifteen seconds to ten minutes in case of hot water, and, on the other hand, in the one temperature of 198° F. when steam was employed. The utensils in the experiments were the small-top milking pails, and the common forty-quart cans. The pails and cans were first washed and rinsed in the usual way. Then the pails were rinsed with 500 cc. of sterile water, and this rinse water was plated. The cans were rinsed with 1000 cc. of sterile water and this rinse water was also plated. The figures in the table on the opposite page show the total number of bacteria in the pails and cans and not the number of organisms to the cubic centimeter of the final collection water.

This table shows that hot water, even at a temperature of 160° F., for a short exposure of fifteen seconds is sufficient for all practical purposes. However, to be certain of obtaining good results and not to be below the minimum temperature and exposure, it is well to maintain a temperature of 180° F. for at least thirty seconds.

**18. Methods of applying boiling water.** — Boiling water may be applied to dairy utensils and apparatus in one of the following ways: 1. The water may be heated by steam in a half-barrel or in a vat. Then the utensils may be plunged into it. 2. Water may be boiled in a wash-boiler on a stove or in a similar apparatus of sufficient size to hold the largest utensil. 3. These utensils, such as dippers, ladles, separator parts, may be placed in a pail and then the pail should be filled with very hot water from the water heater found in many kitchens. 4. A special hot water container should be provided for the proper application of heat to sanitary piping if direct

Table VIII — Bacteria Killed by Hot Water and Steam at Different Temperatures and for Exposures of Different Periods of Time

| | Hot Water | | | |
|---|---|---|---|---|
| Temperature . | 160° F. | 170° F. | 180° F. | 200° F. |
| Initial count . . | 223,000 | 792,500 | 556,200 | 96,000 |
| Aver. per cent decrease | Time exposed — 15 seconds | | | |
| Five pails . . . | 98.78 | 99.61 | 99.73 | 99.06 |
| Aver. per cent decrease | Time exposed — 30 seconds | | | |
| Five pails . . . | 99.50 | 99.39 | 99.48 | 99.74 |
| Aver. per cent decrease | Time exposed — 1 minute | | | |
| Five pails . . . | 99.52 | 99.89 | 99.83 | 99.74 |
| Aver. per cent decrease | Time exposed — 5 minutes | | | |
| Five pails . . . | 99.68 | 99.95 | 99.82 | 99.58 |
| Aver. per cent decrease | Time exposed — 10 minutes | | | |
| Three pails . . | 99.66 | 99.98 | 99.80 | 99.31 |
| | (198° F.) Steam (Time exposed 1 hour) | | | |
| Initial count . . | 128,000,000 | 2,200,000 | 2,650,000 | 6,250,000 |
| Aver. per cent decrease | Exp. 1 | Exp. 2 | Exp. 3 | Exp. 4 |
| Five pails . . . | 99.99 | 99.96 | 99.98 | 99.99 |

steam is not employed. Often the piping is placed in a vat and then covered with boiling water. As a result of this practice, holes are sometimes punched through the bottom of the vat. This special container for scalding sanitary piping should be constructed of tin and it should be just large enough to hold the piping. After the scalding, one end may be lifted and the gate opened at the opposite end. This is to insure drainage. Such a container should be placed conveniently for scalding as well as where it will appear tidy. 5. A churn with a capacity of three or four hundred pounds of butter should be scalded by putting into it about eight or ten gallons of boiling water. Less water may be used in smaller churns. The churn should then be revolved at high speed for two or three minutes. 6. The floor, which is usually the last to be cleaned, should be flushed with sufficient hot water to carry away the washing solution and to dry the floor. The tendency of many creamerymen is to use two or three times more water in cleaning the floor than is necessary.

**19. Methods of applying steam.** — Both steam and water must be confined in order that the heat may be utilized for scalding. Of the two, hot water is more readily confined. Steam may be applied to advantage in a steam-chest or it may be turned directly into such utensils as cans, pails, and the like.

**20. Draining and drying.** — A drying cloth should not be employed, because it smears bacteria over the scalded surface which is almost free from micro-organisms. The heat in the utensils after scalding should be sufficient to dry them so that rust will not form. In order that the moisture may be drained away readily, it is best in scalding to put the smaller utensils into larger ones, as for example, dippers, strainers, and separator parts may be put into pails and all submerged in boiling water at one time. After the utensils have been thoroughly scalded and drained, or perhaps not yet drained, depending on conditions, they should be put away. They should be so placed that the room will have a neat appearance, and they should also be put where dust and flies cannot lodge on them. Many dairy-men leave the utensils in the direct sunlight and often the dust and flies do more harm than the sun's rays do good. It is needless to put dairy utensils in the direct sunlight especially after scalding, and it is a question whether it ever pays to rely much on this treatment of killing bacteria, since there are many days when the sun does not shine. Again, it is impossible to place all the utensils so that the sun's rays will strike all surfaces. If the room is not sufficiently tight to keep out the dust and if there are many flies, a cupboard should be provided.

It is often difficult to dry cans properly. This is especially true if it is desired to put the lids on the cans in order that they may be immediately hauled or shipped from the creamery. Can-driers are convenient and essential in such cases. These can-driers, which are used extensively, are constructed in such a way that the air is forced over steam pipes. Then this air is blown into the cans. A can may be dried very quickly in this way. Drying and ventilation have a direct effect on the improvement of the flavor of the milk or cream, for a damp can soon becomes very musty.

**21. Cleansing a musty churn and preparing a new one.** — A churn used several times in a week does not easily become musty if it is thoroughly washed with a washing solution and scalded after each churning.

If it does become stale, it should be treated with a disinfectant. The one usually applied is a saturated solution of lime-water. Stronger disinfectants may be employed if care is exercised in rinsing the churn after the cleaning process.

If a churn has not been employed for several weeks or months, or if a churn is new, it may be soaked by putting water-tight utensils, such as pails and tubs, in the churn, which may be filled with boiling water. The steam from the boiling water will soon swell the wood and thus make the churn cream-tight. If the pails, tubs, and the like, are refilled every hour or so, a churn may be soaked cream-tight within a day, even though it was badly dried. If the water is put in an unsoaked churn before it has been steamed, much water is likely to be wasted and several days will be required to soak it.

A new churn should be thoroughly scalded to cleanse it; also the heat of the boiling water will open the pores of the wood, thus freeing some of the woody flavor. It is the custom in some creameries to put buttermilk or skimmed-milk in a new churn to absorb some of the flavor of the wood. It is wise to put the milk in the churn in the morning, and occasionally during the day the churn should be revolved to bring the milk in contact with all the interior parts. A good plan is to leave either buttermilk or skimmed-milk in the churn overnight.

**22. Cleaning the test-ware.** — After the tests have been completed, the remaining portions of the samples of cream and butter should not be thrown away and thus wasted. In case of composite samples, when a preservative is employed, it is not possible to save the sample; however, in many creameries where daily tests are made no preservative is used. The left-over portions of the butter and cream samples may be put into the cream-ripening vat before the cream is pasteurized.

In cleaning the sample bottles, the same kind of procedure as described for general cleaning should be followed. As the tests are read the test-bottles should be placed in a rack of the same capacity as the Babcock centrifuge. When the contents of the test-bottles are emptied, they should be agitated to loosen the calcium sulfate deposit in the bottom of the bottles. The entire case of bottles should be submerged in a washing solution. This solution should be fairly strong and as hot as the hands can stand. After the bottles are filled with the washing solution, a brush of the proper size should be employed to loosen the fat in the necks of the bottles. The next step should be to rinse the bottles in warm water. When the washing solution is made of soap, the acid should be flushed from the test-bottles, for if it remains in the bottles it will free the fatty acids of the soap. These fatty acids are likely to produce a greasy condition. If a strong alkali were put in the soap solution to neutralize the fatty acids, the grease would not be formed. It is usually easier to rinse the sulfuric acid out of the test-bottles than to employ a stronger solution. When a sodium carbonate solution is employed, the chemical reaction is different. In this case, the solution may be put in the test-bottles even though there may be a little acid present, thus saving a few minutes. Then the bottles should be rinsed with hot water.

## CAREFULNESS AND NEATNESS

Nothing appeals more to a consumer than to know that the food he eats is made or prepared in a neat and sanitary manner. When he obtains food from a factory, such as a creamery, he wants a product that is made under careful methods and where everything is kept in a neat and tidy condition. When he visits the plant he hopes to find his expectations fully met. In the following paragraphs are stated certain requirements that cannot be overlooked. In every way, the place should be orderly.

**23. Operators.** — The operators must be clean in every way. They must be washed clean, neatly shaved, hair combed properly and a suitable cap to prevent hairs from falling into the product, and dressed in clean clothes. Which of the men in Figs. 1 and 2 has the appearance of

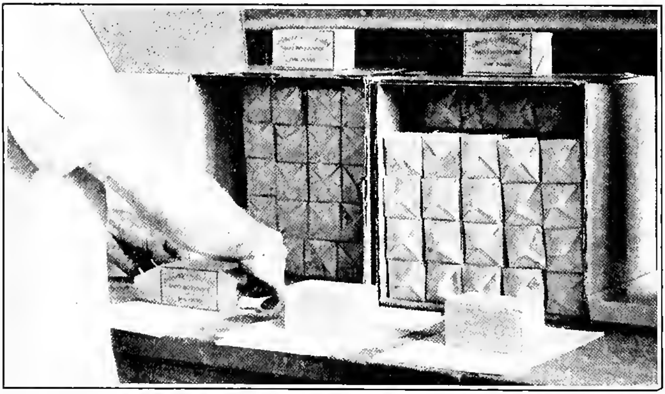


Fig. 1. — An operator who is clean and does his work in an orderly manner.

doing the best work? The one in Fig. 1 probably wears a big specially made apron when doing dirty work, such as lifting cans, working in the boiler and engine room; and removes it when he is working with the milk, cream, and butter. He makes a practice of not sitting on cans that have just come from the route, truck, receiving platform, and the like. He does not wipe his hands on his clothes. On the other hand, the man in Fig. 2 violates all these precautions.

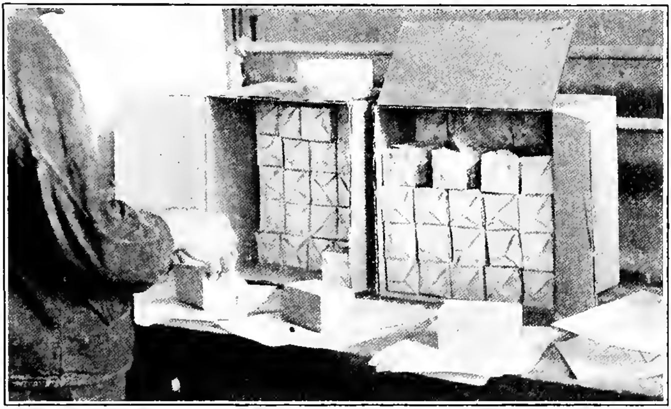


Fig. 2. — An operator whose suit is greasy and who is a shiftless worker.

**24. Equipment.** — Tables, shelves, and cabinets on which and in which to keep utensils, apparatus, and supplies must be provided and used. If it is the practice of the creamery operator to dip his floor brush in the pail when washing, instead of pouring the solution or water on the floor, a special pail should be provided for that purpose. Can tops, dippers, strainers, churn tops, separator parts, starter-can agitator and top, butter tub covers, should never touch the floor. It should not be necessary to step over a dairy product container such as an open conveyer spout of milk leading from the weigh-can to the receiving-vat. Figs. 3 and 4 show a creamery in which butter is easily handled in a sanitary way, for it is well supplied with up-to-date equipment. The operator is careful and neat. Fig. 5 calls attention to a

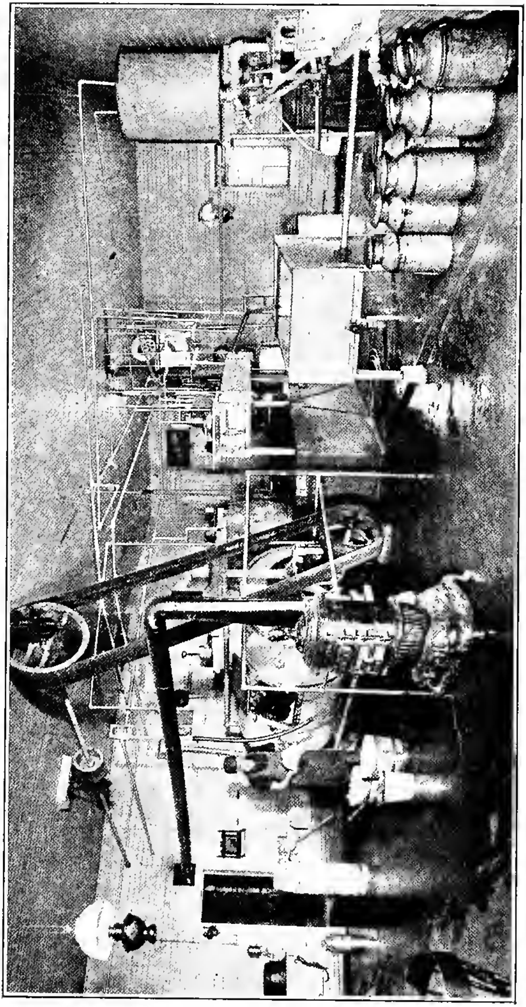


FIG. 3. — A well arranged and neatly kept creamery.

creamery in decided contrast to the one in Fig. 3. It is well to have a heavily built low table on which to pack butter in order that none of it may come in contact with

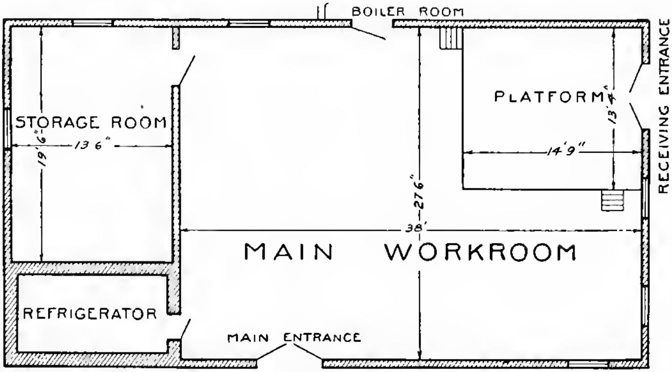



FIG. 4. — Floor plan of the creamery shown in Fig. 3. The boiler room is convenient to both the platform and the main floor. There is sufficient space for handling cans when shipping milk or cream.

the floor. This table may be employed for other things, such as holding a churn cover or other large piece of apparatus.

**25. Workmanship.** — A carefully and neatly finished package is usually indicative of thoughtful and neat workmanship in making the product, and in the quality of the goods. A careful operator will always use a spoon or other utensil to obtain milk or cream to taste. He will use a ladle or a trier to secure a portion of butter to examine. In neither case will he stick his finger into the product and then lick it. After taking a temperature, a careful dairy-man or creamery-man will wash the milk or cream from the thermometer and then he will flush it with boiling water and place it in a clean rack provided for that purpose. He will not lick it off and then without

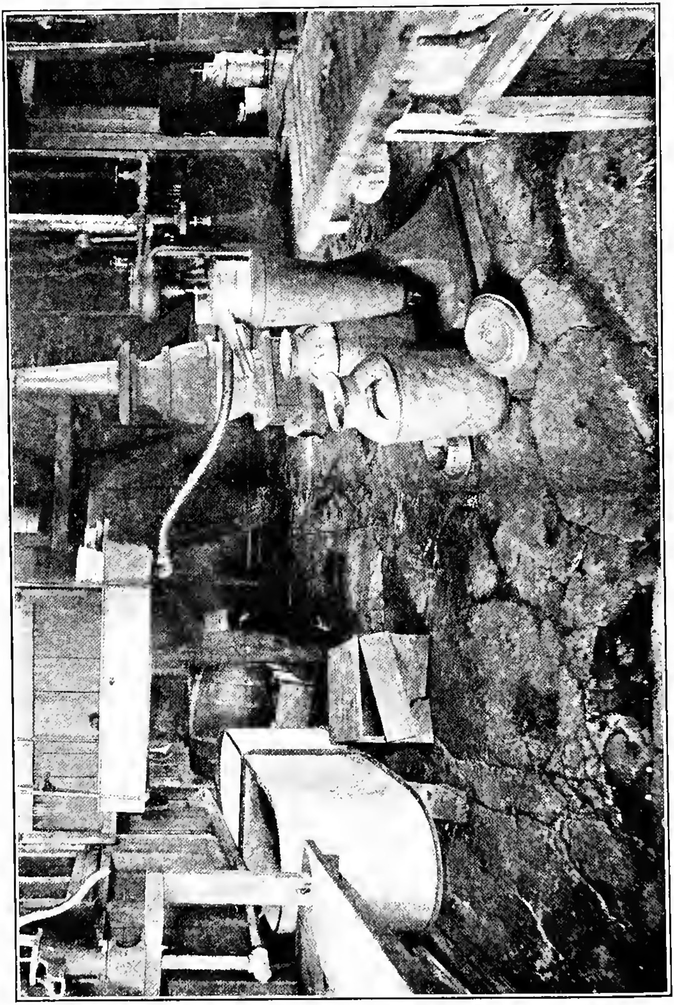


FIG. 5. — A poorly arranged and constructed creamery. The operator is careless, as shown by the old broken box and by the can lids on the floor.

further treatment lay it on a ripener or a shelf which is not perfectly clean and where it is likely to be broken.

**26. Influence of creamery surroundings.** — The surroundings of a creamery, whether high weeds, muddy or dusty roads, or an attractive lawn and graveled roads, have a distinct effect on the grade of workmanship in the establishment. Pride and interest are features that must

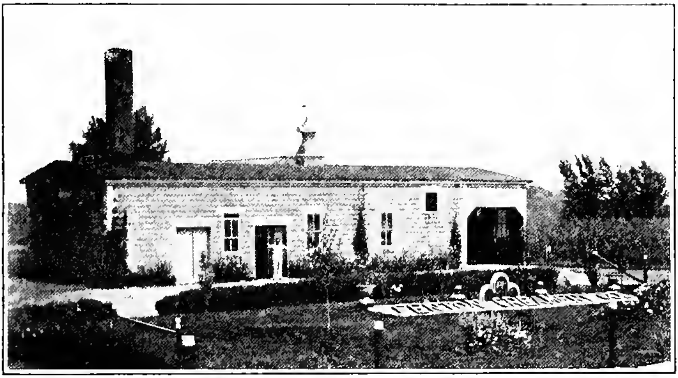


FIG. 6. — A plain neat creamery, with attractive grounds.

not be forgotten in this relation. They cannot be engendered within the surroundings of many creameries. Conditions such as are seen in Fig. 6 have a good influence on operators and patrons. They also appeal to the consumer who has an opportunity to see them.

**27. Influence of creamery buildings.** — Paint properly applied has an important place in improving the appearance of creamery buildings. Light-colored paint is the universal shade for dairy apparatus and buildings. Dirt is easily seen on a white surface; therefore, a light-colored object is more likely to be kept clean than a dark one. When a light color is used in a dark corner, the light is reflected so that spots on darker colored surfaces are more readily seen. Some of the equipment should be painted a dark color, as for example the gearing of machinery, a square place around a door knob where hands touch the door, and the like. Often the application of the proper paint will make it possible to clean more easily. Creamery buildings should be kept in good repair, not only to insure longer life, but to encourage carefulness on the part of the persons who work in them.

As a whole, the milk establishments of the country are not only unattractive but repelling. In no direction is there greater need for reform. The cases in which the buildings and the premises have been touched with pride are so few that they always arouse comment.

# CHAPTER IV

## *CARE OF MILK AND CREAM*

THE making of butter does not begin with the churning process, but as soon as the milk leaves the udder. It is impossible to make fancy butter from a poor raw product because of the presence of certain bacteria and the by-products of their growth.

**28. Bacteria and how carried.** — In the manufacture of butter, micro-organisms play such an important part that the question may well be asked: What are bacteria and how do they move from one place to another? Bacteria are the lowest or the simplest forms of plant life. They do not fly or crawl as insects, but are transported by attaching themselves to objects that are moved in different ways from one position to another; as, for example, they may lodge on particles of dust, feed, bedding, hairs, flies, cobwebs, dairy utensils and the milker. Some of these objects are carried by the wind, or by undue circulation of air. Some may drop from a near-by surface. Water may carry them. There are many ways by which bacteria may be carried into milk and other dairy products. In dairy work, it is important to eliminate these carriers. This may be accomplished by simple and inexpensive methods.

### METHODS OF KEEPING BACTERIA OUT OF MILK

**29. The air of the barn.** — The ceiling of the barn should be so constructed that nothing will sift through

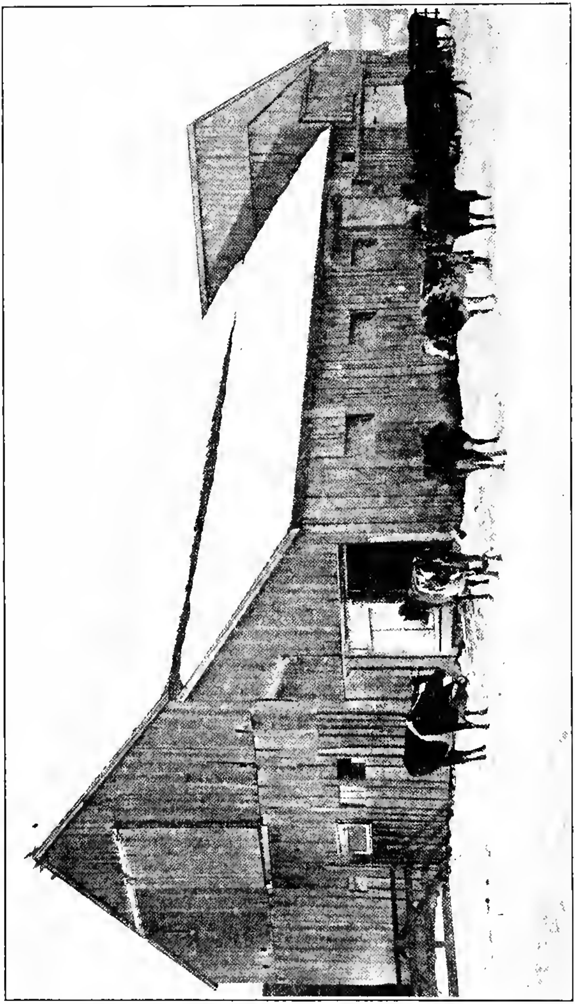


FIG. 7.—High-grade milk is produced in this barn by means of carefulness.

it. The number of places where dust might collect on the walls, stanchions, and the like, should be minimized. The floors should be tight and easily drained and cleaned. In order that clean milk may be produced, it is not necessary that the barn be up-to-date in every detail. Many old barns may be renovated satisfactorily. Fig. 7 shows the exterior of a barn where milk equal in quality to "certified milk" is produced. The average number of bacteria for one year was 5,133 micro-organisms to a cubic centimeter in the morning's milk and 5,000 bacteria to a cubic centimeter in the night's milk. The interior of this barn is seen in Fig. 8. In contrast to this building, notice Fig. 9, where it is almost impossible to obtain clean milk.

**30. The body of the cow** has on it more or less dirt and dross. Therefore, the udder and the flank should be carefully wiped and in some cases they should be thoroughly washed. In Fig. 10 Stocking[1] gives data on wiping the dirt from the cow. This is a simple and effective way to keep bacteria out of milk. It is evident from the above figures that it pays to observe this essential in the production of clean milk.

The small-top milking pail is effective in keeping many bacteria of the air and from the cow's body from falling into the milk. The type of milking pail now in general use has about two-thirds or three-fourths of the top covered.

**31. The utensils.** — The condition of the utensils, bacteriologically, is a consideration in obtaining milk of good quality that must not be overlooked. Prucha and Weeter[2] say that even under wide extremes in barn

[1] Stocking, W. A., Jr., Quality of Milk Affected by Common Dairy Practices, Conn. (Storrs) Agri. Exp. Sta., Bul. 42.

[2] Prucha, M. J., and Weeter, H. M., Germ Content of Milk, Univ. Ill. Agri. Exp. Sta., Bul. 199, p. 51, 1917.

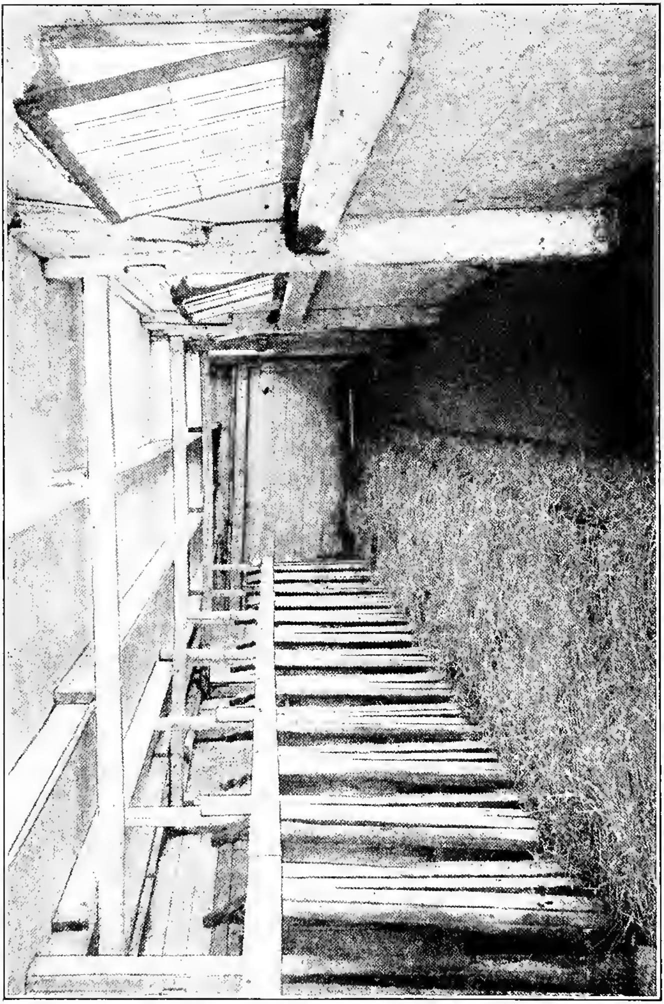


Fig. 8. — Interior view of the barn shown in Fig. 7.

conditions it is possible to produce milk with a germ-content of less than 10,000 bacteria to a cubic centimeter

FIG. 9. — An old barn with cracks filled with straw is not a sanitary place in which to milk.

when the utensils are properly prepared. For data and proper methods of cleaning dairy utensils, see Chapter III.

### A METHOD OF PREVENTING THE GROWTH OF BACTERIA

A question that naturally follows the above discussion is: What factors are important in the growth of bacteria and what may be done to prevent the development of those that gain access to milk?

**32. Conditions of growth.** — Like other forms of plant life, bacteria require moisture, warmth, and food. Unlike most plants, they do not require sunlight. In fact, the direct rays of the sun are very injurious to them. To prevent the development of bacteria, it is necessary either to kill them by pasteurization or in some cases by sterilization; or to change one of the essential requirements of their growth. The only method that is practicable on the farm is the usual custom of putting the temperature down to such a point that the bacteria will not grow. It at least consists in cooling the milk to such a degree that their development is slow.

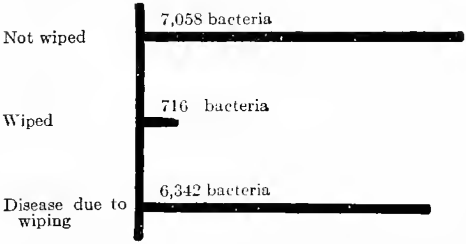



FIG. 10. — Showing the decrease in bacteria-content of the milk due to wiping the cow's udder with a damp cloth immediately before milking.

**33. Reasons for cooling milk.** — The principle of cooling applies in the same way to cream as to milk. Regarding the cooling of milk Stocking[1] says:

"After we have taken as much care in producing the milk as we can, there will still be some bacteria in it, and these should be prevented from growing by immediately cooling the milk to such a degree that their development will be checked. The more quickly milk can be cooled to a temperature of fifty degrees or lower, the slower will be the development of the bacteria. The effect of temperature upon milk is strikingly shown by the

[1] Stocking, W. A., Jr., Problems of the Milk Producer, New York State Dept. of Agri., Cir. 10, p. 62, 1910.

results obtained from a sample of milk which was thoroughly mixed and then divided into six equal parts. The six bottles were then placed in water at different temperatures for twelve hours, at which time the germ-content of each lot was determined. The six bottles were then all placed together in a temperature of seventy degrees and allowed to remain until they curdled. As each sample curdled, the time was recorded. The difference in the germ-content and the keeping time is the result of the difference in temperature for a period of twelve hours only, and shows what may easily happen in milk which is allowed to stand over night without thorough cooling.

"Effect of Different Temperatures for Twelve Hours on the Growth of Bacteria and on the Keeping Quality of Milk

I

Kept at 45 degrees
Number of bacteria, 9,300.
Curdled in 75 hours

II

Kept at 50 degrees
Number of bacteria, 18,000
Curdled in 72 hours

III

Kept at 55 degrees
Number of bacteria, 38,000
Curdled in 49 hours

IV

Kept at 60 degrees
Number of bacteria, 453,000
Curdled in 43 hours

V

Kept at 70 degrees
Number of bacteria, 8,800,000
Curdled in 32 hours

VI

Kept at 80 degrees
Number of bacteria, 55,300,000
Curdled in 28 hours"

According to Ross and McInerney,[1] "Most germs thrive best at a temperature of about 98° F., or 36.6° C.,

[1] Ross, H. E., and McInerney, T. J., Cooling Milk, Cornell Reading Course Lesson, No. 102, 1915.

and this is very nearly the temperature of freshly drawn milk. Milk should be cooled to at least 50° F. as soon as possible after it is drawn; it is still better to cool it to a temperature as low as 40° F. While it is true that many of the bacteria commonly found in milk either do not develop at all or at least develop very slowly at 50° F., still there are some forms that grow with comparative rapidity at this temperature. For this reason the colder the milk is kept, the better it will be, provided it is not frozen.

"Table IX — Comparison of Bacteria Count of Samples of Milk Held at Different Temperatures for One Hour

| Sample | Number of Pounds Milk Used | Bacteria per c.c. in Original Milk | Bacteria per c.c. in Milk Held at 50° F. | Bacteria per c.c. in Milk Held at 90° F. | Increase in Bacteria per c.c. of Milk Held at 90° F. over Milk Held at 50° F. |
|---|---|---|---|---|---|
| 1 | 40 | 747,750 | 727,750 | 2,499,500 | 1,771,750 |
| 2 | 43 | 308,900 | 566,250 | 1,487,750 | 921,500 |
| 3 | 72 | 537,500 | 420,000 | 7,625,000 | 7,205,000 |
| 4 | 85 | 575,000 | 470,000 | 6,000,000 | 5,530,000 |
| 5 | 85 | 179,375 | 158,125 | 4,920,000 | 4,761,875 |
| 6 | 85 | 223,125 | 282,500 | 760,000 | 477,500 |
| 7 | 80 | 31,875 | 65,000 | 1,675,000 | 102,500 |
| 8 | 64 | 47,750 | 110,000 | 355,000 | 245,000 |
| 9 | 85 | 20,625 | 29,375 | 37,000 | 7,625 |
| 10 | 75 | 86,875 | 141,875 | 1,350,000 | 1,208,125 |

" A comparison of the bacteria count of various samples of milk is given in Table IX. Each sample was divided into two parts, and one part was held at a temperature of 50° F. for one hour, the other at 90° F. for the same time. In each case the samples were thoroughly mixed by pouring the milk several times from one can to another, before they were held at their respective temperatures for the period stated. The table indicates that there was a large increase of bacteria, due to keeping milk at the higher temperature, and also that those samples of milk that had high initial bacteria count had a correspondingly high count at the end of an hour. This point is of great practical importance, and shows the necessity of producing clean milk even though it is to be kept cold or is to be pasteurized. If conditions favorable to the growth of bacteria arise, a large initial count means that the bacteria have a proportionately better chance to multiply.

"It is interesting to note that in four of the ten tests here recorded the bacteria count of the milk, after it has been held for one hour at 50° F., was less than the initial bacteria count. This is probably due to the fact that the low temperature was unfavorable to the particular species of germs that happened to be present.

"TABLE X — EFFECT OF HIGH TEMPERATURE ON MILK HAVING SMALL INITIAL BACTERIA COUNT

| Sample | Number of Pounds Milk Used | Temperature (Degrees Fahrenheit) at Which Milk Was Held for 2 Hours | Number of Bacteria per c.c. | | Increase of Bacteria per c.c. | |
|---|---|---|---|---|---|---|
| | | | At Beginning of the 2-Hours-Period | At End of 2-Hours-Period | Number | Percentage |
| 1 | 80 | 85° | 560 | 4,000 | 3,440 | 614.2 |
| 2 | 80 | 89° | 2,862 | 6,335 | 3,473 | 121.3 |
| 3 | 86 | 80° | 2,967 | 15,925 | 13,958 | 470.4 |
| 4 | 86 | 85° | 2,612 | 24,450 | 21,838 | 836.0 |
| 5 | 50 | 85° | 3,062 | 64,700 | 61,638 | 2,012.9 |
| 6 | 50 | 85° | 362 | 2,025 | 1,663 | 459.3 |
| 7 | 60 | 88° | 2,675 | 28,662 | 25,987 | 971.4 |
| 8 | 70 | 84° | 500 | 9,800 | 9,300 | 1,860.0 |

"The importance of cooling milk and of keeping it cold is still further emphasized in Table X which sets forth the results of keeping, at a high temperature, milk that had a low initial bacteria count. In each case the milk was held at a high temperature for a period of two hours, and it will be noted that in every case there was a large increase in germ-content."

It would seem from the figures given by Stocking, and by Ross and McInerney, that there is no one thing to prevent the growth of bacteria in milk more important than cooling, and the maintenance of a low temperature.

**34. Methods of cooling milk.**[1] — "Milk becomes cool, of course, when it gives up its heat to some substance colder than itself, and in order to have a rapid exchange of temperatures between two substances it is necessary that they have approximately the same density. On account of the great difference in density between air and milk, the latter will cool very slowly in air even though the temperature of the air is rather low. If milk is allowed to cool by standing in a cold atmosphere, it will do so unevenly, and by the time the milk in the center of the can is cooled, that part near the walls may be frozen." This factor must not be overlooked.

**35. Tanks.** — Ross and McInerney[1] write: "On farms milk is most often cooled by setting the cans containing it in a tank of water. The most convenient and in the long run the cheapest kind of tank for this purpose is made of cement and sunk in the floor so that only about twelve inches of the sides extend above it. This arrangement obviates lifting the cans to any great height and

[1] Ross, H. E., and McInerney, T. J., Cooling Milk, Cornell Reading Course Lesson No. 102, 1915.

prevents dirt from washing into the tank. The top of the walls of the tank should be faced with strap iron to prevent the cans cracking the cement as they are lifted in and out. Some outlet should be provided in the bottom of the tank so that it can be easily and thoroughly cleaned as often as may be necessary. It is almost impossible to prevent milk from spilling into a cooling tank of this sort, and unless this is cleaned out, the tank soon becomes unfit for use from a sanitary standpoint. Outlets should be made

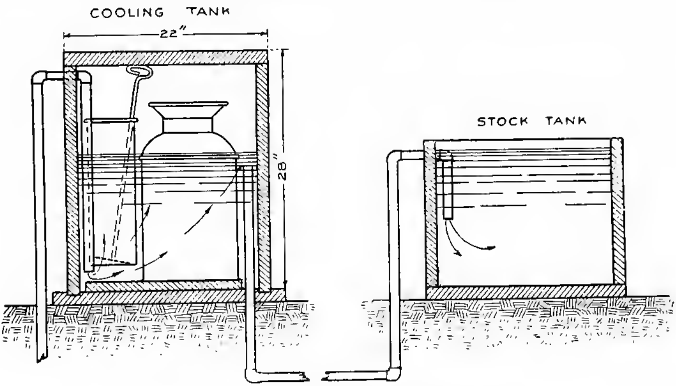



Fig. 11.—A tank for cooling cream.

at the top of the tank in order to carry off surplus water and to prevent the cans from being flooded."

A heavy wooden top should be employed to keep out the warm air.

The tank shown in Figs. 11 and 12 is convenient. Notice how the water is guided to the bottom of the tank when it enters, and that the outlet is at the top. This method of delivering the inflowing water at the bottom produces a much more efficient cooling process than when the water simply flows into the top of the tank.

**36. Effect of stirring milk during cooling in tanks.** — According to Ross and McInerney,[1] "The cooling process, in order to be thorough, requires more than setting the can of milk in a tank of ice water; the milk must be stirred frequently. If the milk is not stirred, that which is near the walls of the can will become cold, while that in the center of the can will, for a long time, maintain a high temperature favorable to the growth of bacteria. Results showing the rate of cooling when milk was and was not stirred during the cooling process are given in Table XI. In each experiment in Table XI can 1 was stirred at intervals of five minutes, and the temperature recorded; can 2 was stirred at intervals of ten minutes, and the temperature recorded; can 3 was not stirred at all, but the temperature of the milk in the center of the can was recorded at intervals of ten minutes; can 4 was stirred continuously, and the temperature recorded at intervals of ten minutes.

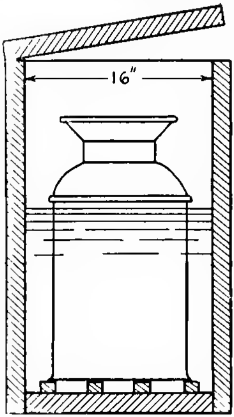



Fig. 12. — End view of tank shown in Fig. 11. The water space under the can aids in rapid cooling.

"In each experiment, with the exception of one, recorded in Table XI the milk in can 4, which was stirred continuously, registered the lowest temperature at the end of an hour; while the milk in cans 1 and 2, which was stirred every five minutes and every ten minutes, respectively, registered about the same final temperature but not so low as that obtained in can 4. The milk in can 3,

[1] Ross, H. E., and McInerney, T. J., Cooling Milk, Cornell Reading Course Lesson No. 102, 1915.

which was not stirred at all during the hour, had a higher temperature than that in the three other cans. This was due to the fact that the milk in the center of the can was not near enough to the cooling mixture; however, when the milk in this can was stirred at the end of the hour, the mixed milk had a temperature that compared very favorably with that of the milk in cans 1 and 2. This would indicate that the milk near the walls of the can had a low temperature.

"TABLE XI — EFFECT OF STIRRING MILK AT DIFFERENT INTERVALS OF TIME ON RAPIDITY OF COOLING

| Experiment | Can | Number of Pounds Ice Used | Temperature of Milk (Degrees Fahrenheit) at | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 9.00 A.M. | 9.10 A.M. | 9.20 A.M. | 9.30 A.M. | 9.40 A.M. | 9.50 A.M. | 10.00 A.M. |
| 1 | 1 | 322 | 95° | 70° | 60° | 55° | 51° | 48° | 45° |
| | 2 | 322 | 95° | 73° | 62° | 56° | 52° | 48° | 46° |
| | 3 | 322 | 95° | 85° | 78° | 70° | 69° | 63° | 61° |
| | 4 | 322 | 95° | 64° | 54° | 47° | 43° | 41° | 39° |
| 2 | 1 | 323 | 95° | 78° | 71° | 65° | 61° | 58° | 54° |
| | 2 | 323 | 95° | 80° | 72° | 65° | 62° | 59° | 55° |
| | 3 | 323 | 95° | 90° | 83° | 81° | 76° | 73° | 72° |
| | 4 | 323 | 95° | 75° | 68° | 63° | 60° | 56° | 54° |
| 3 | 1 | 225 | 87° | 75° | 65° | 62° | 58° | 55° | 53° |
| | 2 | 225 | 87° | 75° | 66° | 63° | 59° | 57° | 53° |
| | 3 | 225 | 88° | 85° | 77° | 73° | 70° | 68° | 67° |
| | 4 | 225 | 88° | 70° | 60° | 54° | 51° | 49° | 47° |
| 4 | 1 | 140 | 95° | 79° | 71° | 66° | 62° | 59° | 57° |
| | 2 | 140 | 95° | 80° | 72° | 67° | 63° | 60° | 58° |
| | 3 | 140 | 95° | 90° | 82° | 75° | 70° | 68° | 63° |
| | 4 | 140 | 95° | 74° | 63° | 59° | 56° | 54° | 53° |

TABLE XI — *Continued*

| Experiment | Can | Number of Pounds Ice Used | Temperature of Milk (Degrees Fahrenheit) at 9.00 A.M. | 9.10 A.M. | 9.20 A.M. | 9.30 A.M. | 9.40 A.M. | 9.50 A.M. | 10.00 A.M. |
|---|---|---|---|---|---|---|---|---|---|
| 5 | 1 | 360 | 95° | 75° | 66° | 60° | 55° | 52° | 48° |
| | 2 | 360 | 95° | 75° | 67° | 61° | 56° | 53° | 49° |
| | 3 | 360 | 95° | 88° | 79° | 72° | 65° | 61° | 57° |
| | 4 | 360 | 95° | 73° | 58° | 51° | 46° | 43° | 41° |
| 6 | 1 | 293 | 93° | 72° | 63° | 61° | 56° | 54° | 52° |
| | 2 | 293 | 93° | 73° | 64° | 61° | 56° | 54° | 52° |
| | 3 | 293 | 93° | 84° | 76° | 70° | 64° | 60° | 56° |
| | 4 | 293 | 93° | 69° | 57° | 52° | 48° | 46° | 43° |
| 7 | 1 | 125 | 96° | 81° | 71° | 65° | 59° | 56° | 53° |
| | 2 | 126 | 96° | 80° | 72° | 71° | 59° | 56° | 58° |
| | 3 | 125 | 96° | 92° | 80° | 71° | 67° | 63° | 58° |
| | 4 | 125 | 96° | 73° | 61° | 53° | 49° | 46° | 44° |
| 8 | 1 | 200 | 95° | 80° | 71° | 66° | 61° | 58° | 55° |
| | 2 | 200 | 95° | 80° | 70° | 66° | 61° | 58° | 55° |
| | 3 | 200 | 95° | 92° | 83° | 73° | 69° | 64° | 59° |
| | 4 | 200 | 95° | 71° | 60° | 55° | 50° | 48° | 46° |
| 9 | 1 | 200 | 95° | 82° | 71° | 65° | 61° | 57° | 55° |
| | 2 | 200 | 95° | 82° | 71° | 66° | 61° | 57° | 55° |
| | 3 | 200 | 95° | 90° | 80° | 72° | 67° | 63° | 58° |
| | 4 | 200 | 95° | 71° | 59° | 54° | 51° | 48° | 46° |
| 10 | 1 | 200 | 95° | 78° | 69° | 65° | 60° | 57° | 54° |
| | 2 | 200 | 95° | 78° | 70° | 65° | 60° | 57° | 54° |
| | 3 | 200 | 95° | 91° | 82° | 76° | 66° | 62° | 61° |
| | 4 | 200 | 95° | 64° | 53° | 48° | 44° | 42° | 40° |

"Stirring milk during cooling produces a rapid drop in temperature, which is advantageous because it checks the growth of bacteria. They develop more slowly, as has been stated, as the temperature of the milk decreases. In each experiment recorded in Table XI all the milk in can 4, which was stirred continuously, was cooled very rapidly, and the largest drops in temperature occurred near the beginning of the period; while in can 3, which was not stirred at all, the temperature of the milk ranged as high as 72° F. at the end of the hour. The point is further illustrated in Table XIII, according to which, at the end of twenty minutes, the difference in temperature due to stirring the milk varied from 3° to 17° F., and the average difference in temperature between the milk stirred and not stirred was 9.7° F. This average drop in temperature, 9.7° F., in twenty minutes due to stirring means an effective check on the development of bacteria. For all practical purposes it seems that stirring the contents of the can once every ten minutes for an hour is sufficient.

"TABLE XII — COMPARISON OF TEMPERATURE OF MILK IN CENTER OF CAN AT END OF COOLING PERIOD BEFORE STIRRING AND AFTER STIRRING

| SAMPLE | TEMPERATURE OF MILK (DEGREES FAHRENHEIT) IN CENTER OF CAN | |
|---|---|---|
| | Before Stirring | After Stirring |
| 1 | 66° | 49° |
| 2 | 73° | 57° |
| 3 | 68° | 61° |
| 4 | 61° | 58° |
| 5 | 72° | 53° |
| 6 | 70° | 56° |
| 7 | 60° | 54° |
| 8 | 68° | 54° |
| 9 | 64° | 52° |
| 10 | 62° | 56° |

"TABLE XIII — EFFECT OF STIRRING MILK ON RAPIDITY OF COOLING

| Can | Stirred at intervals of 10 minutes — Temperature of milk (degrees Fahrenheit) at: Beginning of experiment | Stirred at intervals of 10 minutes — Temperature of milk (degrees Fahrenheit) at: End of 20 minutes | Not stirred — Temperature of milk (degrees Fahrenheit) at: Beginning of experiment | Not stirred — Temperature of milk (degrees Fahrenheit) at: End of 20 minutes | Difference in temperature (degrees Fahrenheit) due to stirring |
|---|---|---|---|---|---|
| 1 | 95° | 68° | 95° | 75° | 7° |
| 2 | 95° | 73° | 95° | 85° | 12° |
| 3 | 90° | 75° | 92° | 80° | 5° |
| 4 | 96° | 73° | 96° | 79° | 6° |
| 5 | 98° | 71° | 98° | 88° | 17° |
| 6 | 95° | 69° | 95° | 78° | 9° |
| 7 | 98° | 73° | 98° | 76° | 3° |
| 8 | 98° | 73° | 98° | 88° | 15° |
| 9 | 96° | 72° | 98° | 86° | 14° |
| 10 | 99° | 73° | 99° | 82° | 9° |

"When a sufficient amount of ice and water are used, stirring the water in the tank at frequent intervals has little, if any, effect on the rapidity with which the milk cools (Table XIII). In this experiment the milk was also stirred every ten minutes. The large quantity of ice used in this experiment is accounted for by the fact that the can of milk from which these temperatures were taken was cooled with three others in the same tank."

**37. Coolers.** — A conical or tubular cooler may be used to advantage if the herd is large and there is a large quantity of milk to be cooled. If the milk is separated at the creamery, it should be cared for as outlined above or a cooler may be employed. If the cream is separated on the farm and if there are several gallons from each separation, it may pay to spout the cream over a cooler so that it may be cooled at the time of separation. If the quantity of cream is small, it should be separated into a shot-gun can and cooled before it is placed in the larger can of cream.

**38. The operator.** — In nearly all branches of any industry, the man is the essential consideration. In dairying the disposition of the operator toward keeping things clean is the main item in the production of a high-class product. The presence of neatly dressed men in a creamery and a tidy butter factory always has a wholesome effect on the patrons who bring milk or cream.

# CHAPTER V

## *CREAM SEPARATION*

The practice of skimming cream from the top of a vessel of milk is centuries old. Until recent years butter was made from cream obtained in this way, or it was made from whole milk. The modern introduction of mechanical devices has unified and improved the process.

### SEPARATION BY THE FORCE OF GRAVITY

**39. Principle of separation.** — The separation of cream and skimmed-milk is possible because of the difference in the specific gravity. The specific gravity of cream is difficult to ascertain because of the exceedingly variable fat-content and because there is a tendency for air to be incorporated in it. For the purpose of separation, it is sufficient to say that the specific gravity of milk-fat is .91 or .92, and of milk-serum about 1.036. As long as well separated skimmed-milk contains only .01 to .04 per cent fat by the Babcock method of testing, it is considered to be all serum. In view of the fact that about one-fourth to one-half of cream is milk-fat, it is readily seen that cream is much lighter than skimmed-milk. The force of gravity acts in direct proportion to the weight of matter. Skimmed-milk is attracted to the earth with greater force than milk-fat. The lighter substance, cream, is crowded away from the earth, or is less attracted to it. Thus the cream rises to the surface of the vessel that contains whole milk. In ordinary phraseology, therefore, cream "rises."

**40. Gravity methods.** — There are three methods of cream separation, depending on the force of gravity. They are the shallow-pan method, the deep-setting method, and the water-dilution method. In the first, the cream is skimmed off with a shallow dipper, and in the other two methods the skimmed-milk is drawn off, leaving the cream. These gravity methods, however, have distinct disadvantages, one of the most important being the loss of a small amount of milk-fat each time they are used. Tests of the relative merits of the gravity methods of separation have been made in order to determine how great is this loss. (See Figs. 13 to 15.)

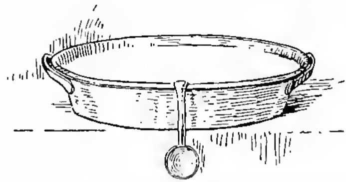


Fig. 13. — The shallow-pan method of cream separation.

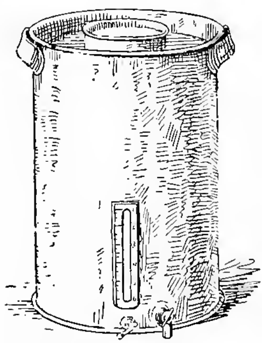


Fig. 14. — The deep-setting method of cream separation.

**41. Efficiency of different methods of separation.** — According to experiments made by Hunziker,[1] the percentage of milk-fat in the skimmed-milk separated from cream by these gravity methods of cream separation is as follows: water-dilution method, .68 of 1 per cent of fat; shallow-pan method, .44 of 1 per cent of fat; deep-setting method, .17 of 1 per cent of fat.

[1] Hunziker, O. F., The Hand Separator and the Gravity Systems of Creaming, Purdue Univ. Agri. Exp. Sta., Bul. 116.

This loss of milk-fat from the milk of a single cow giving 5000 pounds of milk each year, is shown in Fig. 16. The skimmed-milk usually amounts to about 85 per cent of the whole milk, which in this case would mean 85 per cent of 5000 pounds of whole milk, or 4250 pounds of skimmed-milk. In the manufacture of butter, certain amounts of moisture, salt, and casein are incorporated. Thus it is possible to make more butter from a certain amount of milk-fat than there was original fat. This increase is known as over-run. In the computation in Fig. 16, allowance was made for an over-run of one-sixth of the original amount of milk-fat.

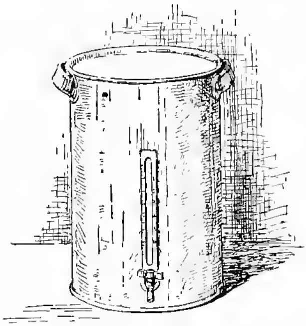


FIG. 15. — The water-dilution method of cream separation.

According to the statements given, if the price of butter were 30 cents a pound, there would be an annual loss of $9.60 on each cow by the use of the water-dilution method, and $2.25 on each cow by the use of the deep-setting method. These losses are computed on the basis of the amount of milk-fat lost through the use of these methods as compared with the amount lost if a modern centrifugal separator were employed.

## SEPARATION BY CENTRIFUGAL FORCE

The centrifugal cream separator has meant very much to the dairy industry. It would not be possible, with the old gravity methods, to separate the cream in some of the modern creameries where 50,000 to 75,000 pounds of whole milk are handled each day. As the dairy industry grew, a greater need was felt for a more efficient method of obtaining the milk-fat in the form of cream. The result of this need was the discovery of a method of separating the cream and milk-serum by centrifugal force.

Centrifugal force acts in direct proportion to the weight of matter. The specific gravity of skimmed-milk

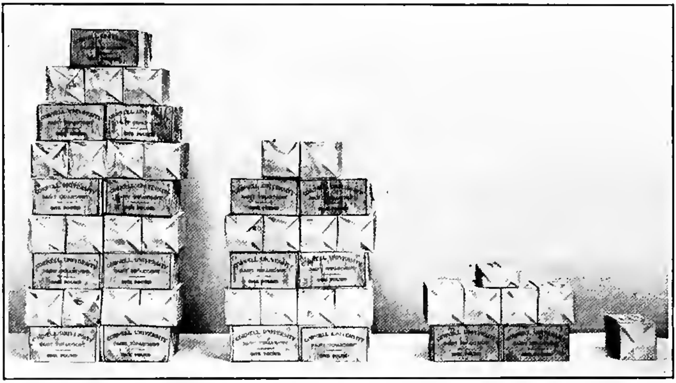


FIG. 16. — A comparison of the amount of butter lost in the skimmed-milk from one cow producing 5000 pounds of milk in one year, by the use of different methods of cream separation. Reading from left to right: water-dilution method, 33 pounds; shallow-pan method, 22 pounds; deep-setting method, 8.5 pounds; centrifugal method, 1 pound.

is greater than that of cream; therefore the skimmed-milk is thrown from the center with greater velocity than the cream. This concentrates the cream toward the center of the bowl.

**42. Intermittent separation.** — The first centrifugal cream separator consisted of pails attached to cross-arms which were probably three to six feet in length. The pails were fastened in such a way that the heavier substance, the skimmed-milk, was thrown to the bottom, thus forcing the cream, which is lighter, to the surface. It is not definitely determined who was the first person to study this subject. However, it is known that Rev. F. H. Bond[1] of Northport, Massachusetts, used a similar plan of generating centrifugal force, and doubtless the other early investigators employed the same methods. C. J. Fuchs[2] of Carlsruhe, Germany, was one of the first persons to suggest the utilization of centrifugal force to separate whole milk into cream and skimmed-milk. Approximately four years later, in 1864, Albert Fesca[2] of Berlin and Antonin Prandtl[2] of Munich made studies similar to those of Fuchs. Bond, whose work is mentioned above, made his studies in 1870. One of the first pieces of apparatus employed in separating cream is shown in Fig. 17. These were intermittent methods.

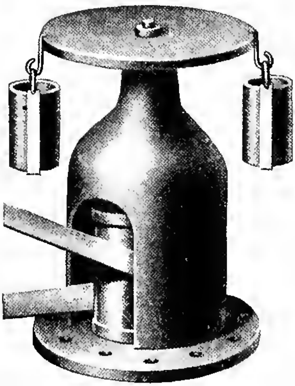


FIG. 17. — An early cream separator experiment. This machine consisted of a device for whirling buckets in which the milk was placed. After whirling a short time the machine had to be stopped and the cream removed from the buckets by hand skimming. This machine was about four feet high, and each bucket held about two gallons.

**43. Continuous separation.** — The intermittent method was slow and wearisome. Therefore, in 1874, the idea of continuous separation was conceived. It is said

[1] McKay, G. L., and Larsen, C., Principles and Practice of Buttermaking, p. 130, 1906.

[2] Fleischmann, W., The Book of the Dairy, p. 120, 1896.

that a patent was granted in France in 1874 to the Company of Fives Lille for a system of continuous centrifugal decantation. Prandtl[1] displayed a continuous separator at Frankfort-on-the-Main. It did not attract much attention because of the great power needed to operate it. A Danish engineer, Winstrup,[2] succeeded in improving the old intermittent bucket method in 1876. In 1877 Lefeldt and Lentsch[2] of Schoenigen, Germany, placed on sale four continuous separators with a capacity of 110 to 600 pounds of whole milk an hour. It is interesting to know that the Lefeldt and Lentsch patent covered the introduction of new milk into the machine back of the cream wall, so that the cream line would not be disturbed by the new milk roughing up the surface. It seems that P. L. Kimball of the Vermont Farm Machine Company was granted a patent in 1896 on a similar method of introducing milk into the bowl, and later, in 1903, a patent was issued to him after improvement had been made. Also in 1877 Houston and Thompson, teachers in the high school of Philadelphia, filed an application for a patent for the continuous method of separating cream from skimmed-milk. This patent was granted in 1881. Again the year 1877 is noted, for Carl Gustof Patrik DeLaval, a young Swedish engineer, invented a continuous-flow cream separator. The commercial manufacture of the DeLaval machine was begun in 1878.

**44. When and where the first separators were made and sold.** — In Europe the first centrifugal cream separators were made and sold by Lefeldt and Lentsch of

[1] Fleischmann, W., The Book of the Dairy, p. 120, 1896.

[2] McKay, G. L., and Larsen, C., Principles and Practice of Buttermaking, p. 130, 1906.

Schoenigen, Germany; Burmeister and Wain, shipbuilders, of Copenhagen, Denmark; and DeLaval and Oscar Lamm, Jr., of Stockholm, under the firm name of Oscar Lamm, Jr. Later the last company was organized under the firm name of Aktiebolaget Separator.

In America the agency for the Burmeister and Wain separator was secured by Jonathan Evans, president of

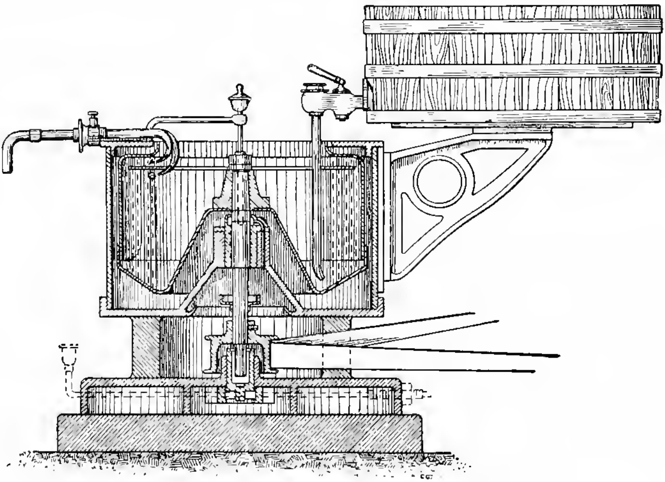


Fig. 18. — A Burmeister and Wain separator.

the Philadelphia Creamery Supply Company, Philadelphia, Pennsylvania. Later an arrangement was completed whereby this company made the separators and Burrell and Whitman of Little Falls, New York, sold them. At this time the name of the machine was "Philadelphia Danish-Weston Cream Separator." Later it was known as the Danish-Weston Separator. It is said that D. M. Weston, a sugar refiner of Boston, Massachusetts, made some improvements on the Burmeister and Wain machine, which accounts for his name being connected with the separator. Fig. 18 shows the Burmeister and Wain separator. The shepherd's-crook shape outlets for the cream and skimmed-milk used on this machine, and which were adjustable, were invented by Oscar Lamm, Jr., who later sold the DeLaval separator. He secured the patent in 1885. It is stated that Nels H. Blom [1] was the operator of the first centrifugal cream separator in the United States. He used a Burmeister and Wain separator on the farm of Jeppe Slifsgaard, Fredsville, Iowa, in 1882. In order that Burrell and Whitman might sell the Danish-Weston Cream Separator, it was necessary for them to pay a royalty to Theodore Bergner of Philadelphia, who owned both the Thompson and Houston and the Lefeldt and Lentsch patents.

The DeLaval separator was sold in America by Joseph H. Reall, agent of the Aktiebolaget Separator of Sweden. In 1882 the American DeLaval Company was organized, and Reall became the manager and selling agent. From 1883 to 1888 P. M. Sharples of West Chester, Pennsylvania, and A. L. Vail of Middletown, New York, manufactured the frames for the American DeLaval Company. In 1888 the American DeLaval Company established its own manufacturing plant, and shortly afterwards Sharples began to manufacture a separator of his own, which was known as the Sharples Separator.

**45. Bowl devices.** — A device in all separator bowls guides or feeds the whole milk into the region of the greatest centrifugal force. With one exception, all centrifugal separators with which the author is familiar have

[1] News Item, Butter, Cheese, and Egg Jour., Vol. 7, No. 41, p. 16, 1916.

internal bowl parts, such as disks, cones, and blades. The purpose of these parts is to form pathways for the skimmed-milk and the cream to pass each other. It must be remembered that these devices do not cause separation; they simply aid the centrifugal force. The introduction of these devices has made possible the use of a much smaller bowl for a given capacity. In the evolution of improvement in this direction, the bowls of cream separators have become lighter, and they are consequently easier to turn and to handle. The separator referred to as being the one exception has a long and narrow tube-like bowl, in the smaller sizes in which it is manufactured. It should be understood that the small tubular bowl is so narrow that the disks, blades, and the like are not necessary. The length of this bowl permits the milk to be subjected to the centrifugal force for a sufficient length of time to cause efficient separation without the use of the bowl devices.

The first bowl device to divide the milk in layers was the disk. It was invented by Baron Clemens von Bechtolsheim, a German living in Sweden, in 1888. Immediately after this invention, the manufacturers of separators recognized that the big hollow bowl was a thing of the past. It is interesting to know that the bowl of the Danish-Weston separator was large and ungainly. It was 15 inches deep by 24 inches in diameter and weighed 100 pounds. As a result of this new invention, an agreement was made in 1889 by Bermstrom, president of the Aktiebolaget Separator, and D. H. Burrell of Burrell and Whitman, whereby Burrell and Whitman, later D. H. Burrell and Company, obtained an agency of the DeLaval separator in the United States. It must be remembered, however, that the American DeLaval Company continued to manufacture and sell separators. The Danish-Weston cream separator, which had been manufactured from 1881 to 1890, was no longer made. After the expiration of all patents, the Reid separators were patterned after the Danish-Weston. However, they did not have much sale, for they were too big and clumsy.

**46. Later separators.** — As the separator industry grew, the idea of a centrifugal butter extractor was conceived by C. A. Johansson of Stockholm, Sweden. It was manufactured by the United States Butter Extractor Company. This machine first separated the cream from the milk. The cream was conveyed into an inner chamber of the separator bowl. It was churned within the inner chamber and the granules were conveyed in one direction, the buttermilk was carried in another and the skimmed-milk was taken in still another direction. This machine, it is said, was successful in accomplishing what Johansson claimed for it, but the demand for sweet cream butter was not sufficiently great to make the use of a butter extractor popular. The patents on Johansson's butter extractor were purchased by the Vermont Farm Machine Company of Bellows Falls, Vermont. Improvements on this extractor, which was later modeled into a cream

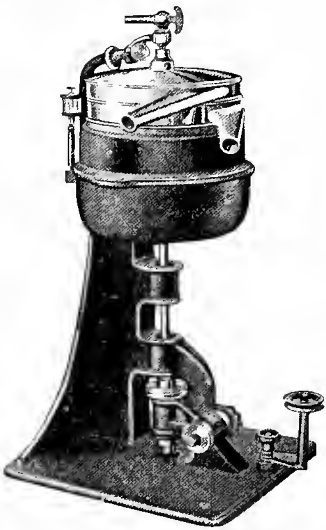


Fig. 19. — The first Sharples factory separator.

separator, were made by Olaf Ohlsson in 1892. Since then many improvements have been made by employees of the Vermont Farm Machine Company. The Sharples Separator Company of West Chester, Pennsylvania, began manufacturing the Sharples factory separator, as seen in Fig. 19, in 1889. About this time the hand machine was first made as seen in Fig. 20. In 1894 this company

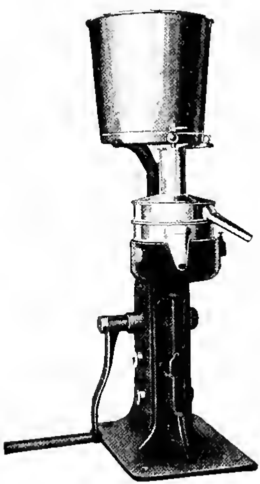


Fig. 20. — The first Sharples hand separator.


Fig. 21. — The first Sharples tubular factory separator.

manufactured the tubular bowl machine as seen in Figs. 21 and 22. The tubular machine was developed by Herbert McCornack, P. M. Sharples, and D. R. Sharples, in 1893 or 1894. At about that time D. H. Burrell and Company began to manufacture the Simplex separator with the link blade invented by Hoyt of that factory. Since that time many companies have been organized to manufacture cream separators, until now there are seventy-five to one hundred different makes of cream separators used in the United States. There are about five companies in this country that manufacture separators sufficiently large for creamery use. Among the first companies to manufacture cream separators in America, other than the above mentioned concerns, were the Empire Cream Separator Company of Bloomfield, New Jersey, and Davis and Rankin, of Chicago, Illinois.

FIG. 22. — The first Sharples tubular hand separator.

In Continental Europe and the British Isles, the first separators to be manufactured, other than the ones already mentioned, were the Balance[1] separator made by the Carlsshops in Nendsburg, Germany; Mèlotte separator of Brussels, Belgium; The Flensburger[1] made by the Flensburger Iron Works in Germany; Ludloffs[1] separator made by F. Ludloff and Sons of Berlin, Germany; Gerauschlose separator built by Laidlow and Company in Glasgow; Victoria[1] separator made by Watson, Laidlow, and Company in Glasgow; Prinzess separator, also made by Watson, Laidlow, and Company in Glasgow; Westfalia[1] separator made by Ramsuhl and Schmidt in Oeldt; Acheiters[1] separator manufactured by Friedrich

[1] Kirchner, W., Milch Wirtschaft, p. 182, 1898.

Scheiter of Niederwürschnitz; Dasekings [1] separator made by Theodore Heilbron, Hanover; Kantz [1] separator made by Ferd. Shultz, and Company, Lünen; the Helice [1] separator and the Butterfly separator which were made by F. H. H. Koch, Hamburg; and the Fesca separator made in France.

It seems from the number of separators put on the market, that the centrifugal method of separation was


FIG. 23. — Modern Sharples tubular turbine factory separator.

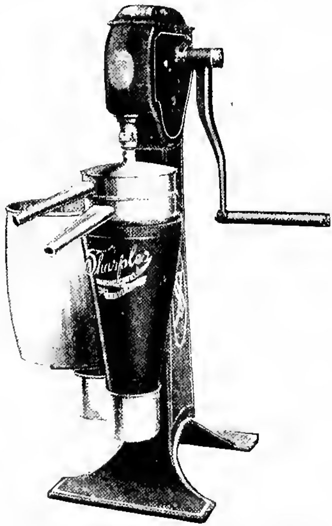


FIG. 24. — The new Sharples suction feed hand separator.

recognized as the future method of obtaining cream from milk; and evidently many manufacturers saw a prosperous business in the building of these machines.

Immediately following the manufacture of smaller

[1] Kirchner, W., Milch Wirtschaft, p. 182, 1898.

bowls, came the small separator with hand power for farm use. Many separators now, and yet only a small proportion of the total number of machines on the farm, are driven in a similar way to the larger ones in the creameries. Electricity, gas, and steam are the powers usually employed. Occasionally a treadpower is found. Gas is the most common form of power on the farm, and steam is usually employed in the creamery. Figs. 23 to 32 show the improvement in the construction of hand and power driven separators. In some cases the supply tanks are lower, the mechanism is more simple, they run easier, they have greater capacity, and they are more efficient than they were fifteen years ago.

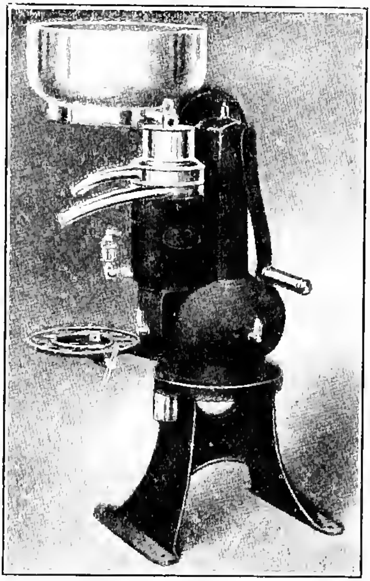


FIG. 25. — A Simplex hand separator.

As the dairy industry has grown, there has been a demand for a greater variation in the capacities of separators. At present there is a variation in the hand machines from 80 to 100 pounds of whole milk an hour to 700 or 800 pounds an hour, and in the power sizes the variation is from the capacities of the hand separators to 10,000 pounds an hour. Thus it is seen that separators are made sufficiently small for a herd of only two or three cows, and some are so large that two or three machines can handle the milk of the largest creameries.

Among some of the most recent developments of the separator are the interchangeable disks, which simplify the assembling of the bowl, the addition of speed indicators, better oiling systems, and other improvements that naturally follow in developing a machine. One of the most noticeable recent inventions is the suction feed of the tubular

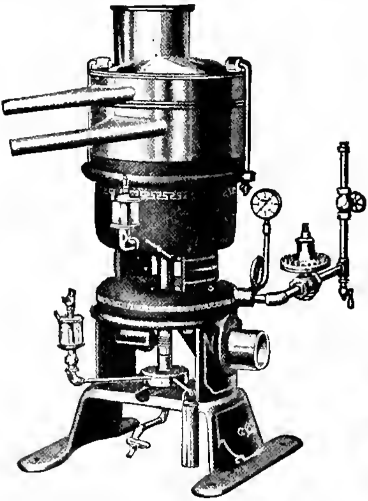


Fig. 26. — A Simplex power separator.

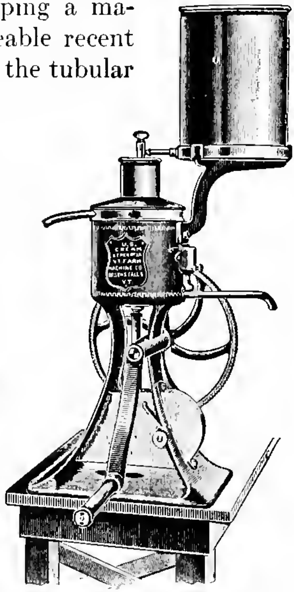


Fig. 27. — The original United States separator.

machine. The important feature is that, within certain limits, a change in speed does not affect the percentage of fat in the cream. The bowl is constructed in such a way that more milk is fed into the bowl when the speed of the machine is high than when it is low; thus the centrifugal force is applied in proportion to the amount of milk that is flowing into the bowl.

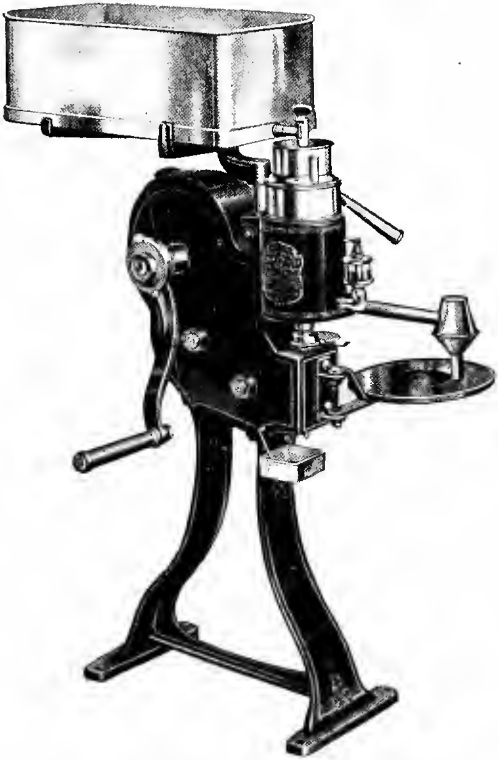


FIG. 28. — The modern United States separator.

THE OPERATION OF THE CENTRIFUGAL SEPARATOR

The modern centrifugal separator is simple and easy to operate. However, it must be kept in mind that it is a delicate piece of machinery and that it runs at high speed. It is reported that at one time early in the history of centrifugal separators, before the machines were perfected, a separator bowl burst at Hazelton, Kansas, and killed seven persons. A few similar accidents have happened before and since because machines are often overspeeded. This means that an operator should be well acquainted with the machine itself and with the important considerations affecting the separation of milk. In the following paragraphs are some of these important factors.

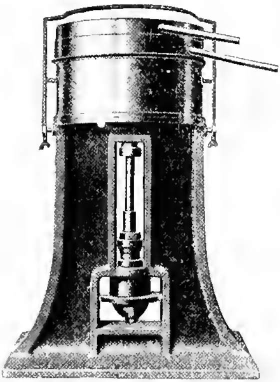


FIG. 29. — DeLaval power separator. This machine was belt-driven and consisted of a large hollow bowl and a frame for supporting it. This separator had a capacity of about 600 pounds of milk an hour, and in size was about 3 feet high. The bowl was $11\frac{1}{4}$ inches in diameter.

**47. Regulation of the fat in the cream.** — The richness, or the percentage of fat, in cream derived from whole milk by the use of a centrifugal separator is regulated by either a cream screw or a skimmed-milk screw. Two main facts should be remembered when one sets either of these screws. The first is that the richness of the cream depends on the point in the bowl from which it is drawn. The richest cream is drawn from the center of the bowl, and the richness decreases as the distance from the center increases. The other fact is that the smaller the proportion of cream to skimmed-milk, the richer is the cream in fat. The percentage of fat in cream should be regulated according to the use that is to be made of the cream. Ordinarily for churning purposes, the proportion of cream to skimmed-milk should be approximately one to eight, or one to ten. For example,

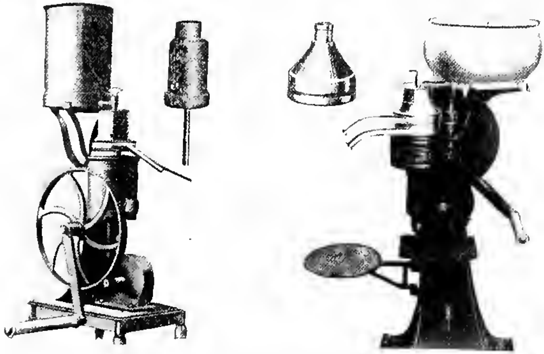


FIG. 30. — Old and new types of DeLaval hand separator.

in 100 pounds of whole milk testing 4 per cent fat, there are four pounds of fat (100 pounds × 4 per

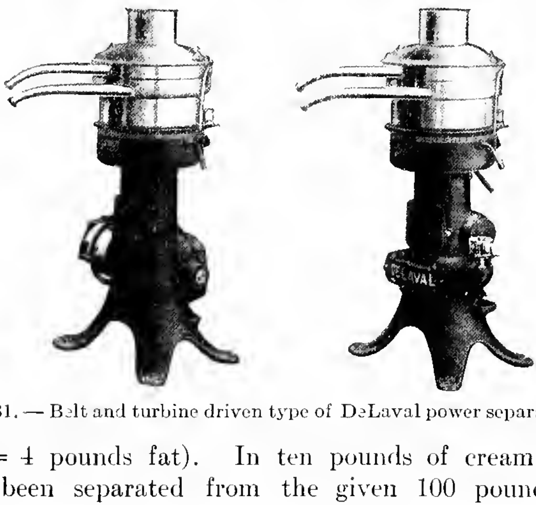



FIG. 31. — Belt and turbine driven type of DeLaval power separators.

cent = 4 pounds fat). In ten pounds of cream that have been separated from the given 100 pounds of whole milk and that test 40 per cent fat, there are approximately four pounds of fat (10 pounds × 40 per cent = 4 pounds). If there is no waste, there are ninety pounds of skimmed-milk (100 pounds − 10 pounds = 90 pounds). The ratio of the cream (10 pounds) to the skimmed-milk (90 pounds) is one to nine. If cream having a lower percentage of fat is desired, this ratio will be less. Cream with a lower pereentage of fat is often used on the table and for making ice eream. In separating eream for these purposes the ratio of cream to skimmed-milk should be about one to four, to five, or to six, depending on the percentage of fat in the whole milk.

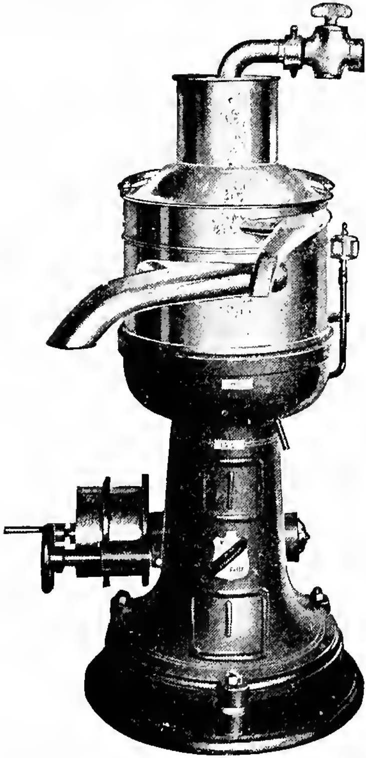


FIG. 32. — The Titan-Alexandra, the largest separator made, with a capacity of 10,000 pounds of whole milk an hour.

It is easily seen that a comparison of the quantities of cream and skimmed-milk obtained in separation gives a close approximation to the pereentage of fat in the cream. These ratios are shown in Fig. 33. It also gives the results of temperature study of one separator; this topic is discussed later in the chapter. The figure makes clear the fact that if cream with a high percentage of fat has been separated, no more fat has

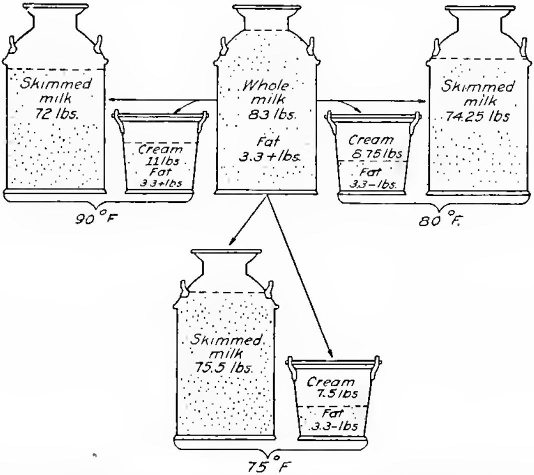



Fig. 33. — A comparison of the amounts of cream from one can of whole milk separated at different temperatures. The pounds of fat in the whole milk and in each pail of cream are practically the same.

been obtained from a given amount of whole milk than if the cream has a low fat-content, for the weight of the cream is less.

If a well-made centrifugal separator is operated properly, it will separate cream containing as high as 45 to 50 per cent of fat, and there will be only the normal loss of fat in the skimmed-milk. Usually it is not desirable that cream should contain more than 40 to 45 per cent, for very rich cream is wasted by adhering to cans, dippers, and other utensils, and it is difficult to obtain a representative sample of it for testing.

The fat-content of cream cannot be controlled to a definite percentage by the regulation of the cream screw or the skimmed-milk screw, and the percentage of fat in cream will not remain constant even when these screws are not changed. There is one possible exception in one machine, *i.e.* the Sharples suction feed. There are certain factors that affect the percentage of fat in cream to a greater or less degree as it is being separated. The effect of these factors on the percentage of fat in skimmed-milk is not so noticeable as their effect on the percentage of fat in cream.

**48. The temperature of the whole milk.** — The temperature of milk that is being separated should be such that the milk will flow easily, in order to facilitate rapid and thorough separation of the cream and the skimmed-milk. The temperature does not need to be as high as the body temperature of the cow, which is normally about 101.4° F.; however, if the separation takes place on the farm, milk should be separated as soon as possible after it has been drawn, especially in the winter. In creameries and in other places where milk is separated after it has cooled, the temperature of the milk should be raised to 85° to 90° F. beforehand. The temperature of the whole milk has a direct effect on the percentage of fat in the cream and the skimmed-milk. To show the exact effect of variation in temperature, tests were made[1] of cream and skimmed-milk that had been separated by five different types of separators. The results of these tests are given in Figs. 34 and 35. The cream and the skimmed-milk separated by all the machines were

[1] Guthrie, E. S., and Supplee, G. C., Variations in the Tests for Fat in Cream and Skimmed-Milk, Cornell Univ. Agri. Exp. Sta. Bul. 360, 1915.

not affected alike by different temperatures. From a study of Fig. 34, it may be thought that there is an advantage in having the whole milk at a low temperature because the cream from two of the separators contained a much higher percentage of fat when the temperature was low. However, the loss of fat in the skimmed-milk

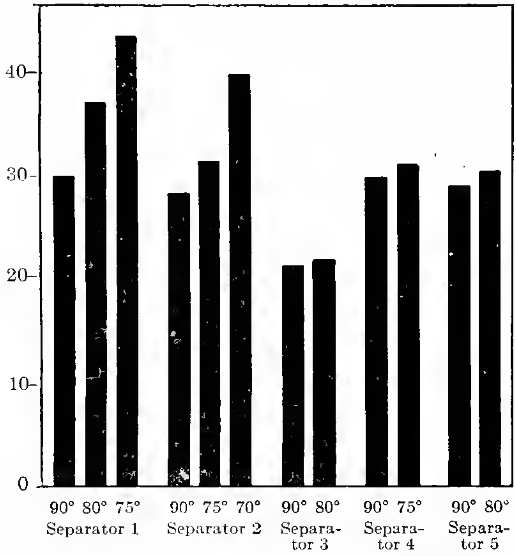



FIG. 34.—A diagram representing percentage of fat in cream as influenced by the temperature of the whole milk. Temperatures are expressed in degrees Fahrenheit. Percentages at left.

was comparatively greater, as shown in Fig. 35. When the fat-content in the skimmed-milk does not vary greatly, the amount of cream from a certain quantity of whole milk decreases in direct proportion to the increase of the amount of milk-fat in the cream. This fact is clearly brought out in Fig. 33. It should be noticed in Fig. 33

that the weight of the fat in the whole milk and in all three pails of cream was approximately the same,

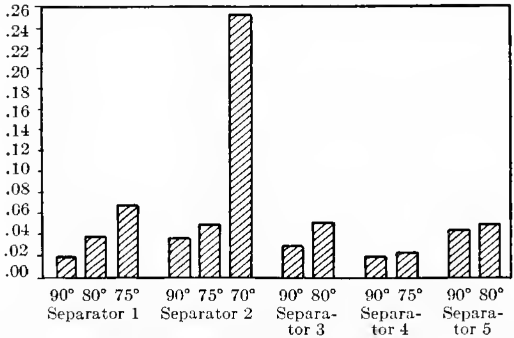



FIG. 35. — A diagram representing percentage of fat in skimmed-milk as influenced by the temperature of the whole milk. Temperatures are expressed in degrees Fahrenheit. Percentages shown at left.

but that there was a distinct variation in the weight of the cream.

**49. The rate of speed.** — The centrifugal force that causes separation is produced by the rapid revolving of the bowl. The separator bowl, about four inches in diameter, makes approximately nine thousand revolutions a minute. Thus a point on the circumference of the bowl travels at the rate of somewhat less than two miles a minute. The number of turns of the crank necessary to effect thorough separation varies for different machines from forty-five to sixty-five a minute. A slight variation in the speed exerts a great effect on the velocity of the bowl; and care must be exercised in producing a regulated speed, if uniform results are to be expected. The effect of a decrease of six or ten revolutions a minute on the percentage of fat in the cream is considerable, as shown in Fig. 36; and the effect on the percentage of fat in the skimmed-milk is very slight, as shown in Fig. 37. A slight variation in the speed of the crank does not

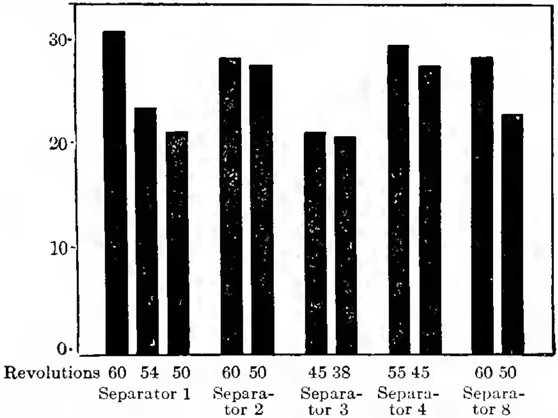



FIG. 36.—A diagram representing percentage of fat in cream as influenced by the number of revolutions of the separator crank a minute.

affect the amount of fat separated from the whole milk, but it does affect the quantity of the cream.

All hand separators have the number of revolutions necessary for efficient separation marked on the crank, and

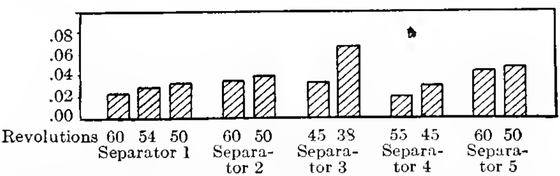



FIG. 37.—A diagram representing percentage of fat in skimmed-milk as influenced by the number of revolutions of the separator crank a minute. Percentages at left.

all power separators carry instructions as to the proper rate of speed at which they should be operated. Naturally the manufacturer is careful not to state a rate of speed that will give results just above the border line of poor separation. If these instructions of the manufacturers are followed carefully, the separation of milk will be found to be thorough. The fact remains, however, that the rate of speed may drop several hundred revolutions of the bowl below the number designated, and still the skimmed-milk will contain approximately the same percentage of milk-fat as when the bowl is revolving at the so-called normal speed. In the case of the hand separators, this amounts to five or ten revolutions of the crank less than the number given for normal speed.

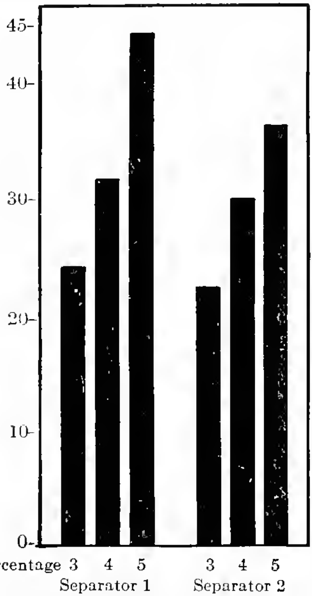



FIG. 38. — A diagram representing the percentage of fat in cream as influenced by the percentage of fat in whole milk. The figures on the left of the diagram represent percentage of fat in cream, and those underneath represent percentage of fat in whole milk.

**50. Percentage of fat in whole milk.** — The percentage of fat in whole milk is variable. In this respect, the milk from individual cows may vary as much as two or three per cent from one milking to another, and yet the cow may appear to be in a normal condition. The fat-content of the milk of a herd is not so variable as that from a single cow. Other things being equal, the larger the herd, the smaller is the variation of the fat-content. The difference in the percentage of fat is not so great from day to day as it is from milking to milking, and this variation is still less from week to week and from month to month. The influence of a variation in the fat-content of the whole milk on the percentage of fat in the cream is shown in Fig. 38. The percentage of fat in the cream is in almost direct proportion to the percentage in the whole milk.

**51. Variation in the quantity of whole milk or in the amount of liquid used for flushing.**—There is variation in the quantity of milk from one milking to another, and this causes variation in the amount to be separated from one time to another. Very few persons operating separators use a fixed amount of skimmed-milk or water for flushing the separator bowl. For the hand machines, two or three quarts of flushing material are sufficient. For the larger power separators, more milk is usually separated; consequently, there is more cream and it is possible to use more skimmed-milk or water in proportion to the size of the separator for flushing without very great dilution of the cream. The amount of flushing material that goes into the cream is only a small percentage of the total, and it affects only slightly the percentage of fat in the cream. Under average conditions, these factors are not of much importance if approximately the same quantities of milk and flushing material are used each time.

**52. Slime deposit.** — If the passages for the cream and the skimmed-milk in a separator are closed or partly so by slime deposit, the efficiency of the separator is affected. This slime deposit is composed of fibrin from the milk and of dirt, and it accumulates in a greater or less amount even from the best milk. Generally, this accumulation is not sufficient to cause excessive loss of fat in the skimmed-milk if the separator is run the length of time of the average separation.

### ADVANTAGES OF THE CENTRIFUGAL METHOD OF CREAM SEPARATION OVER THE GRAVITY METHODS

**53. Fewer utensils.** — Ordinarily, fewer utensils are used in the centrifugal than in the gravity methods. If the herd is composed of only two or three cows, this may not be true; but if there are eight to ten cows, it holds.

**54. Skimmed-milk fresher and warmer.** — The skimmed-milk that has been separated from the cream by a centrifugal separator is fresher and warmer for use in feeding stock than the skimmed-milk produced by the old methods. This may not be an advantage in some cases; yet in no case is it a detriment.

**55. Fat more easily handled.** — The fat, which is the most valuable constituent of milk, is immediately obtained in a small quantity and is, therefore, more readily cooled and otherwise handled. If the old gravity methods of separation are employed, about thirty-six hours are required for the cream to "rise."

**56. Less loss of fat.** — Cream separation by the centrifugal method is more thorough than by the gravity methods because less milk-fat is left in the skimmed-milk.

### FACTORS TO BE CONSIDERED IN BUYING A CENTRIFUGAL SEPARATOR

Since improvements in the construction of separators are being made constantly, it is impossible for any one person to collect sufficient data to determine which is the best machine. However, a few points may help to guide the buyer. Following is a list of these points (57–59).

**57. Size.** — Ordinarily, for farm use, a separator should be of such a size or such capacity that it will separate the milk produced by a herd at one milking in one-half hour or less. Usually a farmer's time is worth sufficient to make it cheaper for him to buy a large enough separator than to use more time in operating a smaller and cheaper machine. Other farm conditions must be considered in the choice of a separator of proper size. It may be the plan of the farmer to increase or decrease the size of his dairy herd, and, since a separator will wear for many years, these expectations must be borne in mind. In buying a separator for creamery use, both the maximum and the minimum quantities of milk for different seasons of the year should be considered.

**58. Supplies for repairing purposes.** — The obtaining of supplies without difficulty is one of the most important considerations in buying a separator, and this point should be especially emphasized in localities where transportation facilities are limited. Most of the manufacturers have supply centers in many sections, so that in case of a breakdown new parts can be obtained quickly. Some dealers in separators carry a stock of supplies.

**59. Other factors.** — The other factors to be considered need little discussion. They are: preference for certain makes; price; amount of power required for operation; accessibility to parts, and number of parts to be cleaned; simplicity of entire construction; indication of durability; efficiency, as shown in the amount of milk-fat left in the skimmed-milk and in the ability of the machine to separate the guaranteed number of pounds of whole milk an hour.

### THE LOCATION OF A CREAM SEPARATOR

The location of a separator in a creamery is not so difficult as the finding of a suitable place for the machine on some farms. The two main considerations in either

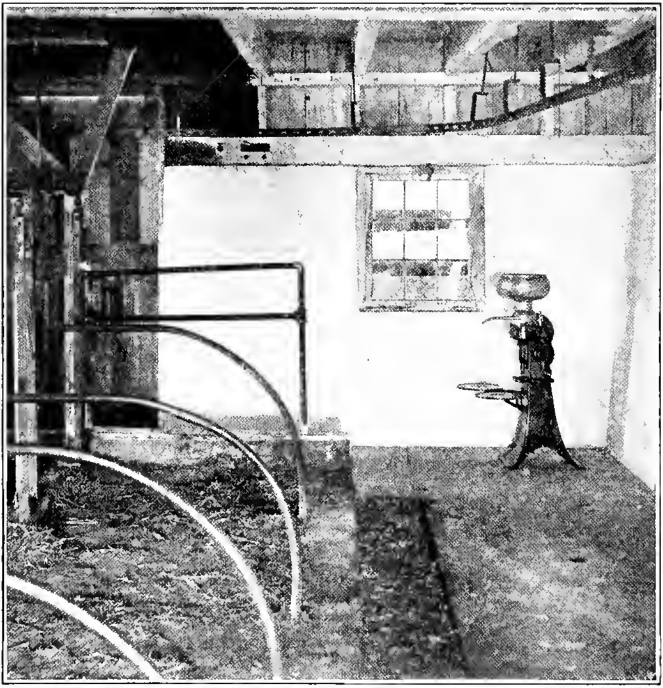


Fig. 39. — The barn is not a desirable location for a separator.

case are sanitation and convenience. The separator should be placed in such a position that during the period of separation the milk and the cream will not come in contact with bad odors and sources of contamination from micro-organisms. In creameries or other large dairy plants, no such sources of trouble should exist.

**60. In the cow stable.**—On farms, separators are often placed in barns and in some cases behind the cows, as shown in Fig. 39. Under no circumstances should a separator be located in such a position, even though it is convenient to the cows, to the calf-pens, and to the pig-pens where the skimmed-milk is fed.

**61. In the kitchen.** — There are probably more hand separators placed in the kitchen than in any other one place on the farm, especially for the winter. The kitchen is a comfortable place in which to work, and it is near the source of hot water, which is absolutely essential in the proper care of dairy products. The woodshed is also usually near the source of hot water and is likewise a convenient place for a separator. Either the kitchen or the woodshed may be used with satisfactory results if the floor is sufficiently solid to prevent vibration of the machine when it is in operation, and if proper precaution is exercised in ventilation and in the prevention of such odors as those coming from burned bacon, cabbage, and onions. The one great objection to handling dairy products in the kitchen, which is often the living room of the house, is the danger of spreading pathogenic organisms, in case any member of the family has a contagious disease. It is preferable, therefore, to have the

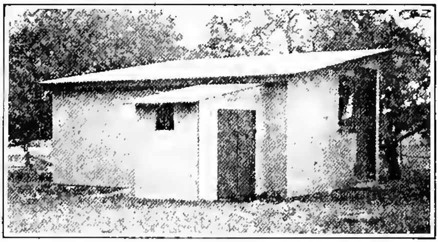


Fig. 40. — A convenient and inexpensive building in which to make farm butter. The gasoline engine is in the lean-to.

machine in a separate room or building, even if it is necessary to take the movable parts to the kitchen for cleaning.

**62. In a milkhouse.** — A separate milkhouse, or dairy building, is recommended when the dairy herds are larger than the average, which is probably less than ten cows, if cream is separated on the farm; when cream of a special grade is being produced; when conditions in

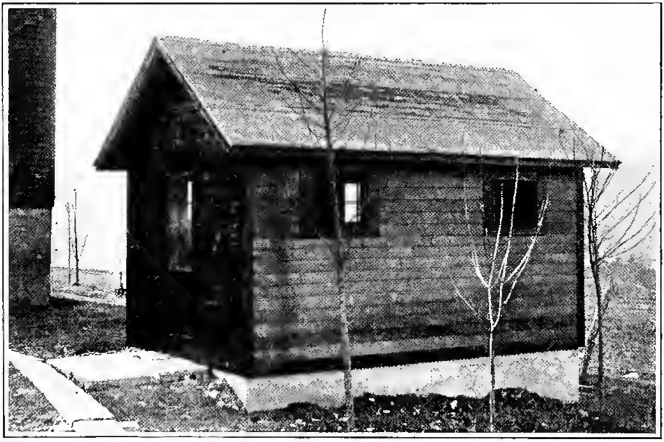


FIG. 41. — A satisfactory building in which milk may be handled in a sanitary way, and a good location for a separator and churn.

the house are too crowded; or when it is desirable to use a power-driven separator. Examples of neat and simple buildings are shown in Figs. 40 and 41. The dairy house in Fig. 40 is a plain building with unfinished interior. It is twelve by sixteen feet in size, and the cost of construction, according to the owner's statement, in 1913 was about $65. The drainage is through a trap into a pipe leading to a gravel bed. This building houses a complete outfit for making butter, including a cream separator. The building in Fig. 41 is a little more expensive and is better finished. The view of it in Fig. 42

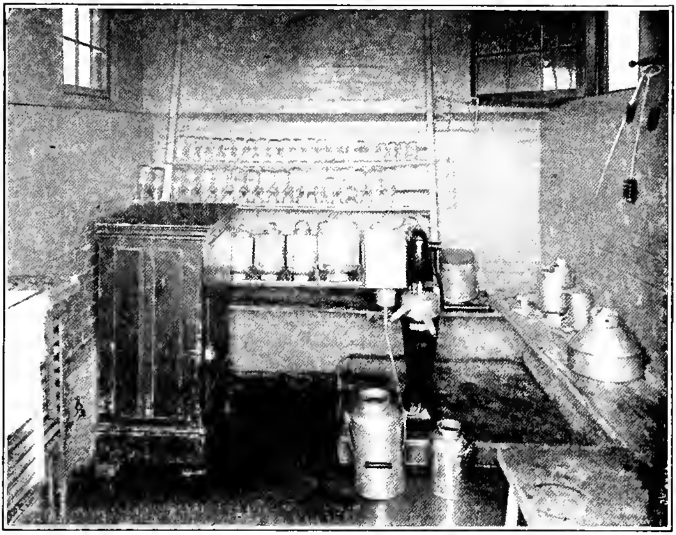


FIG. 42. — Interior view of the building shown in Fig. 41.

shows a brick veneer that makes cleaning a little easier than when the interior of the building is unfinished. The size of this building is ten feet six inches by fourteen feet.

# CHAPTER VI

## *GRADING MILK AND CREAM, AND NEUTRALIZING ACIDITY*

The grading of any commodity is not only good itself, but it sets standards and ideals that are likely to influence one's action in other directions. The idea of grades and of definite packs has now become well established in agriculture, and the application of it will spread. Modern marketing is largely a question of grades and packs.

### GRADING CREAM AND MILK

The principle of paying according to quality is as fundamental to good business in buying milk and cream as it is in buying grain, live-stock, or other commodities. However, the practicability of buying on quality must always be considered even though the principle is correct. Such conditions as the amount of product that is made, the capacity of the apparatus in the creamery, way in which the cream is delivered to the creamery, difference in price, must not be overlooked. When only a few hundred pounds of butter are made a day, it is not possible to handle more than one grade. It pays to grade in a big creamery where there are two or more ripening vats, where there is enough butter in each grade to handle in the normal way, and when the difference in price warrants the additional expense.

**63. History.** — Cream was first graded about 1905. In most of the smaller creameries, the grading has consisted in not accepting the poor goods, thus leaving only one grade. In many of the large centralizer creameries, several methods have been tried. The first method consisted of the collection of farm-separated cream by agents in various towns. These agents were usually store-keepers. When the farmer took his cream to the store, the agent weighed and sampled it, putting the sample in a small screw-top bottle. Then he either dropped it into the can of cream into which the farmer's cream had been poured, or placed it in a rack which fitted in the neck of the can. When the cream reached the factory, which may have been as far as 400 or 500 miles away, it was graded by the butter-maker according to taste and smell. The percentage of fat was also considered in the grading, for cream containing less than 25 per cent fat was difficult to pasteurize and churn. It is apparent that this method of grading could not be satisfactory, because the good and bad cream were mixed; also the average small collector is not a good judge. In other creameries, where the cream was collected by route drivers, a poor attempt was made to grade on the fat basis only, for these men were not good judges of cream. The route drivers weighed and sampled the patron's cream and then poured it into a large can in their wagons. Still other creameries had collecting stations larger than the store stations described above. These operators attempted to grade the cream. By the time it had reached the creamery, the flavor had changed often to such an extent that the first grading was of no avail.

**64. Practicable methods of grading.** — The methods of grading milk or cream have varied, and in many cases they have been difficult to put into practice. The bacteriological analyses of these products require too much time, and are too expensive. The acid determination may be satisfactory in some creameries. In such cases, the acidity may be quickly determined as follows: With a small dipper of proper size, take a small sample of cream and pour it into a white cup. Then with another dipper of the proper size, measure some tenth normal alkali solution containing the indicator and put it into the white cup with the cream. If there is more than .3 or .4 per cent lactic acid in the cream, the color of the mixture will remain unchanged. If the acidity is less than the fixed limit, a pink color will appear. The quickest and best method of grading milk and cream for the manufacture of butter is by the taste and smell of a careful operator.

The general practice now in both small and large creameries is to deliver the cream to the factory in the farmers' cans, even though there may be only two or three gallons. There it is graded by the butter-maker, who is the best fitted to judge cream by taste and smell. It should be remembered that butter is sold largely on the quality of its flavor. It is logical, therefore, to buy the cream on the basis of its quality or flavor. Very often cream may be sour and yet it is better than goods of lower acidity. On the other hand, the high acidity is usually accompanied by the development of other products that give " off " flavors to the butter.

Many creameries have only two grades of product. In case a farmer should send cream too poor to be classed with either of these grades, it is received and a message concerning its quality and a few notes about how to care for the cream is sent to the producer. This very poor cream is saved a few days until a sufficient quantity is accumulated to make a churning. Payment is then made to the producers on the basis of the price received for the butter.

### NEUTRALIZING ACIDITY IN CREAM

Very sour cream is not desirable in the manufacture of butter. Since the advent of the hand separator and with it less frequent deliveries of cream, there has been difficulty in getting the cream to the butter factory in good condition. As noted previously, the lactic acid in butter soon causes it to deteriorate. The logical way to decrease the acid in cream is to neutralize it; the plan adopted by many centralizer plants to carry away the bad odors of poor and sour cream is to force air through it. The more effectual improvement is obtained by neutralization of the acid.

**65. History.** — The neutralizing of the lactic acid in milk is practiced by some cheese-makers. A product known as "viscogen" was used by Babcock and Russell[1] to restore the viscosity of pasteurized cream for table use. The practice of neutralizing the acidity of cream for the manufacture of butter has been general in centralizer creameries for about ten years. In connection with its early use, McKay[2] writes: "As far as I know I was the first to use neutralizers in butter-making. A number of years ago I conducted experiments that lasted several months, using various kinds of alkalies. A large

[1] Babcock, S. M., and Russell, H. L., On the Restoration of the Consistency of Pasteurized Milk and Cream. Agr. Exp. Sta. Univ. Wis., 13th Ann. Rpt., p. 81, 1896.

[2] McKay, G. L., The Use of Neutralizers, N. Y. Prod. Rev. and Amer. Cry., Vol. 39, p. 366, 1914 and 1915.

butter-manufacturing firm in Omaha was the first, to my knowledge, that used lime-water commercially in the manufacture of butter."

**66. Methods of neutralizing.** — Several neutralizing agents are used in decreasing the acid-content of cream. The most important are sodium carbonate, sodium bicarbonate, salsoda, calcium carbonate, and lime-water. Usually milk of lime is preferred to lime-water. The sour cream, which may contain as high as .7 per cent lactic acid, is first heated to about 90° F. At this temperature the neutralizing agent can be readily mixed with the cream. A sufficient amount of the neutralizer is added to reduce the acidity to .2 or .25 per cent lactic acid. After this the cream is pasteurized and a good starter is added. Care must be exercised to prevent the flavor of the neutralizer from being imparted to the butter. Skill is necessary to determine the exact amount of acid in the cream, and in calculating the correct quantity of lime solution to add. It is not possible, with any degree of accuracy, to add a certain quantity of lime and then titrate the cream for acidity, because it requires more or less time for the neutralization to take place. It is, therefore, important that the creamery operator ascertain the acidity with definiteness and that he have a good knowledge of the character of the lime or other neutralizer.

**67. Advisability of neutralizing cream.** — So far as known, there is nothing deleterious to health in the process of adding lime or lime-water to a food product, such as sour cream; but the practice opens a field for discussion. The principle of letting a product deteriorate so that it must be remade is wrong. It is not conducive to permanent dairying. In fact, it encourages carelessness. In many sections, such as in the South and in other new dairy regions, where not many cows are kept, possibly this method of handling cream for the manufacture of butter must be tolerated until a better one can be adopted.

# CHAPTER VII

## *PASTEURIZATION*

PASTEURIZATION is the process of heating a liquid to such a temperature and for such a period of time that nearly all the micro-organisms in it are killed. It also includes the subsequent rapid cooling of the liquid.

**68. History.** — Pasteurization was developed by Louis Pasteur, from whom it derives its name. In the years 1860 to 1864[1] this eminent scientist discovered that wine fermentation is due to micro-organisms, and he found that if the wine were heated to a certain temperature and cooled again, the fermentation stopped. In 1886 Soxhlet[1] applied this method of destroying bacteria to milk and to certain milk products. Pasteurization is not sterilization, as shown in Chapter XVI. Nevertheless, efficient pasteurization will kill at least 99.9 per cent of the micro-organisms.

Pasteurization was first accomplished by the "holder" method. In this system all the milk or cream was heated at one time in a receptacle, and held for a definite period at a certain temperature, then it was cooled. Russell[2] was one of the first to study the application of pasteurization to commercial dairying. He began his studies

[1] Rosenau, M. J., Pasteurization. U. S. Hygienic Laboratory, Bul. 41, p. 591, 1908.

[2] Russell, H. L., Pasteurization of Milk and Cream for Direct Consumption, Wis. Exp. Sta., Bul. 44, 1895.

about 1893. In 1894 or 1895 he persuaded Cornish, Curtis, & Green to build one of the first "holder" pasteurizers made in this country. About the same time Strauss of New York City began to pasteurize milk under the general direction of Dr. Freeman. This milk was for the Strauss charity infant feeding.

*Continuous method.* — The dairy industry seemed to demand a faster method of pasteurization, which could be accomplished by the continuous method. As early as 1896, A. Jensen, now president of the Jensen Creamery Machinery Company, perfected a continuous-flow pasteurizer, at Beloit, Kansas. This machine was first exhibited at the National Creamery Butter-makers' Association convention in 1898 at Lincoln, Nebraska. The present continuous-flow Jensen pasteurizer was first made in 1902. About this time the Reid, Farrington, Miller machine and Sturgis & Burns machine were put on the market. Two or three years later the Progress, Simplex, Triumph, and other pasteurizers were invented.

The regenerative method of continuous pasteurization was the next step in the development of pasteurizers. This process consists in conducting the cold milk or cream into the machine in such a way that it is heated by the outflowing hot milk or cream. It is said that efficient regenerative pasteurization employs only about 10 per cent as much heat by steam as the old method. It is, therefore, much more economical than the first system of continuous pasteurization. Lehfelt [1] of Germany was the inventor of the regenerative system. Willmann [1] perfected this system in 1899 while in the factory of his father-in-law, Edward Ahlborn, Hildesheim, Germany. Later, Willmann came to America.

[1] Willmann, J., Letter to author, 1917.

"*Holder*" *method.* — The real test of most types of machinery is efficiency. After approximately ten years of experience with continuous-flow pasteurizers, the dairy industry found that the vat or "holder" method was more efficient. During this time the old Potts pasteurizer, which was first made in 1899 to 1901, was not much employed. The first vat pasteurizer after the Potts machine, and used more extensively than the Potts apparatus, was the Jensen Vertical Pasteurizer and Ripener[1] which came on the market in the same year. The Jensen Peerless was developed at Ferndale, California, in 1904. In 1908 The Creamery Package Manufacturing Company, Chicago, Illinois, began to sell the Wizard, which at first had a continuous disk heating and cooling device. Later the disk was replaced by a coil tube. D. H. Burrell and Company, Little Falls, New York, placed the Simplex pasteurizer and ripener on the market in 1905 or 1906. This machine had an oscillating tube heating and cooling device. In about 1913 the Burrell concern replaced this pasteurizer and ripener with a vat which has a spray mechanism for heating and cooling.

**69. Flavor improvement.** — Financially, in many instances, the improvement of flavor is the greatest advantage of pasteurization to the butter industry; for if the flavor of the butter is improved, the effect is immediately noticeable in a higher price. It is considered by many manufacturers that when most of the bacteria are killed, the cause of the "off" flavors is removed. On the other hand, it must be recognized that pasteurization is a process of killing micro-organisms and not of extracting flavors, so that when old cream and poor milk in which the bacteria have been growing and producing their undesira-

[1] Jensen, A., Letter to author, 1917.

ble flavors is pasteurized, there is not so much possibility of flavor improvement as when the milk or cream is fresh.

According to Rogers, Berg, and Davis,[1] cream of good quality may be efficiently pasteurized, from the bacteriological viewpoint, if the temperature is raised momentarily to 71° C. (160° F.). They state that this is near the limit of safety, and that if the bacterial-content of the raw cream is high, a temperature of 74° to 77° C. (165° to 170° F.) must be used to secure uniform flavor. Their results, which were based on data of scoring butter when 40 and 150 days old, show that the flavor of the product made from pasteurized cream was higher than the raw cream butter. Judging from the bacteria count, this butter was made from sour or very nearly sour cream.

Hunziker[2] declares that butter made from pasteurized cream shows a decided improvement over that from raw cream of the same quality. He evidently included both sweet and sour cream in this statement. Later he[3] shows that in thirty days sour raw cream butter deteriorates two and one-half points more than butter that has been properly pasteurized. Again Hunziker[4] writes: "The experiment embraces the pasteurization of cream by three different processes of pasteurization; namely, vat pasteurization at 145° F. holding for 20 minutes, flash pasteurization at 160° to 165° F. and flash pasteurization at 180° to 185° F. The cream for four churn-

[1] Rogers, L. A., Berg, W. N., and Davis, Brooke J., The Temperature of Pasteurization for Butter Making, U. S. Dept. of Agri., B. A. I., Cir. 189, 1912.

[2] Hunziker, O. F., Investigations in Dairy Manufactures, Purdue Univ. Agr. Exp. Sta., 28th Ann. Rpt., p. 39, 1915.

[3] Hunziker, O. F., Pasteurization, N. Y. Prod. Rev. and Amer. Cry., Vol. 42, No. 6, p. 236, 1916.

[4] Hunziker, O. F., Cream Improvement, Purdue Univ. Agri. Exp. Sta., 29th Ann. Rpt., p. 34, 1916.

ings was placed in the vat and thoroughly mixed. The cream was then divided into four lots. One lot was churned without being pasteurized, or 'raw'; one lot pasteurized in vat at temperature of 145° F. and held 20 minutes; one lot was pasteurized at a temperature of 160° to 165° F. in a Jensen flash pasteurizer; and one lot was pasteurized at 180° to 185° F. in a Jensen flash pasteurizer. The following table shows the average scores of 18 experiments, in which the butter was held 90 days:

TABLE XIV

| | | Fresh | 30 Days | 60 Days | 90 Days |
|---|---|---|---|---|---|
| Raw cream | . . . . . . . | 87.63 | 85.46 | 85.53 | 84.75 |
| Pasteurized | 145° F. — 20 min. | 90.66 | 89.14 | 89.37 | 89.26 |
| | 165° F. — Flash | 87.96 | 87.48 | 88.13 | 87.94 |
| | 185° F. — Flash | 87.12 | 87.78 | 88.16 | 87.97 |

"The following table shows the average scores of 33 experiments in which the butter was held for 30 days:

TABLE XV

| | Raw Cream | Pasteurized 145° F. 20 Min. | Pasteurized 165° F. | Pasteurized 185° F. |
|---|---|---|---|---|
| Fresh . . . . . . | 88.48 | 91.02 | 89.45 | 87.78 |
| 30 days . . . . . | 86.03 | 89.82 | 88.25 | 88.18 |

"The above figures indicate that, in case of sour, gathered cream that is not neutralized before pasteurization, pasteurization at 145° F. for 20 minutes is the most satisfactory process from the standpoint of germ-killing efficiency and quality of butter."

The most extended work on pasteurization in relation to flavor of butter was conducted by Lee.[1] His conclusion is quite in contrast with the above statements. He says: "Pasteurization does not improve the quality of butter made from sour farm skimmed cream." Mortensen, Gaessler and Cooper[2] state: "Pasteurization of either sweet or sour cream improves the flavor of the resulting butter." Evidently the improvement is only slight, for in the same bulletin Hammer writes: "From the results obtained in the present study together with the data reported by Lee, it seems reasonable to conclude that pasteurization of cream does not materially improve the keeping qualities of the butter made therefrom." Later he concludes, "Butter made from raw cream had practically as good keeping qualities as butter made from pasteurized cream." Farrington and Godfrey[3] found that pasteurized cream butter holds its good qualities much longer than that made from raw cream. The cream in these experiments was sweet when pasteurized. Rogers, Berg, Potteiger, and Davis[4] say that butter made from sweet pasteurized cream keeps much better than that made from similar cream without pasteurization. This statement calls attention to the advantage of pasteurization, and it also places emphasis on the

[1] Lee, Carl E., Pasteurization as a Factor in Making Butter from Cream Skimmed on the Farm, Univ. of Ill. Agri. Exp. Sta., Bul. 138, 1909.

[2] Mortensen, M., Gaessler, W. G., and Cooper, W. H., 2d part. Hammer, B. W., The Pasteurization of Cream for Buttermaking, Agri. Expt. Sta. Iowa State Col., Bul. 156, 1914.

[3] Farrington, E. H., and Godfrey, J. H., Pasteurized Cream Butter, Univ. of Wis., 13th Ann. Rpt., pp. 138–143, 1902.

[4] Rogers, L. A., Berg, W. N., Potteiger, C. R., and Davis, B. J., Factors Influencing the Change in Flavor of Storage Butter, U. S. Dept. of Agri., B. A. I., Bul. 162, p. 69, 1913.

selection of sweet cream in making butter of good keeping properties.

**70. Killing pathogenic micro-organisms in cream.** — The two diseases most readily transmitted by butter are typhoid and tuberculosis. Typhoid fever is a disease of man. On the other hand, tuberculosis is common to man and beast, which, together with its greater prevalence and viability, makes it to be feared far more than typhoid. The spread of tuberculosis by butter has been studied by many investigators. The table on page 97 by Briscoe and MacNeal [1] shows the results of the research on this important subject up to 1908.

It should be noted that the table shows that 13.2 per cent of the 1233 samples of butter contained the *Bacterium tuberculosis*. According to researches by Briscoe and MacNeal themselves, two of six samples of butter contained tubercle bacilli virulent to guinea pigs. Later Briscoe [2] reports the duration of life of the *Bacterium tuberculosis* in butter, as found by other investigators, to vary from four days to six months. His own work showed tubercle organisms to be alive at the end of 274 days at 10° C. below zero, and 4° and 20° C. above zero. This shows that the *Bacterium tuberculosis* is just as active after the butter has been held in cold storage as when it has been kept at higher temperatures. Mohler, Washburn, and Rogers[3] state: "The work recorded in our investigations, as well as that by contemporaneous writers, proves

[1] Briscoe, Chas. F., and MacNeal, W. J., Tuberculosis of Farm Animals, Univ. of Ill. Agri. Exp. Sta., Bul. 149, 1911.

[2] Briscoe, Chas. F., Fate of Tubercle Bacilli Outside the Animal Body, Univ. of Ill. Agri. Exp. Sta., Bul. 161, 1912.

[3] Mohler, John R., Washburn, Henry J., and Rogers, Lore A., The Viability of Tubercle Bacilli in Butter, U. S. Dept. Agri., B. A. I., Ann. Rpt., pp. 179–191, 1909.

### Table XVI — Bacillus Tuberculosis in Market Butter

| No. | Author | Date | Place | Samples Examined | Samples Positive | Per Cent Positive | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | Brusaferro | 1890 | Turin | 9 | 1 | 11.1 | |
| 2 | Roth | 1894 | Zurich | 20 | 2 | 10.0 | Microscopic method |
| 3 | Obermüller | 1895 | Berlin | 13 | 8 | 61.0 | |
| 4 | Schuchardt | 1896 | Marburg | 42 | 0 | 00.0 | |
| 5 | Obermüller | 1897 | Berlin | 14 | 14 | 100. | 16 tested, 2 lost |
| 6 | Gröuing | 1897 | Hamburg | 17 | 8 | 47.0 | |
| 7 | Himesch | 1897 | Wien | ? | 0 | 0.0 | Reported by Markl |
| 8 | Rabinowitsch | 1897 | Berlin | 30 | 0 | 0.0 | |
| 9 | Rabinowitsch | 1897 | Philadelphia | 50 | 0 | 0.0 | |
| 10 | Petri | 1897 | Berlin | 102 | 33 | 32.3 | |
| 11 | Horman and Morganroth | 1897 | Berlin | 10 | 3 | 30.0 | |
| 12 | Rabinowitsch | 1899 | Berlin | 15 | 2 | 13.3 | First Series |
| 13 | Rabinowitsch | 1899 | Berlin | ? | ? | 87.2 | Second Series |
| 14 | Rabinowitsch | 1899 | Berlin | 15 | 15 | 100. | Third Series |
| 15 | Rabinowitsch | 1899 | Berlin | 19 | 0 | 0.0 | Fourth Series |
| 16 | Obermüller | 1899 | Berlin | 10 | 4 | 40.0 | |
| 17 | Korn | 1899 | Freiburg | 17 | 4 | 23.5 | |
| 18 | Ascher | 1899 | Königsberg | 27 | 2 | 7.4 | |
| 19 | Täger | 1899 | Königsberg | 3 | 1 | 33.3 | |
| 20 | Coggi | 1899 | Milan | 100 | 12 | 12.0 | |
| 21 | Weissenfeld | 1899 | Bonn | 32 | 3 | 9.4 | |
| 22 | Grassberger | 1899 | Wien | 10 | 0 | 0.0 | |
| 23 | Herbert | 1899 | Tübinger | 43 | 0 | 0.0 | |
| 24 | Herbert | 1899 | Württemberg | 58 | 0 | 0.0 | Pseudo-tuberculosis 5 per cent |
| 25 | Herbert | 1899 | Berlin | 20 | 0 | 0.0 | Pseudo-tuberculosis 8 per cent |
| 26 | Herbert | 1899 | München | 5 | 0 | 0.0 | Pseudo-tuberculosis 4 per cent |
| 27 | Abenhausen | 1900 | Marburg | 39 | 0 | 0.0 | |
| 28 | Hellstrom | 1900 | Helsingfors | 8 | 1 | 12.5 | 12 samples, 4 lost |
| 29 | Bonhoff | 1900 | Marburg | 28 | 0 | 0.0 | 39 samples, 11 lost |
| 30 | Pawlowsky | 1900 | Kiew | 23 | 1 | 4.3 | |
| 31 | Tobler | 1901 | Zurich | 12 | 2 | 16.7 | |
| 32 | Lorenz | 1901 | Dorpat | 30 | 0 | 0.0 | |
| 33 | Markl | 1901 | Wien | 43 | 0 | 0.0 | |
| 34 | Herr und Beninde | 1901 | Breslau | 52 | 6 | 11.1 | Two are doubtful |
| 35 | Aujeszky | 1902 | Budapest | 17 | 3 | 17.6 | |
| 36 | Thu | 1902 | Christiana | 16 | 0 | 0.0 | |
| 37 | Teichert | 1904 | Rosen | 40 | 12 | 30.0 | |
| 38 | Reitz | 1906 | Stuttgart | 94 | 8 | 8.5 | Butter from 88 dairies |
| 39 | Eber | 1908 | Leipsic | 150 | 18 | 12.0 | |
| | Totals | | | 1233 | 163 | 13.2 | |

that constant storage in icy temperature does not destroy the virulence of butter which contains dangerous tubercle bacilli."

Lumsden[1] states that Bruck found that *Bacillus typhosus* would live as long as twenty-seven days in milk. Lumsden adds, "Under ordinary conditions, however, it would seem that the presence of many vigorous saprophytes, the washing out of the large numbers of bacteria in the buttermilk, and salting, would lessen the chances of the *B. typhosus* remaining in the butter, and it is improbable that butter frequently plays much part in the spread of typhoid fever."

Lazer[2] reports that Heim found *Bacillus typhosus* active after remaining in butter three weeks. However, Lazer himself did not find this organism active on the seventh day. Lazer[2] also states that the cholera micro-organism could not be recognized after remaining in butter five days.

**71. Pathogenic micro-organisms in margarine.** — Margarine also contains the dreaded organism of tuberculosis. Briscoe and MacNeal[3] show the results of seven studies along this line, in the table on page 99.

It would appear that not so many organisms of tuberculosis are in margarine as in butter. This may be accounted for by the fact that many brands of margarine are composed largely of vegetable oils, and also it should be noted that many of the above analyses were made before the days of pasteurization.

[1] Lumsden, Leslie L., The Milk Supply of Cities in Relation to the Epidemiology of Typhoid Fever, U. S. Hygiene Lab., Bul. 41, p. 151, 1908.

[2] Lazer, H., The Behavior of Bacteria of Typhoid Fever, Tuberculosis and Cholera in Butter, Exp. Sta. Rec., Vol. 3, p. 423, (abs. from Zeitsch. of Hygiene, 10, pp. 513–530), 1891.

[3] Briscoe, Chas. F., and MacNeal, W. J., Tuberculosis of Farm Animals, Univ. of Ill. Agri. Exp. Sta., Bul. 149, p. 329, 1911.

TABLE XVII — BACILLUS TUBERCULOSIS IN OLEOMARGARINE

| No. | Author | Date | Place | Samples Examined | Samples Positive | Per Cent Positive | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | Morgenroth | 1899 | Berlin | 10 | 8 | 80.0 | |
| 2 | Annette | 1900 | Berlin | 15 | 0 | 0.0 | |
| 3 | Annette | 1900 | Liverpool | 13 | 1 | 8.0 | Nearly 8% |
| 4 | Bonhoff | 1901 | Marburg | 3 | 0 | 0.0 | 7 samples, 4 lost |
| 5 | Markl | 1901 | Wien | 3 | 0 | 0.0 | |
| 6 | Thu | 1902 | Christiana | 15 | 0 | 0.0 | |
| 7 | Eber | 1908 | Leipsic | 150 | 0 | 0.0 | From 4 factories |
| | | | | 209 | 9 | 4.3 | |

**72. Killing pathogenic micro-organisms in skimmed-milk.** — The skimmed-milk, which is an important by-product of the butter industry, is also a carrier of disease germs. In this case the infection is spread to live-stock rather than to man, for in the creamery in which the milk is separated and the skimmed-milk is returned to the farmer, the probability is that tuberculosis or foot-and-mouth disease will be carried to uninfected herds. This is especially true if the milk from diseased cows has been received at the butter factory. It should be remembered that the practice in creameries is to run the skimmed-milk into a common supply tank from which it is drawn and taken back to the farms for the calves, pigs, and poultry. It is evident that skimmed-milk should be treated to prevent this dissemination of disease. Dotterrer and Breed [1] write: "The best procedure is to return the skim-milk to the patrons' cans at a temperature high

[1] Dotterrer, W. D., and Breed, Robert S., The Pasteurization of Dairy By-Products, N. Y. State Agri. Exp. Sta., Bul. 412, pp. 582–590, 1915.

enough to remain above 145° F. for 30 minutes. This pasteurizes the milk in the final container and increases the keeping qualities of the skim-milk."

If the skimmed-milk is cooled by the creamery, it is put into cans that are not thoroughly scalded and immediately the pasteurized skimmed-milk is seeded by the organisms that are already in the can. The skimmed-milk should be cooled by the farmer after he returns home, for it will remain sweet much longer than if it is not cooled. It should keep sweet at least twenty-four hours. It is well to note the fact that the creamery cannot afford to cool the skimmed-milk, that is returned to the farmer. The patron is the person who profits most by the pasteurization of the skimmed-milk, and he should be willing to cool it in case he wishes to feed it sweet. If he is not willing to cool it, he ought at least not to complain about it. Dotterrer and Breed [1] refer to the fact that the Pennsylvania law requires the heating of dairy by-products to a temperature of at least 178° F.; Iowa, 185° F.; Minnesota, 180° F.; while Michigan requires 185° F. or 145° F. for thirty minutes. According to Rosenau [2] the temperature necessary to kill pathogenic bacteria is 140° F. (60° C.) for twenty minutes. Russell and Hastings [3] say that 160° F. or above for one minute is sufficient to destroy the virulence of bovine tubercle cultures. These are the two reasons for

[1] Dotterrer, W. D., and Breed, Robert S., The Pasteurization of Dairy By-Products, N. Y. State Agri. Exp. Sta., Bul. 412, pp. 582–590, 1915.

[2] Rosenau, M. J., Pasteurization, Hygienic Lab., Bul. 41, p. 598, 1908.

[3] Russell, H. L., and Hastings, E. G., Effect of Short Periods of Exposure to Heat on Tubercle Bacilli in Milk, Univ. of Wis. Agri. Exp. Sta., Ann. Rpt., p. 192, 1904.

continuously maintaining the higher temperatures as required in the above laws: 1. There will be no doubt about the proper temperature being reached to kill the bacteria; 2. The Storch test [1] may be applied to determine whether the temperature has been raised to at least 178° F.

**73. Other effects.** — It is generally considered that the pasteurization of the cream causes the buttermilk to whey-off,[2] which is a detriment to its sale.

Pasteurization of sour cream causes a greater loss of fat in the buttermilk than if the cream were not pasteurized. On the other hand, the pasteurization of sweet cream increases its churning properties. Farrington and Russell [3] state: "A richer buttermilk was obtained from the pasteurized than from the unpasteurized churnings in hot weather, when the pasteurized cream, as a rule, was not so easily and thoroughly cooled as the unpasteurized. At other seasons, when both churnings were made at about the same temperature, there was not much difference in the amount of fat left in the two buttermilks." Mortensen, Gaessler, and Cooper [4] report the following: "The percentage of milk-fat lost in the buttermilk when churning raw cream is slightly greater than with cream pasteurized while sweet. Reversed results were obtained

[1] Ross, H. E., Explanation of Boiled Milk Test, A Dairy Laboratory Guide, p. 18, 1910.

[2] Lee, Carl E., Pasteurization as a Factor in Making Butter from Cream Skimmed on the Farm, Univ. of Ill. Agri. Exp. Sta., Bul. 138, p. 368, 1909.

[3] Farrington, E. H., and Russell, H. L., Pasteurization as Applied to Buttermaking, Univ. of Wis. Agri. Exp. Sta., Bul. 69, p. 39, 1898.

[4] Mortensen, M., Gaessler, W. G., and Cooper, W. H., The Pasteurization of Cream for Buttermaking, Agri. Exp. Sta. Iowa State Col., Bul. 156, p. 15, 1914.

when sour cream was pasteurized." The work reported by Farrell [1] confirms this last statement.

It is usually thought that when sour cream is pasteurized, the high heat coagulates it and some fat is inclosed in the small granules of curd. In this way a greater amount of fat is lost in the buttermilk than when the cream is not pasteurized, or when the cream is sweet when pasteurized. In the case of pasteurization of sweet cream, the viscosity is broken, thus making it possible for the fat globules to collect more readily than when the cream has not been heated. Care should be exercised to prevent the temperatures from going too high, for a cooked or scorched flavor is likely to be imparted to the butter. However, even though there is a distinct scorched flavor in cream just after pasteurization, and in the freshly churned butter, in most cases this flavor will disappear within a few days.

**74. Comparison of methods.** — The first method of pasteurization was the "holder" or intermittent. It is often spoken of as the vat method, because the process may be conducted in the ripening vat. The demand for speed brought forth the continuous or flash system. At present there are many machines of each method, varying in style and size. The vats for the "holder" method vary in capacity from 150 to 1200 gallons an hour. Often the large creameries have them especially constructed in larger sizes than these. The continuous-flow pasteurizers vary from 75 to 800 gallons an hour.

*Operation.* — The flash method is more difficult to operate than the vat system, because a variation in the steam pressure and the difference in the rate at which the

[1] Farrell, John J., Pasteurization of Cream for Buttermaking, Albert Lea State Cry., Bul. 63, p. 15, 1916.

milk or cream flows into the machines have direct effect on the temperature of the pasteurized medium. Also, at the beginning and at the end of each run, great care must be used in the continuous method of applying the heat. The temperature should not go below 176° F. because the pasteurization is likely not to be efficient, and it should not be permitted to go above 185° F. for fear of producing a burnt flavor. In actual practice, the vat or " holder " method is likely to be more complete than the continuous system, because the heat is applied for a longer period of time, and there is less opportunity for carelessness.

*Efficiency.* — The question as to which is the more efficient method of pasteurization is pertinent. Hammer[1] states: " The method of vat pasteurization of sour cream at temperatures of 140° to 145° F. for 20 minutes sometimes left large numbers of living bacteria present, although the percentage killed was high. After pasteurizing sour cream with the flash method at 180° or 185° F. only small numbers of bacteria were found in a living condition." It should be noted that in the flash method a high temperature was not only used, but so long as this was experimental work, this temperature was undoubtedly maintained, which might account for the continuous method giving better results than the " holder " system. In the same publication Mortensen, Gaessler, and Cooper[2] say: " Vat pasteurization seems to be the most efficient method of sour cream pasteurization for improvement of flavor." This conclusion might be true even though there

[1] Hammer, B. W., The Pasteurization of Cream for Buttermaking, Agri. Exp. Sta. Iowa State Col., Bul. 156, 2d part, p. 35, 1914.

[2] Mortensen, M., Gaessler, W. G., and Cooper, W. H., The Pasteurization of Cream for Buttermaking, Agri. Exp. Sta., Bul. 156, 1st part, p. 15, 1914.

were more organisms left in the cream of the vat method, as reported by Hammer,[1] for the number of bacteria in cream is not an exact nor a constant measure of the flavor of butter. Mortensen, Gaessler, and Cooper [2] also found that more fat was lost in the buttermilk from the vat method than from the continuous system of pasteurization.

Pasteurization of cream for the manufacture of butter may be conducted in a different way from handling milk and cream for consumption as such, because in the latter case it is desirable that there may be as little physical and chemical change as possible. This can be accomplished at the lower pasteurizing temperatures for a longer period, as in the vat method. However, in the manufacture of butter, the higher temperatures of the continuous method may be used very satisfactorily. In the average creamery where the deliveries of cream are not regular, the vat method is more convenient than the continuous system. Inasmuch as a ripening vat must be used regardless of the particular method, the initial investment for the vat pasteurizer is less than the cost of the continuous pasteurizer plus the cream ripener.

**75. Notes.** — In operating a pasteurizer many perplexing problems arise; such as, proper speed, sour cream, and thin cream.

*Speed.* — Farrell [3] advises that in operating a continuous pasteurizer speed is important in many machines, for it

[1] Hammer, B. W., The Pasteurization of Cream for Buttermaking, Agri. Exp. Sta. Iowa State Col., Bul. 156, 2d part, p. 35, 1914.

[2] Mortensen, M., Gaessler, W. G., and Cooper, W. H., The Pasteurization of Cream for Buttermaking, Agri. Exp. Sta. Iowa State Col., Bul. 156, 1st part, p. 15, 1914.

[3] Farrell, John J., Pasteurization of Cream for Buttermaking, Albert Lea State Cry., Bul. 63, pp. 6–9, 1916.

causes the cream to circulate through the machine in a thinner layer than when the speed is low. He says that the capacity of the pasteurizer is increased 8 to 10 per cent when using dry steam as a heating medium instead of hot water. It should also be noted that when water is used there is much vibration when it boils, and that this is rather hard on the pasteurizer. It is especially injurious to the soldered joints. The amount of injury depends largely on the construction of the machine and on the way in which it is operated. Farrell says further that the steam and water connection to the ripener and vat pasteurizer should be sufficiently large to admit steam and water fast enough for fast heating and rapid cooling. He adds that it should not require more than twenty to thirty minutes to heat a vat of cream and a little longer to cool it.

*Sour cream.* — In large creameries where a fairly large quantity of sour cream is handled, and with the continuous method of pasteurization, a fore-warmer may be employed to good advantage. The cream should be heated in this fore-warmer, which is a small vat with a heating device, to 100° to 120° F., where it should be held for a few minutes before it goes to the pasteurizer. This prevents foaming in cold weather, increases the capacity of the pasteurizer, and the mixing and heating lessens the danger of the cream curdling in the pasteurizer.

*Thin cream.* — Thin cream is often the source of difficulty in pasteurization. In many creameries the cream becomes "mealy" after it is pasteurized if it is sour and low in fat-content. The "mealy" condition is due to coagulation of a small amount of the serum of the cream. When the cream is thin, which means that the percentage of serum is high, even a low acidity is likely to cause some coagulation of the curd during the pasteurizing process. It has been found by experience that if the cream contains 40 per cent fat or above, the " mealy " condition will not be noticeable even though the cream may be fairly sour.

One of the sources of most difficulty in the operation of the " holder " pasteurizer is the boxings that hold the coil tube and in which it rotates. When the boxing itself, or the packing in it, wears the least bit, the oil flows back along the tube and into the cream. Some machines are so constructed that the bearings are not in contact with the cream. All pasteurizers should be safeguarded in this respect.

**76. Cost.** — Bowen[1] finds that the flash process of pasteurization requires approximately 17 per cent more heat than the " holder " process. In addition to this there is a correspondingly wider range of temperatures through which the cream must be cooled. This adds to the cost of pasteurization. He computes the cost of pasteurizing cream to be $0.0756 to 100 pounds. This would amount to .216 cents a pound of fat when calculating 35 pounds of milk-fat in 100 pounds of cream. Mortensen[2] makes the following summary of the expenses of pasteurizing a pound of milk-fat:

TABLE XVIII

| | CONTINUOUS METHOD | VAT METHOD |
|---|---|---|
| Cost of steam | .019 c | .016 c |
| Cost of water | .009 c | .021 c |
| Cost of labor and equipment | .181 c | .054 c |
| Total | .209 c | .091 c |

[1] Bowen, John T., The Cost of Pasteurizing Milk and Cream, U. S. Dept. of Agri., Bul. 85, p. 12, 1914.

[2] Mortensen, M., Cost of Pasteurization, Butter, Cheese and Egg Jour., Vol. 7, No. 22, p. 22, 1916.

The labor and equipment item is the greatest. The equipment is discussed under "Comparison of Methods" (par. 74).

**77. Summary.** — The pasteurization of sweet cream improves the flavor of the resulting butter. The pasteurization of sour cream does not improve the flavor of the butter; on the other hand, it does not injure it. The main purpose of pasteurization of cream for butter-making is to kill any disease germs that may be distributed to man through the butter, and through the buttermilk and skimmed-milk to man and beast. In general the "holder" process is more satisfactory than the continuous method. From the viewpoint of maintenance or improvement of flavor and also from the standpoint of killing pathogenic bacteria, temperatures of 143° to 145° F. for twenty minutes should be used in the vat method and 180° to 185° F. should be maintained in the continuous process.

# CHAPTER VIII

## *CREAM RIPENING*

MOST of the markets of the United States require butter that has been made from soured or ripened cream. This is fortunate, for in many communities are farmers who wish to dairy on a small scale and who cannot go to the expense of keeping their cream in the perfectly sweet condition. Most butter is made from cream that has soured at least slightly before it is received at the creamery. In the most up-to-date creameries, the cream is pasteurized within a few hours after it is received and then a good starter is added to complete the ripening process.

**78. When to use starter.**—There are many creameries in this country, probably over 50 per cent, that do not use starter. This is due to many factors, among them being indifference of the butter-maker, lack of knowledge concerning the propagation of starter, small amount of cream, irregular churning, and difficulty in securing good milk for starter culture. In some cases perhaps it does not pay to use commercial starter in a creamery, but, nevertheless, the butter-maker should know how to use it. On the farm it is doubtful whether it pays to use artificial starter except when the herds are large, when there is a special market for either the butter or for the buttermilk or for both of these products, and when the maker understands the propagation of starter.

It has already been stated in Chapter VI that ripened-cream butter does not keep so well as butter made from sweet cream. There is a question, therefore, whether the cream should be ripened at all when butter is made for certain markets. For other markets the acidity of the cream should be low. Many of the European trades call for butter made from cream with very little acid. The Jewish people are especially urgent that their butter shall be made from perfectly sweet cream. On the other hand, many consumers prefer high acid butter. It is usually considered that the addition of good starter improves the flavor of butter that is made for quick consumption.

## STARTER

A starter is a material containing desirable bacteria for the ripening or souring of dairy products. These bacteria may be purchased of companies whose advertisements appear in the dairy journals. The growing of these bacteria in whole milk or in skimmed-milk is known as starter-making.

**79. History.** — It has been common knowledge among dairy-men that milk or cream will sour quickly if held at certain temperatures. It was also well known that they will sour still more quickly if sour milk, sour cream, buttermilk, or whey is put into them. Often the addition of one of these sour products, which are known as natural starters, greatly improves the flavor of the cream and of the subsequent butter.

The studies of investigators soon showed that certain bacteria were responsible for the souring process and for the desirable flavors. Storch, Wiegmann, Conn, Eckles, Freudenrich, Tiemann, and Russell were among the first investigators to study cream ripening. In about 1890 these bacteria were supplied in commercial form to creamery-men. Dr. Storch of Copenhagen, Denmark, has the honor of doing most of the early work on starter and of commercializing it. Several laboratories manufacture and sell starter cultures.

**80. Natural starter.** — A natural starter is the result of the natural souring of milk or some of its products; such as, buttermilk, sour skimmed-milk, sour whole milk, or sour cream. When an especially fine natural starter is desired, it may be obtained in the following way: 1. Choose as many sample bottles as may be necessary and wash them carefully. 2. Put the bottles in cold or lukewarm water and raise the temperature rather slowly to at least 180° F. If the temperature is raised quickly, the bottles are likely to be broken. 3. After holding them in the water for a few minutes, draw off the water or take the bottles out and place them, bottom up, in a suitable tray. The purpose of placing them bottom up is to prevent the access of bacteria to the cleansed bottles. 4. Samples are to be taken. If on a farm, obtain a sample from each of a few or all of the cows. If in a creamery, the sample should be taken from each of several, if not all, the patrons. 5. Ripen at 60° to 75° F. 6. Examine the curd for condition of body and flavor. It should be smooth and free from gas pockets, thus showing whether little or any filth is present. The flavor should be clean and pleasant with a distinct acid taste. After a good natural starter has been selected, it should be propagated in the same way as artificial starter. At present it is a question whether it pays to use natural starter in this manner, for the artificial starter, which is much better, can be purchased readily and without much expense.

Each package costs about 75 cts. So long as the average person on the farm is not trained in starter propagation, the best starter to use in making dairy butter is one of the natural sorts. Usually buttermilk is the most convenient. Natural starter is not good enough to employ regularly in a creamery.

**81. Artificial starter.** — Artificial starter is a pure culture of lactic acid-producing bacteria. These microorganisms are isolated from milk and are cultivated on a medium that can readily be put in good form for transportation. There are two general forms of media in which artificial starter is shipped, the powdered and liquid. The powdered condition, in which there is very little moisture, holds the bacteria in the active stage longer than the liquid medium. The powder forms may be held at room temperature, while the liquid cultures must be put in the refrigerator. The liquid culture, which contains bacteria not quite so dormant as those in the powder culture, must be used before the expiration of the time that is stamped on each bottle.

Usually it is necessary to set a new starter every three or four weeks. This depends largely on the carefulness of the operator. Often a very careful butter-maker will carry a starter over a year without renewal. In case a liquid starter is employed, the company supplying the cultures has a standing order to send a bottle of starter at regular intervals. When the powder form is used, several samples are purchased at one time.

**82. Apparatus.** — In the cultivation of starter, the usual practice is to carry the starter from day to day in a small quantity, which is more carefully handled. This small amount is termed "mother starter." The choice of containers for mother starter depends largely on conditions and on the preference of the operator. Glass is somewhat preferable, as dirt is easily detected and the condition of the curd is readily noted. Two or three bottles should be used, for they may break in pasteurizing. Metal holders, as copper properly tinned, or heavy tin, may be used. It is always well to employ a sufficient number of containers so that careful selection is possible.

For creamery work, large apparatus is necessary in addition to the mother-starter utensils. Several types of starter cans are on the market, varying in capacity from 30 to 100 gallons. These cans have a jacket about them into which steam or cold water is passed to raise or lower the temperature during pasteurization and in which water of a definite temperature remains during the ripening process. There is a stirring device to agitate the milk and to break the curd.

The Haugdahl can was the first one made. It was invented by Haugdahl in 1895. The Victor can was placed on the market in 1898. The Triumph came into use in 1902. The Victor Trunnion came out in 1906. The Blue Line was put on the market in 1907, and the Minnetonna was first sold in 1917. There are other machines that are not so well known which are used in some creameries.

**83. Steps in propagation of mother starter.** —

1. Employ three one-quart bottles or fruit jars. Larger receptacles may be used if desired.

2. Use fresh, clean milk, which must have a good flavor. It may be either whole milk or skimmed-milk.

3. Fill the containers one-half to two-thirds full of milk. If they are filled full, it is difficult to prevent contamination from the covers, which are difficult to

sterilize when the pasteurization is performed in hot water.

4. Protect the containers with regular covers (caps or tops).

5. Pasteurize by heating to a temperature of 180° to 200° F. for thirty minutes or longer, and then cool to ripening temperature of 60° to 75° F. Lower temperatures are efficiently maintained. Pasteurization may be accomplished by tying a string about the necks of the bottles and suspending them in a pail or vat heated by steam, or in a kettle or dish heated on a stove. If pasteurization is over a fire, the bottles should not rest on the bottom of the receptacle. Other supports may be used to keep the containers from tipping over. If glass containers are used, the temperature should be raised and reduced slowly in order to prevent breaking.

6. After pasteurization, the milk is ready for inoculation. Inoculate in a quiet place where the wind cannot blow dirt and bacteria into this clean seed-bed. With dry fingers remove the cover and place it in a clean spot. Pour in all of the commercial culture, or 1 to 10 per cent from the previous day's culture. Then shake or stir carefully in order to distribute the bacteria throughout the inoculated material. The amount of ripened starter for inoculation can be measured accurately in a vessel, such as a sterilized cup or spoon, or it can be determined rather closely by the eye.

7. Ripen at about 60° to 75° F. The first inoculation from the commercial culture should be ripened at about 70° to 85° F. The smaller inoculations require higher temperatures. By experience an operator can soon learn the inoculation and temperature required to ripen his starter in a given time. Usually a 1 to 8 per cent inocu-

lation will ripen a starter in twelve hours at about 65° F. The temperature must be fairly constant.

8. The starter is ripe when a curd forms. This curd should be soft and custard-like in appearance; it should not be hard and firm. In the soft custard-like condition the acidity is approximately .7 per cent lactic acid. When firm and hard the acidity may be as high as .95 per cent lactic acid. Usually it does not exceed .9 per cent acidity. When the acidity is high, the lactic acid bacteria themselves die and other micro-organisms grow which produce various flavors, especially the disagreeable putrefactive flavor. This is the worst stage of over-ripening, and it should be avoided.

9. When the starter is ripe, it should be used at once. If this is impossible, cool to 50° F. or lower. If the container is small, do not shake the starter before putting it in storage. Sometimes it is desirable to cool a large batch of starter fairly quickly so that it will not over-ripen. In such case, it may be agitated if it is immediately cooled to 50° F. or below.

10. On examination, the curd should be smooth, compact, and without gas pockets. Gas shows the presence of undesirable bacteria. A hard and lumpy curd, whey, and high acid show over-ripeness. These are very undesirable. After the state of the curd is noted, shake well to break it into a smooth lumpless condition. Shake with a rotary motion, being careful not to permit the milk to come in contact with the cap for fear of contamination. Now smell and taste it, but never from the starter container. Always pour some of the curd into a spoon or cup and then replace the cover immediately. After smelling, it is best to put at least a teaspoonful into the mouth. When starter is lumpy it does not taste the same as when

the curd is broken in fine particles. Therefore it should be agitated to about the same consistency day after day. The amounts of starter to taste should be about uniform. A small quantity in the mouth will not taste quite the same as a larger portion. Also the temperature from sample to sample should be approximately the same. A culture that is about 50° F. tastes differently from one with a temperature of about 70° F. Experienced operators unconsciously make allowances for these factors. The flavor should be clean, with a mild acid taste. The first propagation is likely to be somewhat disagreeable because of the presence of some of the original medium in the commercial culture.

**84. How often to propagate.** — The lactic acid bacteria are most vigorous when only a small amount of acid is present. Rahn [1] states, "As soon as a determination of fermentation products is possible it shows the fermentation per cell to be faster the younger the culture." Again, he concludes,[1] "Old cultures acidify slowly even if transferred into fresh milk; the rate of multiplication is also influenced by long sojourn in the same culture." On account of the starter being much easier to examine when a curd is formed, it is the custom to consider that starter is "ripe" when coagulation has taken place and not when the bacteria are most active, which is before the curd has developed. It should be remembered that the microorganisms are more active when the curd first forms than when more acid and other products of fermentation have been produced. It is apparent then, from the viewpoint of the activity of the organisms, that the ideal time

[1] Rahn, Otto, The Fermenting Capacity of the Average Single Cell of Bacterium Lactis Acidi. Mich. Board of Agri., p. 480, 1911.

at which to inoculate cream, or transfer portions of starter from one culture to another, is when the curd is soft. It is usually impossible to make inoculations at this time. Therefore, the custom has arisen to place small cultures in the refrigerator when they are ripe and to cool the larger ones by running water about them. Sometimes when low ripening temperatures are employed, the danger of permitting the cultures to over-ripen is not great.

The ideal method to follow, so far as the actual practice in the dairy and creamery is concerned, is to transfer the starter cultures each day. By careful handling, the mother cultures may be carried successfully by only two or three transfers a week.

### RIPENING CREAM IN A CREAMERY

**85. Method.** — In a creamery or a large dairy, it is necessary to carry more than a pint or a quart of starter. Along with the mother starter, a second starter of ten to fifty pounds may be carried. After the mother starter in the glass container is inoculated, the remainder of the previous day's mother starter is poured into the second starter, and the cream is inoculated from this second starter. In many large creameries, third and fourth starters are carried.

The improved starter-can is a labor-saver, but not an absolute necessity. It may be used to advantage when circumstances warrant it. Some starter-makers prefer to use shot-gun cans; others like the regular ten-gallon milk cans. In either of the two last-named cases, the temperatures can be easily controlled for pasteurization and ripening by placing the cans in a barrel or in a plank box. During pasteurization it is necessary to agitate the milk. In this larger quantity the pasteurization temperature need not be above 180° F. for twenty or thirty minutes. Care should be exercised not to give the milk a pronounced cooked flavor; otherwise this larger quantity of starter should be handled in the same way as is the mother starter.

**86. Inoculation of the cream.** — It is necessary to use a larger inoculation from starter to cream than from starter to starter, because the seed-bed is not so well prepared. The inoculation of the cream may vary from 8 to 50 per cent. This will depend on the following factors: the percentage of fat in the cream, the capacities of the cream-vat and the churn, the capacity of the starter utensils, and the available milk for starter propagation.

*Percentage of fat in cream.* — The cream should be sufficiently rich in milk-fat to permit at least a 15 to 20 per cent inoculation of starter. Many times it is advisable to use a heavier inoculation; however, this may not always be possible. Ordinarily the cream should test at least 30 per cent milk-fat to churn properly. Most butter-makers like to have the cream test approximately 40 per cent milk-fat when it is placed in the ripener. Such cream would be reduced to a test of $33\frac{1}{3}$ per cent milk-fat when a 20 per cent inoculation of skimmed-milk starter is put into it. If whole-milk starter were used, the reduction would not be so great.

*Size of utensils.* — The capacities of the cream-vat and of the churn very often determine whether or not a large or a small amount of starter should be used. If the vat is completely filled, when only a small amount of starter is added, and if there is no other container for the cream, it is evident that a large quantity of starter should not be put into the cream even though the flavor would be improved. In most creameries this condition is likely to exist only a few weeks in the flush of the season; so that it actually would not pay to buy the extra machinery in order to give the cream the ideal inoculations of starter.

What has been said concerning the capacity of cream-vats is also true of the churns and of the starter-cans.

*Kind of milk for starter.* — Obtaining suitable milk for starter propagation is often very difficult. Either whole milk or skimmed-milk may be used. Many butter-makers say that whole milk is the better and others assert that skimmed-milk is more desirable. What is really important is a milk-serum with a clean flavor. The presence or absence of a little fat, such as might be in either skimmed-milk or whole milk, is not important. It is usually considered that whole milk is more easily selected, for the man in the receiving room can quickly pick out the best milk when it is delivered at the creamery. If it were separated, special care would have to be observed in the separation process to prevent contamination with poor milk. The most serious trouble exists in gathered-cream creameries. Usually in such cases, skimmed-milk is obtained directly from a few farms at a special price. When the creamery is in a large city, it is often impossible to secure good starter milk in the liquid condition. In the past few years, several firms that powder milk have placed on the market a dried skimmed-milk product which is very satisfactory for the starter culture. It is useless to ripen cream with an artificial starter if a good milk cannot be obtained for its propagation.

*Making the transfer.* — If it is not the custom of a creamery to pasteurize the cream, the starter may be transferred to the cream-vat before the cream is put into it or when a part or all of the cream is in the vat. In such case, the time of this transfer should depend on when it is most convenient to wash the starter-cans, when the starter milk is received, and when it is most convenient to pasteurize the starter. If the cream is pasteurized, the starter should not be put into it until the temperature has been reduced to below 100° F.

Before making the transfer to the cream, the starter should be thoroughly agitated to break the curd into very small particles. It is possible to distribute the bacteria in the cream better when the curd is in this condition than when it is lumpy. If the curd is soft and custard-like, it breaks up more easily than when it is somewhat over-ripe and consequently is hard. If the curd is very firm, a wise plan is to pass it through a cream strainer when it is poured into the cream. This will help to put it into a more finely divided condition. It is essential that the cream be thoroughly agitated after the inoculation with the starter properly to distribute the bacteria.

### RIPENING CREAM ON A FARM

**87. Method.** — On a farm the cream might be handled in the following manner: Suppose the dairy-man separates, each half day, ten pounds of cream testing about 35 per cent milk-fat. On Monday a new starter of about two-thirds of a quart is inoculated from a starter that has been held from Friday or Saturday. The remainder of the held-over starter is put in the ten pounds of cream. The cream is then set at about 65° F. It may have to be set in a cooler place before evening. In the evening ten pounds more cream are added, and all the cream, which is now in one vessel, is set at about 60° F. On Tuesday morning add the morning's cream and set at 60° to 65° F., as during the day it is more convenient to watch the ripening process than at night. In the evening add the evening's cream and set at 58° to 60° F., for by this time there is a very large army of bacteria at work. On Wednesday morning churn the forty pounds of cream and start the ripening process anew with Wednesday's cream. It is important to watch carefully and maintain the desired temperatures, to stir the cream thoroughly after each addition of fresh cream, and not to over-ripen it.

### RIPENING TEMPERATURES

**88. Proper temperature.** — Ripening temperatures for cream are usually between 60° and 75° F. The degree of temperature that should be used depends on the time that can be allowed for the ripening process, on the quantity of the starter that has been added, and on the amount of lactic acid that must be developed. When these factors are named, it is understood that the temperatures given are actually maintained. Often it is difficult to hold a certain degree of temperature because of varying conditions in the creameries; such as, the nature of the apparatus and the quantity of cream that is handled, and the method of heating the building. If the quantity of cream is large, if the cream-vat is well insulated, and if it is provided with a tight-fitting top, very little difficulty is experienced in holding a fairly uniform temperature. On the other hand, if an open vat with poor insulation is used, there can be practically no control of temperatures.

**89. Temperature and inoculation.** — When the inoculation of the cream has been large, a fairly low temperature may be employed, and, vice versa, when the transfer has been small a higher temperature should be used. If extremely quick ripening is desired, it may be accomplished by a large inoculation of starter and a high ripening temperature. Ordinarily it is safer to ripen cream at 60°–65° F. than at the higher temperatures.

### WHEN CREAM IS RIPE

Cream is ripe when the desirable amount of acid has been developed. This will depend on the requirement of the market.

**90. Uniform ripening.** — To obtain uniform ripening and really to determine when cream is ripe, it is necessary to allow the production of a certain acidity in the serum of the cream. For example, .4 per cent acidity in cream testing 30 per cent milk-fat is not the same as .4 per cent acidity in cream with a fat-content of 40 per cent, for the serum which contains the acid is not present in the same proportion in both creams.

The following method may be used to determine the desired acidity: (100 per cent − per cent fat) × arbitrary factor = desired acidity. This problem should be worked as follows: 100 per cent − 30 per cent milk-fat = 70 per cent serum. 70 per cent × .006 (arbitrary factor) = .42 per cent acidity that is desired; 100 per cent − 40 per cent milk-fat = 60 per cent serum; 60 per cent × .006 (arbitrary factor) = .36 per cent acidity that is desired. Thus it is seen that .42 per cent acidity in cream testing 30 per cent milk-fat is the same degree of ripeness as .36 per cent acidity in cream testing 40 per cent milk-fat. The cream should be ripened until it contains very nearly the proper amount of acid. In case a high acidity is required, such as .6 or .65 per cent, great care should be observed, for over-ripening is likely to take place.

**91. How to ascertain and satisfy the demand of the trade.**—It should be understood that the arbitrary factor is determined by learning the demand of the trade.

The butter-maker should ascertain from the butter-dealer whether the call of the trade is for a low or a high acidity, and then he should try the employment of a certain arbitrary factor such as .006, .007, .008, or .009. After determining which one shows the desired acidity, he should use it consistently day after day. If a high acidity is called for, a chemical determination of the acid in each vatful of cream should be made. If a low acidity is required, there is not much danger of over-ripening. In this case the sense of taste together with an occasional chemical test is sufficient to give good results.

**92. Cooling immediately after inoculation.** — It is the custom in many creameries to cool the cream for holding overnight to a degree below the churning temperature, immediately after the addition of the starter. When this is practiced, very little ripening takes place. The probable benefit of the starter in this case is derived through the absorption of its flavor by milk-fat.

# CHAPTER IX

## *FROM CHURN TO PACKAGE*

THE processes from churn to package include churning, washing, salting, working, and packing. These procedures are the part over which the butter-maker has direct control. If the milk is separated on the farms, the creamery operator has no power to superintend the process. All that he can do is to exert his influence for more carefulness in the supervision of the care of the milk and cream before it reaches the creamery. The proper care of the raw material on the farm is far more important in the production of the desirable flavor in butter than pasteurization and cream ripening, which are conducted in the creamery. It is apparent, then, that the butter-maker is more directly responsible for that part of the manufacture of butter that takes place from the time the cream runs into the churn until it is in the packages than for the flavor of the product.

### HISTORY OF CHURNING

Churning is the process of collecting the fat in milk or cream by agitation, to such an extent that the serum may readily be drawn from it.

**93. Simple churns.** — The first churns consisted of animal skins. They were suspended from a tree or building and swung against these objects to cause agitation. It is said that the Arabs were the first people to apply other than human power. They tied the skin to a horse's tail and then it was dragged over rough ground with sufficient speed to churn the milk. This form of churn is still found in many oriental countries. Following the skin churn came the many types of small wooden churns. Some of these hand machines were in the shape of a barrel, which was revolved to produce agitation. Others

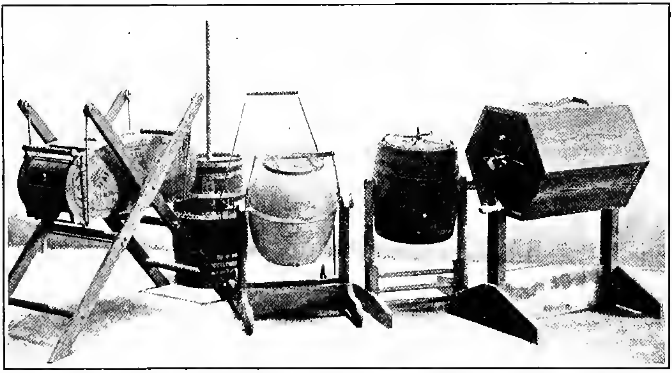


FIG. 43. — A few of the many types of hand churns.

were made with paddles or dashers. There are many small egg-beater and cream-whipping types of churns which collect the fat in a few minutes. These churns are not satisfactory from the standpoint of efficiency of churning and of producing good butter. A few of the types of churns employed on the farms may be seen in Fig. 43.

**94. Large churns.** — The first large churn was the box type. When this came into use, the mechanical worker became necessary, for there was too much butter to work by hand. The need for a more convenient, sanitary, and faster method of churning and working butter was felt as the industry developed. In approximately 1850, which was a few years before the first creamery was organized in the United States, the idea of a combined churn and worker came into existence. It is said that Macnish [1] was one of the first in this country to study and patent butter-workers within churns. The large combined machines, as now known, came on the market about 1893. Cornish, Curtis, and Green built the first combined machine, which was known as the National Combined

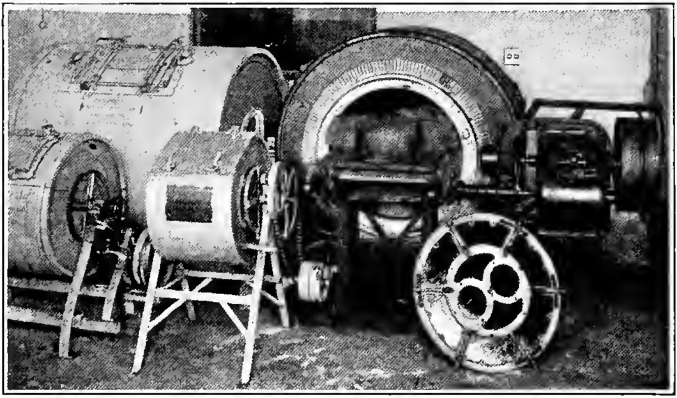


Fig. 44. — Power churns. From left to right the small churns are: Perfection Jr., Minnetonna, Home Creamery. The large churns: Perfection, left, and Simplex, right.

Churn and Butter Worker. The Victor churn was placed on the market about 1896. The Simplex Combined Churn and Butter Worker was designed by the D. H. Burrell & Co.[2] in 1898. The Disbrow was first used about the year 1903. The Perfection churn was invented about 1908. Fig. 44 shows a few of the power churns. The

[1] Macnish, James, Letter to author by R. F. Macnish, who is a grandson of James Macnish, 1917.

[2] Burrell, D. H., Letter to author, 1917.

Wizard, which was invented by Valerius,[1] was placed on the market in 1917. Fig. 45 shows the Wizard churn. A few other combined churn and worker machines, such as The Dairy Queen and the Squeezer, have been on the market. According to Alvord,[2] patents have been issued for new churns by the United States Patent Office at the rate of one every ten or twelve days for the last seventy years. This includes all sizes of churns. Such has been the interest in improving the churning process.

## FACTORS IN THE CHURNING QUALITY OF CREAM

These factors are usually more easily controlled in the creamery than in the dairy, which accounts for less difficulty being experienced in creamery practice.

**95. Temperature** is the most important factor influencing the churning process. The milk-fat globules should be sufficiently warm to cohere, but, on the other hand, the temperature should not be so high as to cause greasy butter, increased loss of milk-fat in the buttermilk, or the incorporation of too much buttermilk.

If the temperature is too low, the cream will whip instead of churn. In such case, a part of the cream should be removed from the churn and warmed sufficiently to raise the entire churning to the proper temperature. Occasionally warm water may be added; however, it is likely to melt some of the fat and it dilutes the buttermilk. In the hand churn, with well-ripened cream testing 30 to 40 per cent milk-fat, the temperature should be 56° to 62° F. In the creamery churn, the temperature should

[1] Valerius, T. L., Letter to author by the Creamery Package Mfg. Co., 1917.

[2] Alvord, Henry E., The Butter Industry, U. S. Dept. Agr., Year Book, p. 13, 1889.

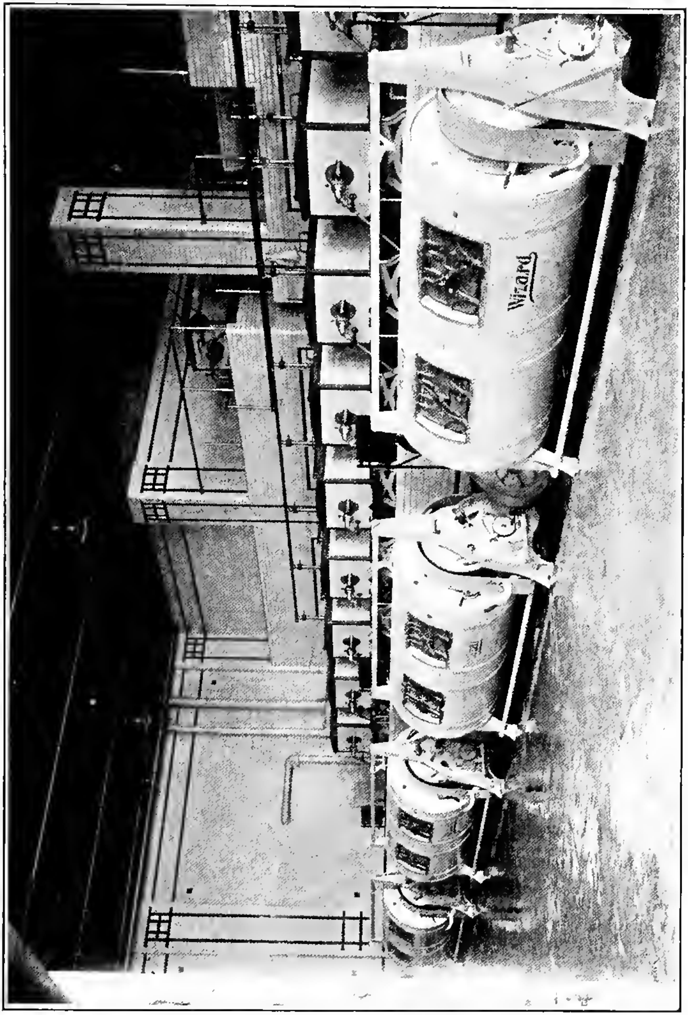



FIG. 45. — Creamery of Fox River Butter Company, Chicago. This is on the top floor of a large cold storage warehouse and is equipped with Wizard churns, cream separators and ripeners, and with sanitary floors and walls.

be 48° to 54° F. After the ripening process and several hours before the cream is placed in the churn, the temperature should be lowered to the proper degree for churning. The reason for this care in cooling the cream is that it requires a few hours for the fat to recrystallize or harden. In cooling, natural ice should not be put in the cream, for much of it contains harmful bacteria.

The butter-maker should regulate the temperature, the richness of the cream, and all other factors, in order that the butter will not have a broken grain and be greasy, but will be firm and waxy. He must remember that the proper churning temperature is that at which the churning process will require thirty to forty-five minutes when all other factors are normal.

**96. Richness of cream.**—It is easy to understand that rich cream, in which there is a comparatively small amount of serum, will churn more readily than cream containing a greater amount which interferes with the concussion of the fat globules. For easy churning, the cream should contain 30 to 40 per cent of milk-fat. Thin cream is often the cause of difficult churning. Sometimes it is necessary to churn cream with a low percentage of milk-fat, but this is at the expense of time or the quality of the butter, and often of both. If the cream is too rich in milk-fat, it will adhere to the sides of the churn. This may cause difficult churning.

**97. Ripeness of cream.** — Ripe or sour cream is less viscous than sweet cream. This viscosity may consist in part of albumin, some of which may be seen in the slime around the separator bowl after separation, and part of the membrane about each fat globule, if such a membrane is present. Regarding the inclosure of the fat globules, Cooper, Nuttall, and Freak[1] write: "The much debated question as to the presence of a mucous envelope around the globules is one of considerable importance in the problem of churnability. This envelope, the membrane of Acherson, was supposed to be derived from the protoplasm of the cell. It is most generally accepted that no such membrane exists; yet Storch (1897) conducted a series of experiments which tend to show that there is such a mucous envelope; also Sturtevant, Aberhalden and Voltz, and others assert that there is a membrane." If the viscosity is broken by ripening or by pasteurization, the cream will churn more easily than when it is sweet or unpasteurized.

**98. Condition of milk-fat.**—It is generally considered that the milk-fat comparatively low in volatile acids and high in olein will churn more easily than the fat that is rather high in these acids and low in olein, for it is softer. The globules of the soft fat cohere more readily in churning than those of the hard fat. Therefore, it is necessary to raise the churning temperature when the fat is too hard to collect properly. The condition of milk-fat is affected by feed, breed of the cow, her individuality, the stage of her lactation period, and perhaps a few other factors.

*Influence of feed.*—The kind of feed that the cows eat has a marked effect on the condition of the milk-fat. Cottonseed products are among the feeds that most affect the fat, especially in relation to churning. Smith, Wells, and Ewing[2] write: "When cows were fed cottonseed

[1] Cooper, W. F., Nuttall, W. H., and Freak, G. A., The Fat Globules of Milk in Relation to Churning, Jour. Agr. Sci., Vol. 4, p. 154, 1911.

[2] Smith, F. H., Wells, C. A., and Ewing, P. V., The Changes in Composition of Butter Fat Produced by Feeding Cottonseed Oil, Ga. Exp. Sta., Bul. 122, p. 110, 1916.

oil the properties of the butter-fat differed from those of a butter-fat when the cows were not receiving the cottonseed oil. The change in properties was greater with the feeding of a larger amount of oil." Eckles and Palmer [1] summarize their report as follows: "The feeding of cottonseed products exerts characteristic effects upon the physical and chemical constants of butter-fat and upon the properties of butter. These are manifested, in general, by a decrease in saponification value and Reichert-Meissl number, and an increase in the iodin-absorption value and melting point of the butter-fat. The effects on the butter are to cause a firmer body, frequently a gummy consistency, a higher standing up quality or ability to withstand a higher temperature without losing its body, a flat, oily taste, and a better keeping quality."

The author has examined many samples of butter from the South and almost invariably the firm gummy body is very apparent. In some cases the butter was too hard to spread nicely on bread even after being held several hours at about 70° F.

Michels and Shiver [2] conclude their study in a southern state in the following words: "It may be added that our experience during the past two years convinces us that, during the warm season, butter produced from a ration containing cottonseed meal is more satisfactory than that produced from concentrates that yield a relatively soft butter-fat. The cottonseed meal butter 'sets up' better at the table." This is an example of the way

[1] Eckles, C. H., and Palmer, Leroy S., Effects of Feeding Cottonseed Products on the Composition and Properties of Butter, Univ. Mo. Agri. Exp. Sta., Res. Bul. 27, p. 41, 1916.

[2] Michels, John, and Shiver, F. S., Water Content, Melting Point and Keeping Quality of Butter, S. C. Agri. Exp. Sta., Bul. 125, p. 14, 1907.

nature provides for various conditions. Cotton grows in the South, and when the by-products of this plant are fed to cows, the butter will stand up much better under the southern range of temperature than butter produced by cows that have not been fed cottonseed products.

Eckles and Palmer [1] say further: "The effects of feeding cottonseed products in the directions indicated are due largely, if not entirely, to the amount of cottonseed oil which they contain." Later Eckles and Palmer write: "The feeding of large quantities of cottonseed meal and whole cottonseed, as still practiced in many localities in the South, must be considerably modified if the butter industry of that part of the country is to attain its proper place in the butter industry of the nation. The use of the whole seed as a feed for dairy cattle is to be strongly discouraged on account of its excessive oil content." According to Hunziker, Mills, and Spitzer,[2] the feed is the most dominant factor controlling the chemical composition of the milk-fat. They say: "Feeds rich in vegetable oils, also blue-grass pasture, produce butter-fat relatively high in olein, low in volatile acids, and make a soft butter. Feeds rich in starches and sugars and poor in vegetable oils, also dry hay, tend to increase the volatile acids, decrease the olein, and produce a relatively firm butter." Eckles and Shaw [3] conclude the report of their work by saying that "the feed of the

[1] Eckles, C. H., and Palmer, Leroy S., Effects of Feeding Cottonseed Products on the Composition and Properties of Butter, Univ. Mo. Agri. Exp. Sta., Res. Bul. 27, p. 41, 1916.

[2] Hunziker, O. F., Mills, H. C., and Spitzer, Geo., Moisture Control of Butter — 1, Factors not under the Control of the Buttermaker, Purdue Univ. Agri. Exp. Sta., Bul. 159, p. 356, 1912.

[3] Eckles, C. H., and Shaw, R. H., The Influence of Breed and Individuality on the Composition and Properties of Milk, U. S. Dept. Agri., B. A. I., Bul. 156, p. 27, 1913.

animal is probably a greater factor than breed or individuality in influencing the nature of the fat."

*Influence of breed.*—It has already been seen that the breed has a certain effect on the condition of the milk-fat. Eckles and Shaw [1] assert that the breed apparently is a factor having some influence on the Reichert-Meissl number, which is a measure of the volatile acids. The highest Reichert-Meissl number was found in the Jersey fat, while the fat of Holsteins gives a lower reading. This statement coincides with the expression of Hunziker, Mills, and Spitzer,[2] who state: "The butter-fat from Ayrshires and Holsteins contains less volatile acids and more olein and makes a softer butter than that from the Jerseys." It would seem from these statements that the fat from the Guernseys and Jerseys would churn with more difficulty than that from other breeds. However, from actual experience in churning, it is known that the milk-fat from these breeds collects more readily than that of the Ayrshires and Holsteins. The probable reason for this is that the larger fat globules in the milk of the Guernseys and Jerseys cohere more readily in the churning process than the smaller fat globules of other breeds. In creameries where large quantities of cream are handled this factor is not of great importance.

*Influence of stage of lactation.*—The milk-fat produced in the latter part of the period of lactation is more difficult to churn than that of any other stage. Hunziker, Mills, and Spitzer [2] found that, at the beginning of the period

[1] Eckles, C. H., and Shaw, R. H., The Influence of Breed and Individuality on the Composition and Properties of Milk, U. S. Dept. Agri., B. A. I., Bul. 156, p. 27, 1913.

[2] Hunziker, O. F., Mills, H. C., and Spitzer, Geo., Moisture Control of Butter — I, Factors not under Control of the Buttermaker, Purdue Univ. Agri. Exp. Sta., Bul. 159, p. 356, 1912.

of lactation, the volatile acids were the highest and the olein was the lowest. They assert that the volatile acids decrease and the olein increases as the period advances. This subject is more fully discussed in paragraph 99. There is a close relation between the size of the fat globules and the condition of the fat, from the standpoint of the churning quality of the cream.

**99. Size of milk-fat globules.** — The size of the milk-fat globules has a marked effect on the churning quality of cream. The large fat globules come in contact with each other more readily than do the small ones. The size of these small divisions of fat is probably affected by the same factors that control the condition of the milk-fat. Very often a "stripper's" cream is difficult to churn because the fat is hard and the globules are small. Hunziker, Mills, and Spitzer [1] say that the size of the fat globules is controlled largely by breed, period of lactation, and by change of feed and other factors affecting the physical condition of the animal. These investigators add: "The Channel Island breeds produce milk with much larger fat globules than the Ayrshires and Holsteins. Milk from fresh cows contains larger fat globules than milk from cows well advanced in their period of lactation. Abrupt changes of feed temporarily increase the average size of the fat globules." Eckles and Shaw [2] report the following: "The stage of lactation exerts a marked and uniform effect upon the relative size of the fat globules. The fat globules are especially large immediately after the

[1] Hunziker, O. F., Mills, H. C., and Spitzer, Geo., Moisture Control of Butter — 1, Factors not under Control of the Butter-maker, Purdue Univ. Agri. Exp. Sta., Bul. 159, p. 356, 1912.

[2] Eckles, C. H., and Shaw, R. H., The Influence of the Stage of Lactation on the Composition and Properties of Milk, U. S. Dept. Agri., B. A. I., Bul. 155, p. 76, 1913.

beginning of the milking period, then the relative size declines sharply during the first six weeks, remains fairly constant for five or six months, after which the decline is much more rapid to the end of the lactation period. . . . The Reichert-Meissl number is the only physical constant of the fat that can be correlated in any way with the relative size of the fat globules. The data indicate that the small fat globules are accompanied by a low Reichert-Meissl number." If the size of the fat globules should remain constant throughout the period of lactation, the cream of "strippers'" milk should churn more readily than when the cow is fresh, for the olein content of the fat increases during lactation, which means that the fat is softer toward the latter end of the period of lactation. However, it is generally known that the milk-fat at the end of lactation is collected with difficulty in churning. Therefore, this difficult churning must be caused by small milk-fat globules. Eckles and Shaw [1] found that the churning of the cream became more difficult toward the end of the lactation period; and with some cows samples were found that could not be churned under any conditions. These authors do not state what they consider to be the exact cause of the difficult churning.

**100. Amount of cream in churn.**—The churn should be one-third to one-half full. There should be enough cream to fall readily, and yet not so much that concussion does not take place. It is usually necessary to raise the temperature a few degrees if the churn is too full, for the agitation is not so great as when the normal amount of cream is in the churn. When the quantity in the churn

[1] Eckles, C. H., and Shaw, R. H., The Influence of the Stage of Lactation on the Composition and Properties of Milk, U. S. Dept. Agri., B. A. I., Bul. 155, p. 77, 1913.

is small, a large proportion sticks to the sides of the machine and thus agitation is diminished.

**101. Speed of churn.**—The greatest possible agitation is desirable. Therefore, the churn must be speeded carefully, not too slow nor too fast. Just before the cream breaks, it is very thick and adheres to the walls of the churn. At this stage, the speed should be lessened when using a hand churn. If a power churn is employed, the speed should be uniform and at the rate designated by the manufacturers.

**102. Abnormal micro-organisms.** — Certain micro-organisms, such as ropy milk bacteria and yeasts, prevent the cohesion of the fat globules. Difficult churning is the result. However, this is not an important cause of difficult churning for it does not often occur.

**103. Steps in "from churn to package."**—The following practices should be observed to secure a marketable product:

1. Have the temperature of the cream correct. (See par. 95.)

2. Place in hot water all the woodenware, such as ladles, printer, and the like, that may come in contact with the butter. In case some pieces of the woodenware are large, it is necessary to run the hot water over them. The purpose of this hot water is to fill the wood with moisture so that the butter will not stick to it. After these utensils have been soaked in hot water sufficiently long, they should be placed in cold water or the water should be sprayed over them. When the wood is warm, the butter soon becomes greasy and sticky; whereas, if it has been properly cooled, the body of the butter is not affected. Improperly prepared woodenware is often the cause of greasy and smeary butter.

3. Keep the churn clean and so set that it will not turn over during the filling process. If the churn has not been used for two or three days, it should be scalded and then cooled with cold water. Even though it is used every day, a good plan is to moisten the interior of the barrel with cold water, so that the cream will not cling to the walls.

4. Pour the cream into the churn through a wire or perforated-tin strainer. In case of small churns, brass or copper wire strainers are the most satisfactory. These wire strainers should have about 20 meshes to the inch. For straining the cream into small churns or straining the buttermilk from either small or large churns, these wire strainers may be made by soldering the brass or copper wire cloth to a suitable frame. Often the wire may take the place of the bottom of a large dipper. The purpose of straining the cream when it is put into the churn is to catch any foreign matter, such as flies and brush bristles, and to cut or retain the lumps of curd that may have formed in the ripening process. When cream is rather poor in milk-fat, and when it has been highly ripened, the serum becomes a rather hard curd, which, if not strained out, will cause streaks or mottles in the butter. Occasionally these particles of curd, if very hard, appear in the butter as little white specks, which are sometimes known as "white-caps." Such variation in color is very objectionable to the purchaser.

5. Add the color to the cream in the churn. Usually one to three ounces of color to one hundred pounds of milk-fat is sufficient. This may vary with different brands of color, seasons of the year, breed of cows, and market requirements. Ordinarily, the butter-maker is not much concerned about the natural color of the milk-fat, for he can easily color the butter artificially when he

knows the strength of the color solution and the demand of the market. These factors he learns by experience. If the butter-maker forgets to put the color in the cream, it may be mixed in the dry salt and worked into the butter. Probably it will be necessary in this case to overwork the butter somewhat in order to distribute the color and salt properly.

If unsalted butter is made in the summer, when the natural color of the product is high, it is often necessary to send a statement to the purchaser, informing him that no artificial color has been used. This is especially necessary if the trade is critical, and if the cows producing the milk-fat are largely Guernsey or Jersey. Unsalted butter should not be high in color, for the trade that consumes this butter, which is largely the Jews, demands that no artificial color be added.

6. After securely fastening the cover, give the churn eight or ten revolutions and then pull out the plug or open the gate in order to let the gas escape. This gas is largely carbon dioxide ($CO_2$), which is one of the products of fermentation. It is usually well to hold the hand over the hole in such a way as to prevent the cream from blowing over the room. Return the plug or shut the gate, and revolve the churn fifteen or twenty times more and again let out the gas. If the churn is not too full, usually two or three stops for this purpose are sufficient.

7. The churning process is nearing completion when the glass becomes clear. The particles of butter should be about the size of a pea or a kernel of corn, for the buttermilk drains off more readily when the granules are of this size than when they are very small. Fig. 46 shows granules that are too small. The butter is not floating sufficiently high. In Fig. 47 the granules are about the

proper size. The butter appears somewhat like a mass of well-popped pop-corn. If churned too long, these butter particles collect in large lumps, and too much

Fig. 46. — The churning process is not complete, for the granules are too small.

buttermilk is incorporated. When too much buttermilk remains in the butter, bacteria will grow on the milk, sugar, casein, and albumin, and thus the flavor of the butter is injured.

8. Drain off the buttermilk through a strainer. This strainer may be supplied with the churn or it may be similar to the wire strainer described in step 4.

9. In washing butter, pour in just enough water to aid in draining off the buttermilk. Then close the door securely and add about as much water as there was buttermilk drained off. Possibly more water should be employed in this second washing, if the churning is small.

The temperature should be about 54° to 58° F. If the temperature is too low, the butter will be too hard to work in the salt nicely. When the butter is hard, extra working is required and it is likely to be tallowy. If the butter is

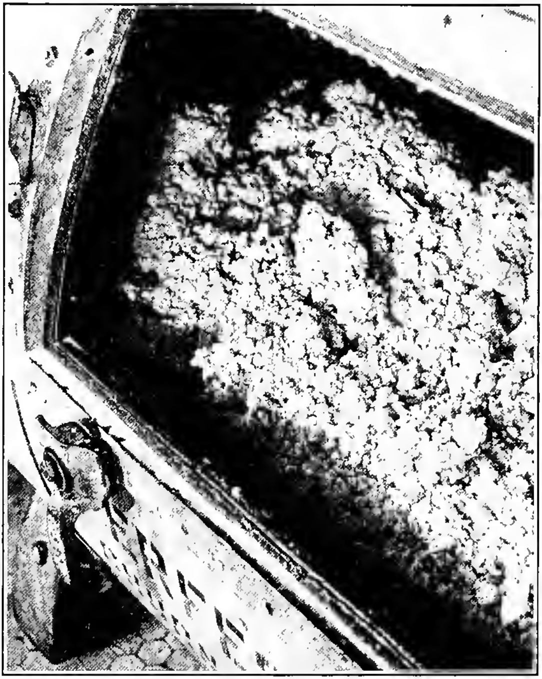


Fig. 47. — The churning process is complete. The granules are about the size of a kernel of corn.

too soft, it will be greasy. Revolve the churn, in high speed, ten to fifteen revolutions to complete the washing. Both wash waters should be drained from the churn through a strainer.

It is very necessary that the water be free from micro-organisms that will affect the flavor of the butter or the health of the consumer. Therefore, in case there is any suspicion of impurity in the water, it should be pasteurized.

10. After washing, and in case a small churn is employed, place the butter on the worker or in the bowl that has been thoroughly cooled, and distribute the salt over it. Sometimes it is easier to spread the salt over the butter, while it is still in the open and clustered condition in the churn, rather than when it is bunched together on the worker. In the large factory churns, the butter should be gathered on the shelf and trenched. Then the salt should be put in the trench and the butter pulled over it in such a way that it is not scattered throughout the churn. This method of putting the salt into the butter does not waste so much as simply scattering it over the butter. In large churns that have two doors, the quantity of salt should be divided equally in two portions and one division placed in each end of the churn. This aids in the even distribution of salt in the butter.

If the salt is dry and hard, or cold, and dissolves slowly, it is well to place it in a vessel and just cover it with water at the same temperature as that of the wash water, or perhaps two or three degrees higher. After standing a few hours, the salt will be softened and warmed and will dissolve in the butter much more quickly than when dry or cold. This method of aiding salt to dissolve is much more satisfactory than to allow the butter to stand a few or many hours, and then to complete the working process; for when it is held it is usually placed at a low temperature and consequently is too hard to work well. In creameries, where not many churnings are made each day, it may be convenient to allow a churning to stand fifteen or twenty minutes to permit the salt to dissolve; but, where many churnings are made, the time is too short for delays of this sort. The salt should dissolve almost immediately after being put in the butter. If it does not soon pass into solution, it may be treated by partially dissolving, as suggested above.

The quantity of salt to put into butter will depend on the market. The average is one to one and one-half ounces to a pound of milk-fat.

11. The purpose of working butter is mainly to distribute the salt, and secondarily to compact the butter. When working by hand, do not give the ladles a sliding motion over the butter, as this will make it greasy. The working process may be in a bowl, in the churn, or on a worker. Work until the butter is compact and shows only a few holes. If the butter has not been worked sufficiently, mottles may be found in it after it has been in cold storage for a day, and the moisture and salt will not be evenly distributed.

The temperature of the butter, as controlled by the churning temperature, the temperature of the wash-water, and that of the room, should be such that the body of the product will be waxy. If the butter is too low in temperature, it will be hard, and the working process will cause it to be tallowy. On the other hand, if the temperature is too high, the butter will become greasy when it is worked.

12. As soon as it is worked, the butter is ready to be placed in packages to suit the market. The packages should be clean and cool, and the butter should be packed firmly. If paper or wooden packages are used, particular precaution must be taken against mold. When the butter is marketed in wholesale packages, such as tubs or boxes,

they may be prepared in the following way if there is danger of mold development: (1) Clean each container, if necessary, and then soak it. (2) Place each tub or box over a steam jet and heat sufficiently to kill most of the mold and to open the pores of the wood. (3) Put the tub or box over the paraffin spray and throw the jet open for an instant. The temperature of the paraffin should be 240° F. If the wood is not hot when the paraffin is applied, it will peal off. (4) Allow the excess paraffin to drain from the package. (5) Line the packages with parchment as in ordinary practice. This paper should have been boiled to kill the micro-organisms on it, and allowed to cool.

**104. Selection of packages for storage butter.** — If the butter is packed for storage, care should be observed in choosing packages of sound wood only. Mold spores are likely to be harbored in unsound material. If retail packages are employed in storing, the wrappers should be boiled.

## MOISTURE OF BUTTER

Moisture is a natural constituent and ingredient of butter. Some of the moisture comes from the cream, some is incorporated in the washing process. The variation of water in butter is about 10 to 20 per cent (see par. 8). Butter is generally eaten on bread. Therefore, the consistency of the butter should be such that it will spread properly. The moisture-content of butter has a direct effect on its spreading properties. If it contains as low as 12 or 13 per cent water, the body of the butter is likely to be too hard. In the United States, as well as in many other countries, butter is considered to be adulterated if it contains 16 per cent or more of moisture (see par. 181). It is right that there should be a legal limit on this component of butter, for unscrupulous manufacturers, by careful control of the working process, could incorporate 20 per cent water without suspicion from the average consumer. Another reason for placing a legal limit on moisture in butter, which is the main one, is that the food value of the product is less when the moisture-content is high.

**105. Variation of moisture.** — The moisture of a certain churning is not constant throughout the mass. The average butter varies. According to Guthrie and Ross,[1] of fifty-one packages of butter, nine, or 17.6 per cent, showed a difference of 1 per cent or more of moisture in adjacent samples, and in eleven packages, or 21.6 per cent, there was a difference of 1 per cent or more between the lowest and the highest moisture tests. This butter was received from different creameries in New York. Lee, Hepburn and Barnhart[2] found that the variation of moisture in butter ranges from .1 to 1.0 per cent between different samples representing the same butter.

The moisture-content of butter in the churn is usually a little greater than after it has been tubbed or printed. Raitt[3] says that the water in butter after being packed was about .4 per cent less than when it was in the churn. Most of the butter was normally worked, and it was finished in a Lusted printer. Even distribution of mois-

[1] Guthrie, E. S., and Ross, H. E., Distribution of Moisture and Salt in Butter, Cornell Univ. Agri. Exp. Sta., Bul. 336, p. 21, 1913.

[2] Lee, Carl E., Hepburn, N. W., and Barnhart, Jesse M., A Study of Factors Influencing the Composition of Butter, Univ. Ill. Agri. Exp. Sta., Bul. 137, p. 314, 1909.

[3] Raitt, J. A., Moisture Control in Butter, Thesis Cornell Univ. Library, p. 31, 1915.

ture in butter can usually be accomplished by careful and thorough working.

**106. Incorporation of moisture.** — There are two extremes in the condition of moisture in butter. Often the butter is not worked sufficiently to incorporate the moisture properly, in which case the water collects in pockets. When this butter is cut, it appears leaky. On the other hand, some butter is worked entirely too much, for the moisture is incorporated in droplets so minute that the product appears to be almost "bone dry," which is not desirable. Such butter may contain even more moisture than the leaky goods.

**107. Control of amount of moisture.** — The amount of moisture in butter has a direct relation to the over-run. Therefore, every creamery butter-maker should be a student of this process.

The many factors affecting the control of moisture in butter have been studied by several experimenters. Such questions as the following have been investigated to this end: the temperature of the cream and of the wash water, amount of cream in the churn, percentage of fat in the cream, amount of working, pasteurized or raw cream, degree of ripeness of the cream, churning butter in wash water, and working butter in wash water. Hunziker, Mills, and Spitzer [1] summarize their work in these words: "The secret of moisture control lies in regulating the churning temperature and in adjusting the amount of water present during the working process according to the firmness of the butter as determined by the chemical, physical, and mechanical properties of the butter-fat,

[1] Hunziker, O. F., Mills, H. C., and Spitzer, Geo., Moisture Control of Butter — 2, Purdue Univ. Agri. Exp. Sta., Bul. 160, p. 418, 1912.

and in the systematic use of a reliable moisture test." Raitt[1] found from a study of 175 churnings, that the moisture-content of butter can be controlled very closely by working it in the presence of water under normal temperatures. The control and the incorporation of moisture in butter are largely processes of properly mixing water and butter. The operator must observe care in maintaining reasonable temperatures so that the butter will be waxy; he must know the amount of butter in the churn; and he must employ the moisture test consistently.

One of the many methods of controlling the amount of moisture in butter is as follows:

1. After the butter has been washed and the water is drawn off, revolve the churn four or five times with the workers in gear, stopping each time so that the doors are on the under side of the churn, so that the remaining water will run out. The churn doors should be fastened loosely to permit the water to pass out and still retain the butter. Many churns do not drain dry unless handled in this way.

2. Make a moisture determination. It is necessary to work the butter a few revolutions of the churn, as directed in step 1, for a representative sample is difficult to obtain immediately after washing.

3. Compute the amount of water necessary to bring the moisture in the butter to a certain standard. For example, there are 900 pounds fat in the churn, which at 20 per cent over-run amounts to 1080 pounds of butter. The preliminary test shows 13.5 per cent moisture in the butter and 15.5 per cent is desired. The difference between these two tests is 2 per cent. The butter, which is

[1] Raitt, J. A., Moisture Control in Butter, Thesis in Cornell Univ. Library, 1915.

1080 pounds, × 2 per cent = 21.6 pounds water, that is necessary to raise the moisture-content of the butter from 13.5 to 15.5 per cent.

4. Add the computed amount of water to the butter. This water may first be mixed with the salt, in case salted butter is being manufactured.

5. Continue the working process until the salt and moisture are thoroughly distributed and incorporated and until the butter is properly compacted. The moisture-content of normally worked butter should not vary more than .5 per cent from one part of the churn to another. If proper temperatures are not maintained, the ingredients may not be thoroughly distributed and incorporated, or the butter may be greasy.

**108. Natural amount of moisture in butter.**—The average person thinks that there is a natural quantity of moisture in butter. It is apparent after careful study that it should rather be thought of as " chance " instead of " natural " in most butter.

**109. Creamery-men should control moisture.**—There is an impression that creamery-men who control the moisture-content of their butter are going beyond reasonable methods; whereas, they are really employing only an approved and definite system in their business. A creamery cannot meet competition unless it practices good methods of operation, such as the control of the composition of its manufactured product.

## OVER—RUN

Over-run is the increase of butter over the milk-fat. It is usually considered that over-run is the difference between the amount of fat that is bought and the quantity of butter that is sold.

**110. Factors that affect over-run.** — Over-run is affected by the amount of moisture, salt, and curd that the butter contains, as well as by the losses that occur in manufacturing. These losses may be as follows: fat in the skimmed-milk, carelessness in weighing the milk or cream, improper testing, spills, fat in the buttermilk, over-weight on butter, shrinkage of butter, fat in milk or cream that adheres to the utensils, and the like.

**111. Over-run on the farm and in the creamery.** — The over-run on the farm is about 13 per cent. Rasmussen [1] found that the average over-run on the farms in New Hampshire was 13.4 per cent. In the creamery, where more butter is made, the over-run is greater, for the percentage loss is usually less. A creamery of average size should obtain a larger over-run than a small one, and the large creamery should average the highest over-run of all. The percentage over-run in a butter factory should be 15 to 22 per cent. Generally a gathered-cream plant secures a greater increase than a whole-milk creamery, because it does not incur loss in separation of the milk. A careful operator with a good accounting system usually maintains a high over-run.

## COLOR

The color of butter is an important factor in the marketing of the product. Certain trades require a light shade, others desire a medium one, and still other consumers want a very dark yellow color. All markets prefer a uniform color throughout the year, in which case artificial coloring material must be added.

[1] Rasmussen, Fred, A Study of Farm Buttermaking in New Hampshire, N. H. Agri. Exp. Sta., Bul. 141, p. 280, 1909.

**112. Natural color.** — The natural coloring matter in butter comes from the feed. Palmer and Eckles[1] state as follows:

"The fat of cows' milk owes its natural yellow color to the pigments carotin and xanthophylls, principally carotin, the well-known, wide-spread, yellow vegetable pigments found accompanying chlorophyll in all green plants.

"The carotin and xanthophylls of milk-fat are not synthesized in the cow's body, but are merely taken up from the food and subsequently secreted in the milk-fat.

"There is some difference among different breeds of dairy cows in respect to the maximum color of the milk-fat under equally favorable conditions for the production of a high color. Each breed of cows, however, will undergo the same variation in color of the milk-fat which follows a withdrawal or addition of carotin and xanthophylls, especially carotin, to the feed. Under some conditions, also, the apparent breed characteristic largely disappears. The popular opinion in regard to the breed characteristic has been overemphasized, and statements in regard to it should in the future be qualified with a statement of the conditions of feed, etc.

"Under normal conditions cows of all breeds produce very high colored milk-fat for a short time after parturition. The pigments of the fat at this time are identical with the normal pigments of the fat. Their increase at this time is probably due to the physiological conditions surrounding the secretion of the milk of the freshening animal."

[1] Palmer, Leroy S., and Eckles, C. H., The Principal Natural Yellow Pigment of Milk Fat, Part II, Univ. Mo. Agri. Exp. Sta., Res. Bul. 10, p. 386, 1914.

**113. Artificial color.** — The first artificial color used in intensifying the shade of butter was a water extract of certain vegetables, the carrot being used chiefly. Later coal tar dyes were employed. Now a few of these dyes only, which are fat soluble and are harmless, are permitted to be used. Following is the position held by the United States Department of Agriculture:[1] "The coloring of butter is specifically permitted in the law of August 2, 1886 (24 stat. 209), and the coloring of cheese in the law of June 6, 1896 (29 stat. 253). It is held by the Department that the Food and Drugs Act does not repeal the provisions of the acts referred to above, and the addition of harmless color to these substances may be practiced as therein provided, and that the presence of coloring matter specifically recognized by acts of Congress as a constituent is not required to be declared on the label." Most butter color, at present, is of vegetable origin; and the annatto seed[2] is the main source of the coloring substance. About 3 per cent of this seed is coloring material. This color is mixed in an oil solvent so that it will color the fat and not the casein of the milk or cream. It is interesting to know that cheese color is mixed in an alkaline solution which has an affinity for the casein of the milk.

**114. Mottles** have a direct effect on the commercial value of the butter, as seen in Fig. 48 (page 150). An ideal color is one that is uniform throughout, as shown in Fig. 49. The exact source of mottles in butter has not been studied as much as many other phases of the manu-

[1] Coloring of Butter and Cheese. Westervelt's Pure Food and Drug Laws, p. 1457, 1912.

[2] The seed of *Bixa Orellana*, a tropical small tree, of the natural family *Bixaceæ*.

facturing process. According to Van Slyke and Hart,[1] "Mottles in butter are due primarily to the presence and uneven distribution of buttermilk adhering to the outer surface of the small granules; and, secondarily, to the hardening and localizing effect of the salt brine upon the

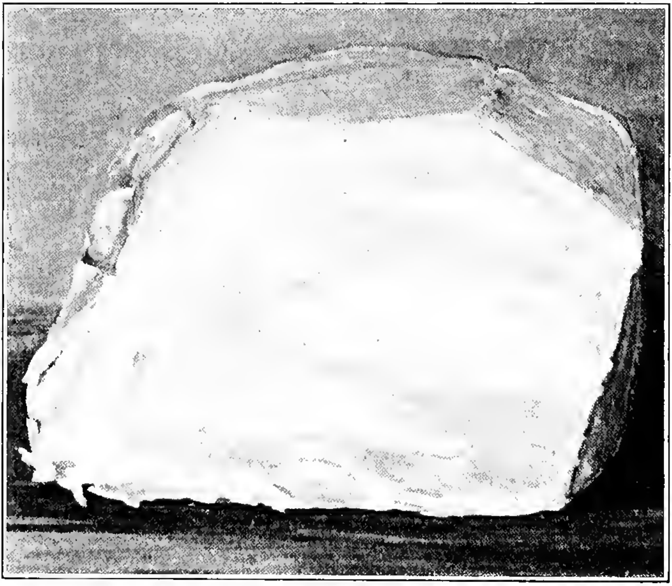


FIG. 48. — A mottled butter.

proteid of the buttermilk thus retained in butter. The light portions of mottled butter owe their lighter color to the presence of localized proteid (usually casein lactate). The yellow or clear portions occur where the spaces

[1] Van Slyke, L. L., and Hart, E. B., The Proteids of Butter in Relation to Mottled Butter, N. Y. Agri. Exp. Sta., Bul. 263, p. 70, 1905.

between the butter-granules are filled with clear brine and are comparatively free from casein compounds. Several hours are required to complete the action of the brine upon the proteid of the butter." A few years later Lee

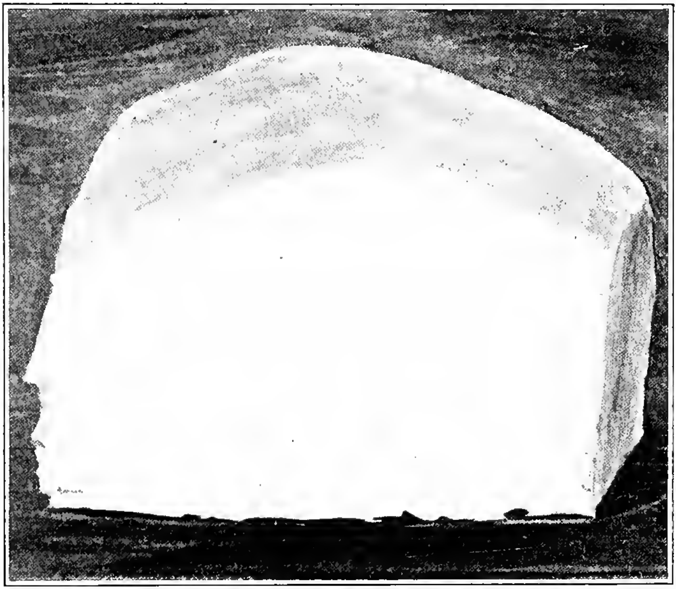


FIG. 49. — Butter with uniform color.

and Sammis[1] reported that they could produce mottles by emulsifying dry milk-fat which had been previously freed from casein by filtering through paper with water by means of the homogenizer. Salt was then added to the product. The butter showed typical mottles when the salt was not evenly distributed throughout the mass.

[1] Lee, Carl E., and Sammis, J. L., Mottles in Butter, Report of the Director, Univ. Wis. Agri. Exp. Sta., p. 31, 1911–1912.

Mottling of butter may thus be produced entirely independently of the casein. Examination of this butter under the microscope showed that in the portions which were lighter in color, the water was present in the form of innumerable minute droplets, thus rendering these layers opaque, while in the darker portions the droplets of water were much larger but fewer in number, thus rendering the butter more translucent.

Occasionally it has been thought that certain streaks may have been due to the mashing or crushing of the butter in the bearings of the butter-worker. If this is true, perhaps the explanation by Lee and Sammis concerning the effect of the small droplets of moisture on the refraction of light would help to explain the phenomenon. Whatever may be the cause of mottles, it is definitely known that under normal conditions, when butter is thoroughly worked, the color is uniform. It is also accepted that mottles are not found in unsalted butter.

**115. Faded color.** — When butter is exposed for only a short time to light and air, it soon loses its color. It may become as white as snow. It is said that when too much neutralizer is added to lower the acidity of cream the color may fade.

## SALT BLISTERS

**116. Cause.** — Salt spots on butter are caused by the evaporation of the moisture, thus leaving a deposit known as a "salt blister." When leaky butter is exposed to the air, the blisters are larger than when the butter has been thoroughly worked so that the moisture is incorporated in minute droplets. Very few blisters should appear on a properly worked product. Excessive salt is not the cause of blisters.

## PACKING BUTTER

Butter should be put in suitable packages properly prepared. It should be carefully packed and not simply thrown into the containers.

**117. Wholesale packages.** — The butter should be packed in a compact mass. In case of the cubes, care should be observed in filling the corners. Much of the butter that is put in tubs is so poorly tamped that great holes are seen when the tub is lifted off, and the liner is stripped from the butter. Such a product does not have a pleasing appearance on the sales counter. The finish of the package is also important, as seen in Fig. 55.

*Shrinkage.* — Careful preparation of the packages by soaking, steaming, and paraffining not only makes them more sanitary but less likely to lose moisture in shipping. Rogers [1] found that the shrinkage of butter in unparaffined tubs was about six times greater than in the paraffined packages. His figures show a loss in weight of .946 per cent in the unparaffined tubs and a shrinkage of .165 per cent in the paraffined tubs. Guthrie [2] reports a loss of .29 per cent on 100 tubs of butter that was held 134 days in paraffined tubs at 0° F. to −10° F.

Different states have laws controlling the weight of butter. New York state, for example, has the following regulation: [3] "Butter in crocks or tubs. The maximum variation allowed will be one per cent (1 %), but the variation of twelve, taken at random, must not run uniformly below."

[1] Rogers, L. A., Paraffining Butter Tubs, U. S. Dept. Agri., B. A. I., Cir. 130, 1908.

[2] Guthrie, E. S., Butter Shrinkage, Jour. Dairy Sci., Vol. 1, No. 2, p. 136, 1917.

[3] Supt. of Weights and Measures New York State. Weights and Measures, Bul. No. 3, 1914.

**118. Retail packages.** — The packages that go to the consumer should be neat and pleasing in appearance. If this butter is in prints, it should be wrapped in parchment and packed in wooden or corrugated paper boxes. The wooden packages should be lined with parchment paper. When shipping long distances, and sometimes in supplying a local trade, the prints should be placed in paper cartons before being packed in the shipping box.

*Shrinkage.* — The shrinkage of print butter is greater than that of butter marketed in the larger packages, as there is more surface. After a study of this subject Pickerill and Guthrie [1] summarize their research in these words: "The rate of loss depends principally on the temperature and humidity of the storage room.

"If the temperature is kept down to 50° F. and the humidity is kept above 90 per cent, at least a month, and perhaps much longer, will be required for the shrinkage to approximate the limit set by law, provided the prints are packed in boxes.

"If the temperature is 60° F. or above, and the humidity is 85 per cent or below, the shrinkage will approximate the limit set by law in a space of ten days to two weeks, even if the prints are packed in boxes.

"The degree of shrinkage is not inversely proportional to the weight of the wrapper used, as is generally supposed." Paper weighing 20, 25, 30, 40, and 50 pounds to the ream was tried.

"The degree of shrinkage decreases to a considerable extent when the prints are placed in cartons. The other two methods of packing, however — leaving the

[1] Pickerill, H. M., and Guthrie, E. S., Two Factors Causing Variation in the Weight of Print Butter, Cornell Univ. Agri. Exp. Sta., Bul. 355, p. 111, 1915.

prints dry after placing them in boxes, or sprinkling them with water — produce about the same effect on the degree of shrinkage.

"In the average small store refrigerator, the loss will approximate the limit set by law in a space of ten days when the prints are piled loosely on shelves."

The law referred to by Pickerill and Guthrie is the New York [1] regulation, which is similar to the rules of many other states, and reads as follows: "The maximum variation allowed on a pound print to be three-eighths of an ounce on an individual print, provided that the average error of twelve prints, taken at random, shall not be over one-fourth of an ounce per pound." A study of the above summary makes clear that the New York regulation on variation in weight of print butter is fair.

**119. Printing.** — Butter is printed in many sizes and shapes, as noted in Chapter XII. At present the most popular print is somewhat the shape of a brick and weighs one pound.

*History.* — Butter was first printed in the region of Philadelphia, Pennsylvania. Until about 1900 [2] this was practically the only print butter market in the United States. A. H. Reid,[3] Philadelphia, was the inventor of the Lafayette Printer, which was one of the first machines on the market. He placed the printer on sale about 1892. It molded a single print at one time, and was operated by a lever. Later several block printers, as seen in Fig. 50,

[1] Supt. of Weights and Measures of New York State, Weights and Measures, Bul. No. 3, p. 21, 1914.

[2] Stewart, R. F., A Brief History of the Print Butter Business, Published by Amer. Butter Cutting Machine Co., Elmsford, N. Y.

[3] Reid, A. H., Letter to author, 1917.

were designed. Soon the call came for machines that would print faster. The first of these larger machines was the "Acme and Lusted" which was used to print the soft butter from the churn. (See Fig. 50.) The Friday, which was the first hard butter-cutter, was invented in 1902 or 1903. (See Fig. 51.) About the same time the Gehl printer was invented. A year or two later the Challenge came on the market. In the operation of these three printers, the butter is packed in boxes which

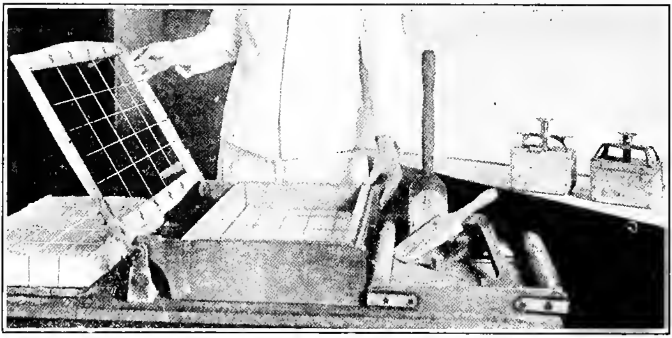


Fig. 50. — Acme and Lusted printer. Single pound block printers are on the shelf at the right.

are held in the refrigerator until the butter is hard. Then it is forced from the box, or the box is pulled from it, depending on which machine is used. The method of cutting the butter, as seen in Fig. 51, is the same in all three machines. These types of printers give good results when the butter is printed in creameries. However, when the tub attachment is employed in the wholesale warehouses, the results are not altogether satisfactory. The tub is not the proper shape from which to cut butter, for there are many small pieces of irregular shape that are cut from the sides of the packages. In 1904, R. F. Stewart, now of the American Butter Cutting Machine Company, Elmsford, New York, placed a machine on the market that is better suited for handling hard butter on a large scale. This cutter, which is seen in Fig. 52, is the most used in the warehouses of any printer. Many other printers are used. Among these are: Reid's Self-Gauging Butter Printer, Elgin Butter Cutter, The Wizard Butter Printer, Low Butter Cutter, Simpson Jumbo Butter Mould and Cutter.

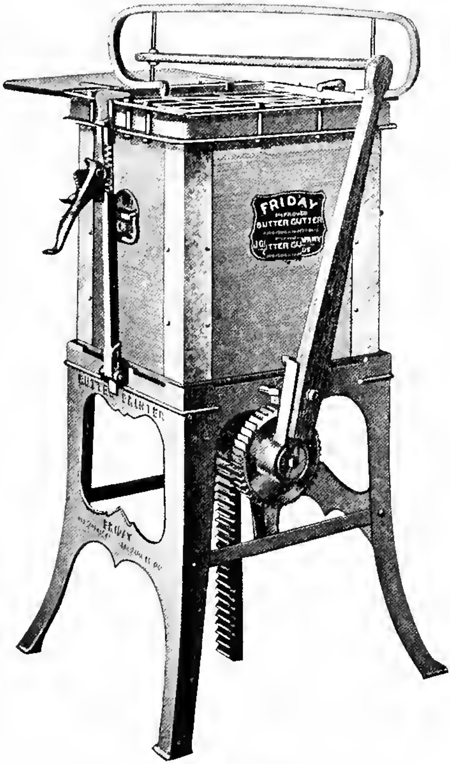



Fig. 51. — Friday butter-cutter.

*Proper weight.* — Cutting or molding butter into bricks of uniform weight is one of the greatest problems of printing. Many creameries have either willfully or carelessly placed a product on the market that was under weight. It became necessary for many states to pass reg-

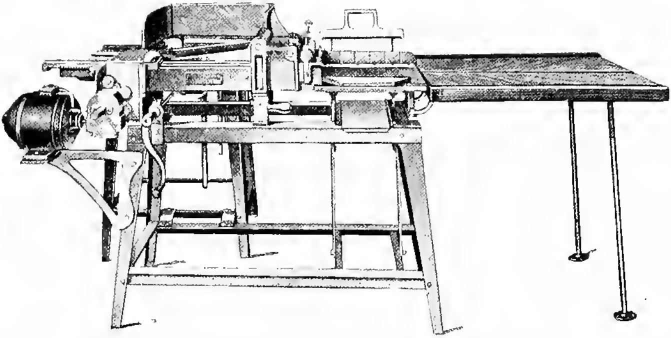


FIG. 52. — American butter-cutter.

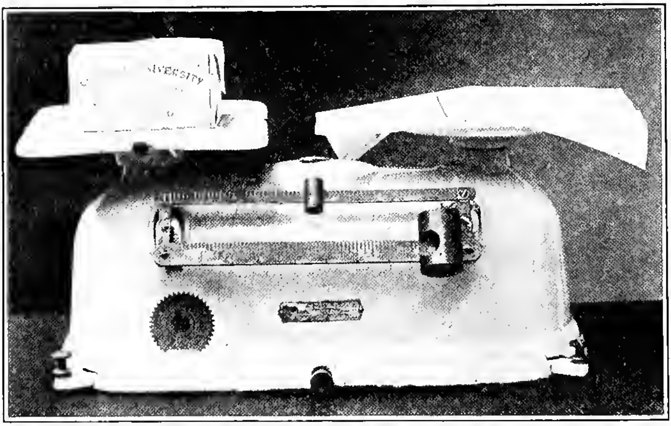


FIG. 53. — Butter scales which are graduated read to one thirty-second of an ounce.

ulations or laws to control this. The following is the rule in New York state:[1] "Butter in prints shall be marked in terms of pounds or ounces in bold-faced letters at least three-sixteenths of an inch in height." (For the remainder of this regulation see par. 118.) Some concerns have been so slack in business methods as to place pound prints on the market that were one-fourth ounce to one ounce too heavy. To prevent this loss, it is necessary to watch the process closely and to make test weights occasionally. Many large creameries weigh each print to make certain that they are giving full weight, and to check loss by over-weight. Delicate scales, of which Fig. 53 shows an example, are necessary for this purpose.

[1] Supt. Weights and Measures of State of N. Y. Weights and Measures, Bul. No. 3, p. 21, 1914.

# CHAPTER X

## *FLAVORS OF BUTTER*

FLAVOR is the most important item on the butter score-card, 45 of the 100 points being allotted to it. Butter is valuable as an appetizing agent, and it is natural to expect that the flavor will appeal more to the consumer than the amount of salt contained, or even the general appearance of the product, as indicated by the condition of the body and of the color, and the finish of the package. The sale of the butter depends largely on the quality of the flavor. Unfortunately, in most markets the difference in price of the various grades is not sufficient to stimulate effort to make a product with the highest flavor. This phase is discussed more fully under "Marketing," Chapter XII.

**120. Basic butter flavor.** — The characteristic flavor of butter is in the butyrin. Butter made from fresh milk has a mild, sweet, and creamy flavor. Those accustomed to butter with rather high acidity consider the flavor of the sweet-cream product flat. On the other hand, many consumers prefer this mild creamy flavor.

**121. Absorbed flavors.** — It has long been recognized that dairy products readily absorb flavors. These absorbed flavors are often termed "taints." Among the taints that may be absorbed by milk, cream, or butter, are the following: the flavor of garlic, onions, cabbages, silage, turnips, cows, barn, dirt, grass, weeds, wood, oil as from butter color, buttermilk, gasoline, paper, groceries, metals, and the like. In order that such flavors shall not be imparted to the butter, extreme care should be observed to prevent the absorption of them by the milk or cream, and by the butter itself. When the flavor comes from the feed, as in the case of cabbage, silage, or turnips, it may be prevented by feeding the cows after milking. The garlic flavor can best be kept from butter by pasturing the cows where there is no wild onion. The flavor from the cows and from the barn may be minimized by proper cleaning and ventilation. Sufficient time should be allowed for the odors of the manure to pass out after cleaning the barn, and for the dust to settle after brushing the cows before milking. Often taints are due to carelessness, such as leaving the product near onions, gasoline, or in a poorly ventilated barn.

**122. Developed flavors.** — There are numerous flavors of butter that develop in the milk or cream from which it is made, or in the product itself. Following is a list of a few such flavors: old cream, poor or sour milk, cheesy, old or storage butter flavor, cowy, dirty, bitter, feedy, stale or musty, rancid, fishy, oily, metallic. It is easy to understand that when cream is permitted to become several days or a week old, it loses its freshness, and fresh-tasting butter cannot be made from it. It is also easily seen that when the man at the weigh-can becomes careless and receives sour or poor milk and cream, which may contain the sum of many flavors that ought not to be present, these are carried through to the butter. Very often the poor milk flavor develops into the cheesy flavor. The old or storage flavor develops in the butter itself. This is common to all grades of butter, although it is less marked in sweet-cream products. The stale or musty flavor may grow in the cream or in the butter. The cowy, dirty, feedy, and bitter flavors may develop through bacterial action. In relation to the feedy flavors, Weigmann and Wolff[1] state: "In studies made of the effect of Swedish turnip, carrot leaves, chives, kohl-rabi leaves, grass, hay, straw, beets, cabbages, and other feeds upon the flavor of butter it was found that changes in flavor were in part due to the taste and odor of the feeds and in part to bacteria found on these feeds which generate new flavors. While it is probable that each group or type of bacteria has a specific action in producing taste and odor, it is not certain if the same feed medium will produce the same taste and odor with different types of bacteria." If these particular bacteria grow in any of the dairy products, it may be assumed that the growth of certain micro-organisms does intensify the flavor of certain plants.

The bitter flavor is usually the product of bacterial growth. Wolff[2] writes: "The author found large numbers of bacteria on the leaves of grass, white clover, and yarrow where cattle were feeding. About 80 per cent belonged to the coli group. Unless the udders of the cows are washed these bacteria may fall into the milk pail in sufficient numbers to cause the bitter taste often noticed." Whether or not Wolff is correct in thinking that these organisms are members of the *B. coli* group, there is no doubt that in many cases the bitter taste is due to micro-organisms. Many observations show that these organisms grow best at low temperatures, such as

[1] Weigmann, H., and Wolff, A., (Landw. Jahrb.), 46 (1914), No. 3, pp. 343–365, abs. Exp. Sta. Rec., Vol. 32, p. 270.

[2] Wolff, A., The Cause and Nature of Bitter Milk, (Milchw., Zentbl.) 5 (1909), No. 2, p. 67–73; abs. in Chem. Zentbl., 1909, 1, No. 11, p. 931. Abs. Exp. Sta. Rec., Vol. 31, p. 379, 1909.

50° F. They flourish in milk or cream that is sweet. When acid is formed, it inhibits the growth of the bacteria. The bitter flavor is found more often in dairy than in creamery butter. When present in the latter, the source is in the old cream which has been held for three or four days at low temperatures in an almost sweet condition if not absolutely sweet to the taste. In other words, the bacteria producing the bitter flavor will not grow in an acid solution, but will grow in a medium not acidic or only slightly sour; and they grow best at low temperatures. This is not an important consideration with a creamery.

The remaining flavors of the above list are treated separately in paragraphs 125, 126, 127. It must be remembered that all the developed flavors have their origin in the activity of micro-organisms or in their enzymes.

**123. Salted *versus* unsalted butter.** — Most of the butter consumed in the United States is salted. Many persons like the flavor of a lightly salted product, but a large percentage require a highly salted butter. The variation in the amount of salt may be from .5 to 5.0 per cent. Usually in America the consumers in the large cities prefer a lightly salted product, while in the smaller towns and in the country the demand is for as high as 3 to 5 per cent salt. The demand for unsalted or so-called "sweet butter" is much less than for the salted goods. It is said that about one-sixth of that consumed in New York City is unsalted. In many of the European countries, the demand for an unsalted or for a lightly salted product is greater than in America. The effect of the amount of salt in butter in relation to its keeping properties is discussed in par. 130.

**124. Acidity.** — The amount of acid that should be in butter depends largely on the market and whether it is to be held in cold storage or consumed within a few days after manufacture. The demand of the consumers is related to the character of the butter flavor. Some persons like the mild flavor of butter low in acidity. Others characterize it as did Patrick [1] when he said, "The sweet cream had lost its insipidity and possessed a flavor approaching that of the ripened cream butter." Meyers [2] makes a rather blunt conclusion, saying that the common preference for the flavor of ripened cream butter is a mere whim and will be done away with as soon as the public finds it can get better butter without. He concludes by stating that it has been the fashion to use butter that has begun sensibly to spoil rather than that from pure sweet cream. It must be remembered that since Meyers made these statements the use of starter has become a general practice in creameries, and through it a much better flavor may be imparted to the butter than when the cream is allowed to ripen naturally.

The history of the acidity of butter is an interesting one. Butter was first made on a small scale. The milk or cream was allowed to accumulate until there was enough to churn. On standing, this milk or cream, usually the latter, became sour. If the cream had been held at low temperatures in order to keep it sweet, it might have developed a bitter flavor as noted above. Also it was learned by experience that the sour cream churned more completely. In view of these facts, it is not surprising that the public in general prefers butter that has a quick acid flavor, for they have been trained to it. Since it has been discovered that butter made from cream with a

[1] Patrick, G. E., Sweet Cream Butter, Agri. Exp. Sta. Ia. State Col., Bul. 8, pp. 318–320, 1890.

[2] Meyers, John H., Abs. Hoard's Dairyman, Nov. 29, 1889.

low acidity keeps better than the high acid cream product, there has been a change in the methods of manufacturing. In time the public will be trained away from its present preference, which is a snappy high acid flavor.

The acidity of the cream for making butter varies from about .13 to .8 per cent in terms of lactic acid. The cream from fresh milk will have an acidity of about .13 to .16 per cent. This depends on the acidity of the whole milk from which it was separated and on the percentage of fat in the cream. Some markets call for butter made from cream with an acidity of approximately .4 per cent, and others call for .5 to .6 per cent acid. The acidity of cream is considered more fully in Chapter VIII. The acidity of butter varies under different conditions; such as, the extent that the butter was washed, the amount of salt contained, whether or not made from pasteurized or unpasteurized cream, whether or not the cream was sour or sweet, the temperature of the room where held. The amount of acid in butter may be seen in Table XIX on the comparison of the acidity of sweet and ripened cream butter by Larsen, Lund, and Miller.[1]

This table not only shows the amount of acid that may be in butter soon after it is made, but also the extent of the increase in acidity in the product from either sweet or sour cream. This butter was held at the temperatures of a creamery refrigerator, which would probably be from 45° to 55° F. According to the researches of Larsen, Lund, and Miller, there was a fairly close comparison in the increase of acidity and the decrease of the score of the butter until the eighth week, when the decrease in the score was much more rapid. According to Rahn, Brown, and

[1] Larsen, C., Lund, T. H., and Miller, L. F., Creamery Butter, Agri. Exp. Sta. S. Dak., Bul. 122, p. 714, 1910.

Smith,[1] "Cold storage butter may be very low in score without any noticeable change in acidity." It should be noted that the first of the above conclusions was under creamery refrigerator conditions, and that the latter observations were under cold storage conditions in which the temperature was – 6° C. On the general market at least, the acidity of the butter cannot be taken as a criterion of flavor.

TABLE XIX

| Tubs | Cream | CC. N/10 Alkali to Neutralize 10 G. Butter | | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | When Made | 2 weeks | 4 weeks | 6 weeks | 8 weeks | 10 weeks | 12 weeks | 14 weeks | 16 weeks | |
| Aver. of 8 | Ripened cream | 2.1 | 2.8 | 3.2 | 3.4 | 3.4 | 3.7 | 3.8 | 4.1 | 4.3 | Cream 3½ days old, acidity 0.65 % |
| Aver. of 8 | Sweet cream | 1.1 | 1.6 | 1.8 | 2.0 | 2.2 | 2.5 | 2.6 | 2.7 | 2.9 | Cream fresh and sweet, acidity 0.14 % |

**125. Fishy flavor.** — Fishy butter has a peculiar mackerel taste and odor. Its character is more pronounced than any other flavor. Fishy flavor is common in many countries, and is one of the usual flavors in cold storage butter unless it has been manufactured from sweet cream. Gray and McKay [2] conducted preliminary work on the fishy flavor, but the first exhaustive research on this

[1] Rahn, Otto, Brown, C. W., and Smith, L. M., Keeping Qualities of Butter, Mich. Agri. Col. Exp. Sta., Tech. Bul. 2, p. 43, 1909.

[2] Gray, C. E., and McKay, G. L., The Keeping Qualities of Butter Made under Different Conditions and Stored at Different Temperatures, U. S. Dept. of Agri., Bul. 84, p. 23, 1906.

subject was conducted by Rogers.[1] Much subsequent research has been made by Rogers and his co-workers, as well as by other investigators, that confirms the first results. Rogers [1] reports that there is a relation between the amount of working that butter receives and the fishy flavor. In the latter experiments this has not been substantiated. His important finding was reported as follows: " In all cases in which the records were complete, it was found that those experimental butters which became fishy were made from high acid cream. Fishy butter was made from cream acidified with lactic and acetic acids. However, cream with high acidity does not uniformly develop fishiness." Rogers' final conclusion was: " Fishy flavor may be prevented with certainty by making butter from pasteurized sweet cream. Butter made from pasteurized sweet cream with a starter added, but without ripening, seldom if ever becomes fishy." A possible reason for the latter butter not becoming fishy may be that less acid remains in it. It is important to know how much acid may be present in the cream from which the butter is made, without causing the fishy flavor. The following statement by Rogers, Thompson, and Keithley [2] sheds light on this subject as well as giving additional data on the relation of acidity of the cream to the fishy flavor of the butter: " In a tabulation of the examination of 259 samples of experimental butter from cream of known acidity, of 137 samples from cream having an acidity below 0.3 per cent or over, 60, or 49.2 per cent, were fishy."

[1] Rogers, L. A., Fishy Flavor in Butter, U. S. Dept of Agri., B. A. I., Cir. 146, 1909.

[2] Rogers, L. A., Thompson, S. C., and Keithley, J. R., The Manufacture of Butter for Storage, U. S. Dept. of Agri., B. A. I., Bul. 148, p. 8, 1912.

The above results have been confirmed by Reakes, Cuddie, and Reid.[1] They report the results of their research as follows: "Pure cultures of organisms isolated from butter having a fishy flavor failed to produce the effect experimentally. Butters of fishy flavor were found to contain a high percentage of acid, and it is therefore thought that a high acid may be a contributing factor though not the direct cause of the trouble." It should, therefore, be recognized that the exact source of the fishy flavor in butter is not known, but that there is a positive relation between high acidity of the cream and this taste. Some data seem to show that trimethyl amine is the basic cause of the fishy flavor.

**126. Metallic flavor.** — This flavor of butter is much like the taste of iron. Very often it is similar to the fishy flavor and usually has a somewhat oily taste. The copper flavor, which is not common, is, of course, metallic. Its taste is rather bitter and is more intense than the characteristic metallic flavor of dairy products. These two metals have been studied in this relation, because they are the most commonly used in the construction of dairy apparatus. There are two sources of the metallic flavor in butter: one is by absorption of the metal, and the other is developed by bacterial growth. When the quantity of iron is as small as one part to one million parts of cream, the flavor of the iron is distinct. In the case of copper, only one-half part of the metal to one million parts of cream is sufficient to cause a distinct flavor of the copper. Rogers, Berg, Potteiger, and Davis[2] state,

[1] Reakes, C. J., Cuddie, D., and Reid, H. A., Fishy Flavor in Butter, Jour. of N. Zeal. Dept. of Agri., 4 (1912), No. 1, pp. 1–6. Abs. Exp. Sta. Rec., Vol. 26, p. 778, 1912.

[2] Rogers, L. A., Berg, W. N., Potteiger, C. R., and Davis, B. J., Factors Influencing the Change in Flavor in Storage Butter, U. S. Dept. of Agri., B. A. I., Bul. 162, 1913.

"The cream may take up iron in quantities sufficient to affect the flavor from rusty cans or even from the exposed boltheads or other metal parts of the churn.

"The action of copper is similar but perhaps more intense."

The writer [1] found that when conditions are favorable bacteria produce the metallic flavor. The most important factor in the development of this flavor is the acidity of the cream. If very little acid is present, the metallic flavor will rarely develop. Except in buttermilk, a high fat-content of the medium is essential. Of 241 samples of cream in sterilized glass bottles, the metallic flavor was produced in 79 by inoculation with buttermilk having this flavor; and of 157 samples of cream in sterilized glass bottles, which were inoculated with individual bacteria, 52 showed metallic flavor. The organism causing this is a member or a strain of the *Bacterium lactis acidi* group. To prevent the formation of the metallic flavor, the cream should be churned when sweet or when the acidity is low, such as .3 per cent lactic acid or less.

**127. Rancid flavor.** — Rancidity is a specific flavor of dairy products. It is a term often used erroneously, for most persons confuse it with the strong or stale, or some other "off" flavor of butter. Quoting Brown: [2] "By the term 'rancidity' is meant not simply, as is generally supposed, a development of free acid, though this is the general concomitant of rancidity, but any chemical or physical change in the character of the fat from the normal. Rancidity, according to the present most

[1] Guthrie, E. S., Metallic Flavor in Dairy Products, Cornell Univ. Agri. Exp. Sta., Bul. 373, 1916.

[2] Brown, C. A., Jr., Contribution to the Chemistry of Butter-fat, Amer. Chem. Soc. Jour., 21, 2, 1899.

commonly accepted understanding of the term, is simply oxidation." Rahn, Brown, and Smith [1] write, "Butter is said to be rancid if it has an undesirable taste or smell, due to an aged condition, that cannot be described definitely by other terms."

In contrast to these definitions are the following statements from two butter judges. According to White: [2] "If the student is given some stale tallow and told that it is rancid and then is given some stale lard and told that it is also rancid, he will be able to distinguish that the smell is not the same. If he is then given some butter which has developed a butyric acid odor he will find still a different odor, and the question would naturally be asked which of the three is and should be defined as rancid. If the odors found in the tallow and lard are rightly defined as rancid, then the butyric acid odor in butter known by all butter judges, commission men, butter buyers, butter makers and dealers in general, should be called something else, as they are not the same; though that found in butter may be called rancid as a general term, meaning stale, but specifically it perhaps should be called butyric odor. The butyric odor gradually passes off since it is volatile, but there will then still remain a stale odor and this will smell like stale tallow. On the other hand, if the butyric acid odor is the true rancid odor, then the odors found in the other fats and oils should not be defined as rancid." Keiffer [3]

[1] Rahn, Otto, Brown, C. W., and Smith, L. M., Keeping Qualities of Butter, Mich. Agri. Exp. Sta., Tech. Bul. 2, 1909.

[2] White, B. D., Rancidity, Letter to the author, 1910. (White was formerly in charge of butter investigations, U. S. Dept. of Agri., B. A. I.)

[3] Keiffer, P. H., Rancidity, Letter to the author, 1910. (Keiffer is the president of the Gude Bros. Keiffer Co., butter merchants in New York City.)

stated that he commonly used the term rancid when butter had an over-sour strong flavor. He pronounced the odor of the distillate of the Reichert-Meissl determination to be much like the rancid flavor. By others rancidity is considered to be a butyric acid flavor. It is easily recognized by an expert butter-judge.

Rancidity in butter is not common. In a recent publication [1] a review has been given of the subject of rancidity, and in subsequent experimental work, such as pumping air through the cream, subjecting the butter for various periods of time to the air, high temperature, and various conditions of light, rancidity was not found. The examination of two samples of old butter did not reveal the rancid flavor. One of these samples was twelve years and the other 680 days old. In each case the iodine number which is a measure of oxidation, and the Reichert-Meissl number which shows the extent of development of volatile fatty acids, remained within the range of these constants in fresh butter. There was an increase in the acid number but no rancidity.

The final conclusion of the study of this flavor is that the cause of rancidity is probably butyric acid; also that rancidity of butter as defined by butter-dealers and expert butter judges is rarely found. It is not the flavor usually known as such by the average person.

**128. Effect of pasteurization.** — If the temperature during pasteurization is too high, a cooked flavor is likely to be imparted to the butter. In a few days this scorched taste will disappear; nevertheless, it is wise not to permit the temperature of the cream to rise too high. For further discussion see par. 69.

[1] Guthrie, E. S., Concerning Rancidity of Butter, Jour. Dairy Sci., vol. 1, No. 3, p. 218, 1917.

**129. Effect of the individuality of the cow.** — It is thought that the milk of different cows varies more or less, even though the animals may be fed and otherwise handled in the same way. The period of lactation may also be an important factor in the flavor of the milk. Eckles and Shaw [1] state: "An abnormal odor and flavor developed in the milk of certain cows when near the end of the lactation period. This condition was not present in the freshly drawn milk, but appeared within twelve hours, even when the milk was held at 10° C."

**130. Effect of minor factors on storage.** — Salt is a chemical compound that inhibits the growth of some micro-organisms. Naturally the strength of the salt solution is important. Regarding this McKay and Larsen [2] assert, "Salt improves the keeping quality of butter." Rahn, Brown, and Smith [3] write, "Salted butter keeps better than unsalted butter, above the freezing point as well as below it." Gray and McKay [4] report the following result of their experimental work: "Butter containing low percentages of salt kept better than did butter of the same lot containing higher percentages of salt." It was the common opinion at one time that butter high in salt is very likely to become fishy. McKay [4]

[1] Eckles, C. H., and Shaw, R. H., The Influence of the Stage of Lactation on the Composition and Properties of Milk, U. S. Dept. Agri., B. A. I., Bul. 155, p. 77, 1913.

[2] McKay, G. L., and Larsen, C., The Keeping Quality of Butter, Ia. State Col. Exp. Sta., Bul. 71, p. 30, 1903

[3] Rahn, Otto, Brown, C. W., and Smith, L. M., Keeping Qualities of Butter, Mich. Agri. Col. Exp. Sta., Tech. Bul. 2, p. 43, 1909.

[4] Gray, C. E., and McKay, G. L., The Keeping Qualities of Butter Made under Different Conditions and Stored at Different Temperatures, U. S. Dept. of Agri., B. A. I., Bul. 84, pp. 22–23, 1906.

comments on this matter as follows: "The high salting did not impart a fishy flavor to the butter made from cream received sweet, so it would seem to the writer that the odors are in the butter, and the salt simply makes them more pronounced."

The author has had opportunity to observe the effect of the quantity of salt on the keeping properties, and he thinks that within reasonable limits, such as 2 to 4 per cent, it has very little to do with the keeping properties. These observations are based on the examination of various lots of butter at different times. Some was made in the creamery laboratory at Cornell University and stored for outside parties, and some was experimental butter, the results of which have been reported.[1] The Navy Department has stored about seven or eight hundred thousand pounds of butter annually for the past seven or eight years and the salt requirement has been 2.5 to 3.25 per cent. A saturated brine solution of ordinary temperatures contains about 26.5 per cent salt. When the butter tests 13.0 per cent water and 2.5 to 3.25 per cent salt, the salt-content of the water in the butter is 17 to 25 per cent.

At the present time there are ice cream factories and certain butter concerns that store large quantities of unsalted butter with good results. Even though butter may be safely stored when it contains no salt, it is fortunate for the industry that the call of the trade is largely for the salted product, for under the average storage conditions there is no doubt that salt acts as a preservative.

The amount of washing that butter receives and the quality of the wash water is important. From the physical standpoint, butter must be washed because the brine

[1] Guthrie, E. S., Some Butter Studies, Butter, Cheese, and Egg Jour., Vol. 7, No. 21, p. 18, 1916.

should be clear and not milky. From the bacteriological viewpoint, the buttermilk should be washed out so that the bacteria will be deprived of it as a food. According to Jensen,[1] lactic acid bacteria were found to multiply much more rapidly in unwashed than in washed butter. This was not true of some of the other types. It is needless to say that the wash water should be practically free from germs. McKay and Larsen [2] advise the use of one of two methods of treatment when the water is impure; *i.e.* pasteurization or filtration. They seem to consider pasteurization more complete. One of their conclusions follows, "Butter made from pasteurized cream and washed in pasteurized water retains its normal flavor about twice as long as butter made from unpasteurized water." Melick [3] asserts that there is a direct relation between the bacterial-content of the wash water and the keeping quality of the butter. He found that a filter for creamery water is likely to be only a source of contamination. He considers that it is both practical and economical to sterilize wash water for washing butter, and he adds that the water should be cooled and used immediately, for otherwise the practice is a useless expense. However, it seems that it should be of value if the water is properly protected from contamination.

**131. Effect of acidity on flavor of storage butter.** — Usually when butter is said to be in storage, it is assumed

[1] Jensen, O. A., Bacteriological Study of Danish Butter. [Rev. Gén. Lait. 8 (1910), No. 18, pp. 409–417; Centbl. Bakt., etc.] 2 abt., 29 (1911), No. 23–25, pp. 610–616; Molk. Ztg. Berlin, 21 (1911), No. 18, pp. 205–207; Exp. Sta. Rec. 216, p. 478.

[2] McKay, G. L., and Larsen, C., The Keeping Quality of Butter, Ia. State Col. Exp. Sta., Bul. 71, p. 30, 1903.

[3] Melick, C. W., Effect of Bacteria in Wash Water of Butter, Kan. Agri. Col. Exp. Sta., Bul. 138, p. 222, 1906.

that cold storage is meant, which is the approved method of holding for long periods. The flavor resulting from holding any butter is known as a " held " flavor. Sometimes this " held " or " storage " flavor is not very noticeable; on the other hand, much storage butter becomes very strong. Among the most common storage flavors are the " fishy " and " metallic," which are discussed above. It should be noticed that the apparent indirect if not the direct cause of the most common " off " flavors is a large or fairly large amount of acid in the butter. Attention has been called previously to the fact that the fishy, metallic, and rancid flavors do not develop in sweet cream butter. In addition to the above discussions on flavors and that in par. 69, the following is offered:

Quoting Dean:[1] " Sweet cream butter does not possess ' keeping quality ' the same as ripened cream butter." Contrary to Dean's conclusion is that of Patrick.[2] He reported that the ripened cream butter became stronger during storage than the sweet cream butter. It agreed with the researches of Gray and McKay, Guthrie and Rogers and his co-workers as reported under " acidity," " flavor improvement," " fishy flavor," " rancid flavor," and " metallic flavor." In eight samples[3] of sweet cream and eight of sour cream butter, it was found that the sweet cream product deteriorated during storage at 0° F., 1.37 points, and that the sour cream butter, which had been stored at the same temperature, scored 5.14 points less after storage than when fresh. This

[1] Dean, H. H., Sweet Cream Butter, Ontario Agri. Col., Ann. Rpt. 21, p. 64, 1895.

[2] Patrick, G. E., Sweet Cream Butter, Ia. Agri. Exp. Sta., Bul. 8, pp. 318–320, 1890.

[3] Guthrie, E. S., Some Studies of Butter. Butter, Cheese and Egg Jour., Vol. 7, No. 21, p. 18, 1916.

butter was scored by five expert judges when put in storage, and was again scored by the same judges when taken out of storage 212 days later. Two churnings were made each day, or the cream came from the same vat, the only difference being that a good starter was used to ripen the cream from which the sour goods were made.

The exact cause of the deterioration in butter is not known. It is undoubtedly due to some of the decomposition products of micro-organisms or to enzymes. It is certain that lactic acid, which exists in butter in larger quantities than any other acid, is very unstable. With this in mind, the discussion of the whole subject of keeping properties may be summarized in the following quotations. According to Rogers and Gray:[1] "It is apparent that the deleterious effect of high acidity was not due to any organism, enzyme, or other substance which can be destroyed by heat. It is evident, then, that some by-product of bacterial growth, unaffected by heat, had a marked influence on the flavor of the butter. It is probable that this was a by-product of the lactic acid and bacteria and that the by-product was the lactic acid itself." Three years later the same general idea was expressed by Rogers, Thompson, and Keithley[2] in the following statement: "It is evident, however, that to make butter of good keeping quality any treatment that increases the chemical instability of the product should be avoided. Butter of good quality can be made from sweet pasteurized cream and the deteriorating influence of the acid thus eliminated."

[1] Rogers, L. A., and Gray, C. E., The Influence of Acidity of Cream on the Flavor of Butter, U. S. Dept. of Agri., B. A. I., Bul. 114, p. 17, 1909.

[2] Rogers, L. A., Thompson, S. C., and Keithley, J. R., The Manufacture of Butter for Storage, U. S. Dept. of Agri., B. A. I., Bul. 148, p. 9, 1912.

**132. Micro-organisms in butter.** — There is a certain relation between the number and the nature of the organisms in butter and its flavor. The number and types of micro-organisms vary considerably. According to Rosenau, Frost, and Bryant,[1] the number of bacteria in twenty-five samples of butter obtained from the Boston market was as follows: The average number of bacteria to a gram of butter was 5,700,000; the lowest number, 8,600; and the highest, 41,000,000. They found that the number of bacteria diminished markedly with age; in one sample the reduction was 85.8 per cent in two weeks; in another, 93.7 per cent in four weeks; and in still another, 95.6 per cent in six weeks. Rogers[2] found that the number of micro-organisms in butter decreases very rapidly. The following table shows the results of a study of twelve samples of creamery butter from one churning that were held in one pound tin cans hermetically sealed and stored at 20° C. (68° F.):

Table XX — Bacteria and Yeasts per Gram of Butter (Series 5)

| Age in Days | Total | Lactic | Liquefiers | Torula Yeasts |
|---|---|---|---|---|
| 7 | 5,351,130 | 5,326,100 | — | 24,550 |
| 14 | 3,012,600 | 2,823,600 | 6,000 | 183,000 |
| 18 | 92,700 | 84,200 | — | 8,500 |
| 25 | 12,460 | 12,000 | 460 | Very few |
| 91 | 18,350 | 17,850 | 500 | 000 |
| 116 | 675 | — | — | — |
| [a] 297 | — | — | — | — |

[a] Sterile.

[1] Rosenau, M. J., Frost, W. D., Bryant, Ruth, A Study of the Market Butter of Boston, Jour. of Med. Research, Vol. 30, N. S., Vol. 25, pp. 69–85, 1914.

[2] Rogers, L. A., Canned Butter, U. S. Dept. of Agri., B. A. I., Bul. 57, pp. 11–13. 1901.

Later Rogers[1] ran another series of experiments with the following results. In this series there were twelve cans of creamery butter from a single churning as in the above experiments. It was held in the laboratory seventy-three days and then was placed in an incubator at 23° C. (73° F.):

TABLE XXI — BACTERIA AND YEASTS PER GRAM OF BUTTER (SERIES 22)

| AGE IN DAYS | TOTAL | LACTIC | LIQUEFIERS | TORULA YEASTS |
|---|---|---|---|---|
| 7 | 362,000 | 318,000 | 21,000 | 23,000 |
| 10 | 194,000 | 173,500 | 3,300 | 17,300 |
| 14 | 125,000 | 122,300 | 2,400 | 300 |
| 21 | 23,600 | 23,040 | — | 560 |
| 114 | 200 | 000 | 150 | 000 |
| [a] 251 | — | — | — | — |

[a] Only a few liquefiers.

The number of lactic acid bacteria in the first examination constituted over 99 per cent of the total number. They decreased rapidly, until at the end of 116 days none was left. The liquefiers were more persistent. The results reported in Table XXI are similar to those of Table XX. Rogers' summary is given in the following words: "It is quite evident that the microscopic life existing in the butter can be considered as only indirectly responsible for the change in the acidity or the flavor. In series 22 there was no perceptible change in the acid number until the bacteria had reached unimportant numbers and the yeasts had nearly disappeared. In

[1] Rogers, L. A., Canned Butter, U. S. Dept. of Agri., B. A. I., Bul. 57, pp. 11–13, 1904.

series 5, in which the acidity was not determined in the first few cans opened, there was no marked change until both bacteria and yeasts had nearly reached their minimum number. Of the bacteria persisting for any length of time only the lactic acid group was present in sufficient numbers to be considered as a possible cause." Sayre, Rahn, and Farrand [1] report similar numbers of micro-organisms in butter.

There are many species of micro-organisms found in butter. Brown [2] asserts that he isolated eighty-eight different species from two samples and these did not include molds or higher forms of bacteria. Of these there were fifty-seven bacteria (cocci, bacilli, or spirilla) and thirty-one yeasts.

There is a definite relation between the amount of salt in butter and the growth of many of the organisms. Brown [2] states that of the eighty-eight species reported above, twenty-four bacteria and fifteen yeasts grew on a medium when the brine composition is 12 per cent salt and when the incubating temperature is 20° C. (68° F.). Four of these bacteria and six of the yeasts grew well on 12 per cent brine at 6° C. (43° F.). He asserts that 12 per cent brine has a much more inhibitive action on the species of liquefying yeasts than it has on the non-liquefiers. It should be remembered that a 12 per cent brine is equal to 1.68 per cent salt in the butter when the latter contains 14 per cent moisture. Giltner and Baker [3] report that salt to a concentration of 12 per cent does not

[1] Sayre, W. S., Rahn, O., and Farrand, Bell, Keeping Qualities of Butter, Mich. Agri. Col. Exp. Sta., Tech. Bul. 1, 1908.

[2] Brown, C. W., Some Actions of Micro-organisms upon the Constituents of Butter, Sci., Vol. 35, No. 893, p. 231, 1912.

[3] Giltner, W., and Baker, J. D., Effect of Salt on Butter Flora, Mich. Sta. Rpt., p. 209, 1915.

retard growth in all cases, and that the growth of some organisms is not prohibited by 20 per cent salt. Streptococci are sensitive to salt, while micrococci and staphylococci tolerate a high percentage. Most of the yeasts and torulæ of butter are not easily affected by salt, yet they cannot withstand as much as some of the cocci. Brine with a salt-content of 8 per cent retards the physiological processes of most organisms. Eight per cent salt in the brine is equal to 1.12 per cent in the butter when the moisture-content of the butter is 14 per cent. Thom and Shaw[1] state that "species of Oidium, Alternaria and Claudosporium cannot develop in butter containing 2.5 per cent of salt. The occurrence of any of these forms in a sample of butter indicates low salting." They also maintain that salt up to 2.5 to 3 per cent in butter is sufficient to eliminate mold or reduce it to a negligible amount. This is equivalent to the use of a 12 to 15 per cent brine. This amount of salt is normal in butter. Thom and Shaw[1] call attention to the fact that excess curd in butter favors mold growth and that if the butter is properly washed it is less subject to the mold.

**133. Enzymes in butter.** — The enzyme-content of butter is probably not an important consideration, especially if the cream has been pasteurized. Rogers, Berg, and Davis[2] list peroxidase, catalase, galactase, and lipase as having a possible effect on the flavor of the product.

[1] Thom, Chas. and Shaw, R. H., Moldiness in Butter, Jour. of Agri. Research, Vol. 3, No. 4, p. 304, 1915.

[2] Rogers, L. A., Berg, W. N., and Davis, B. J., The Temperature of Pasteurization for Butter Making, U. S. Dept. of Agri., B. A. I., Cir. 189, p. 310, 1912.

# CHAPTER XI

## *STORAGE OF BUTTER*

THE storage of non-perishable food products has been successfully accomplished for many years. It has helped to equalize the supply of food during different seasons. The holding of perishable goods from the time of greatest production to other seasons was not possible on a large scale until the advent into commerce of mechanical refrigeration, about the year 1890.

**134. Temperatures.** — Most bacteria grow at a temperature of above 50° F. Consequently, if a butter refrigerator is held at 45° or 50° F., the butter will not only remain firm, which is essential in proper refrigeration of this product, but the growth of the bacteria is largely prohibited. These are the temperatures usually obtained in well regulated refrigerating cars, and creamery and store refrigerators where ice is used as a cooling medium. Great care should be observed in keeping the refrigerator properly closed, for it does not take long for practically all the cold air of a " cooler " to rush out. It is wise to provide an entrance room, when the refrigerator is fairly large, to prevent the interchange of cold and warm air. Brown [1] states that from one lot of cream, twenty-four bacteria and fifteen yeasts grew well at 20° C. (68° F.) and that four of these bacteria and six of the yeasts grew

[1] Brown, C. W., Some Actions of Micro-organisms upon the Constituents of Butter, Sci., Vol. 35, No. 893, p. 253, 1912.

at 6° C. (43° F.). In each case the salt concentration of the medium on which the organisms were studied was 12 per cent. This calls attention to the effect of both low temperature and the quantity of salt. It should also be noted that 68° F. is about room heat and that the temperature of the refrigerator may rise quickly to that of the room if great care is not observed.

For long periods of storage, the temperature must be many degrees lower than may be sufficient for short periods. According to Gray and McKay,[1] butter kept slightly better at −10° F. than at 10° F. There was a marked difference in favor of these lower temperatures over the higher one, which was 32° F. The table on page 183 from Rogers, Thompson, and Keithley [2] shows the advantage of temperatures near 0° F. for storing butter over those a few degrees higher.

The average number of points that the butter deteriorated at 0° F., 10° F., and 20° F., was 1.92, 2.99, and 3.59 respectively. It is apparent that low temperatures are essential in good refrigeration. This table also calls attention to the advantage of pasteurization and to the use of unripened cream in butter-making. The following statement of Rahn, Brown, and Smith [3] concerning the growth of micro-organisms at low temperatures bears out the data in the above table on scores of butter at

[1] Gray, C. E., and McKay, G. L., The Keeping Qualities of Butter Made Under Different Conditions and Stored at Different Temperatures, U. S. Dept. of Agri., B. A. I., Bul. 84, p. 22, 1906.

[2] Rogers, L. A., Thompson, S. C., and Keithley, J. I., The Manufacture of Butter for Storage, U. S. Dept. of Agri., B. A. I., Bul. 148, p. 25, 1912.

[3] Rahn, Otto, Brown, C. W., and Smith, L. M., Keeping Qualities of Butter, Mich. Agri. Col. Exp. Sta., Tech. Bul. 2, p. 43, 1909.

different temperatures: "There are micro-organisms found in butter able to multiply slowly at −6° C. in salted butter. Whether these organisms are able to cause deterioration of butter is not certain." The standard cold storage temperatures for butter are 0° to −10° F.

Table XXII — Average Deterioration of Butter after Storage at Various Temperatures

| Kind of Butter | Points Lost after Storage | | |
|---|---|---|---|
| | Stored at 0° F. | Stored at 10° F. | Stored at 20° F. |
| | Points | Points | Points |
| Raw cream butter — Creamery A | 5.0 | 5.3 | 5.8 |
| Raw cream butter — Creamery D | 1.7 | 4.1 | 3.3 |
| Raw cream butter — All samples | 3.2 | 4.6 | 4.8 |
| Pasteurized, ripened cream — Creamery B . . . . . . . . | 2.2 | 3.0 | 5.1 |
| Pasteurized, ripened cream — Creamery E . . . . . . . . | 1.7 | 3.6 | 4.0 |
| Pasteurized, ripened cream — All samples . . . . . . . . | 2.0 | 3.3 | 4.6 |
| Pasteurized, unripened cream — Creamery C . . . . . . . . | .6 | 1.0 | 1.5 |
| Pasteurized, unripened cream — Creamery D . . . . . . . . | .4 | 1.0 | 1.6 |
| Pasteurized, unripened cream — All samples . . . . . . . . | .5 | 1.0 | 1.6 |

**135. Nature of buildings and business.** — Cold storage buildings are usually large and the business is conducted on a large scale, for the overhead expenses are less than when the enterprise is small. One of the most important and expensive items is the manufacture of the cold, and this is cheaper when produced on a large scale. The buildings are usually constructed of properly insulated concrete. The insulation makes it possible better to retain the cold; and the concrete, besides being a substantial building material, is sanitary. Fig. 54 shows a butter-room in a modern cold storage warehouse. The business of operating a cold storage plant is largely one of renting space. This space is leased to the customer, who usually draws out the product when it is needed to supply his trade. Sometimes goods are placed in storage

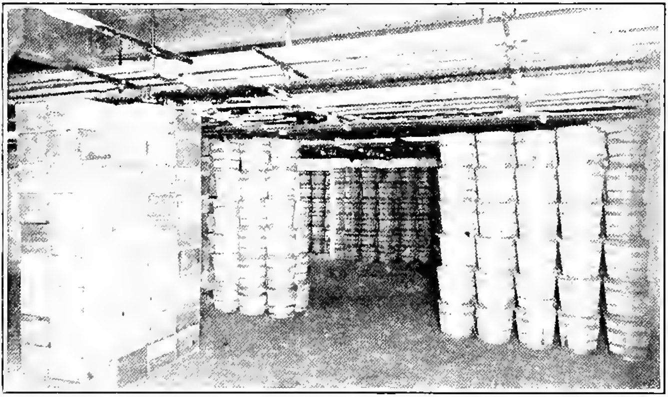


FIG. 54. — Section of butter storage room in a modern fireproof cold storage warehouse. The temperature is maintained steadily at zero Fahrenheit.

on speculation and may all be sold and taken away at one time. The cold storage companies issue receipts that are negotiable. Very often the refrigerating company acts as a commission merchant for its customers. This is probable when the holder of the storage goods lives in a distant part of the country. Some cold storage warehouses are located in the district where the butter is manufactured. Occasionally they may be on the route of transit from the district of production to that of consumption. However, they are usually in large cities near the consumers.

**136. Cost.** — A knowledge of the cost of storing butter may be obtained from the following list of rates:

"Butter[1] (Standard 60 lb. tubs or boxes).
Season Rates at Zero Temperatures.
Season ends Dec. 31st.

| | |
|---|---|
| Under 10 pkgs. | per pkg. 75 c. |
| 10 to 50 pkgs. | per pkg. 60 c. |
| 50 to 200 pkgs. | per pkg. 50 c. |
| 200 to 400 pkgs. | per pkg. 45 c. |
| Over 400 pkgs. | per pkg. 40 c." |

It should be noted that the cost of storage is greater than is shown in this list, for interest and insurance are not included. According to Holmes,[2] the average cost a pound for storage of butter is 2.532 cents or 10.8 per cent of the wholesale price. Holmes also states that the average time of holding butter in storage is 4.43 months.

**137. Home storage.** — The storage of butter on the small scale for home use has been practiced for many years. The important consideration is the obtaining of a good product made from sweet cream. This butter may be packed solidly in jars. Prints may be used. If the butter is to be put in jars in a mass, the containers should first be thoroughly scalded. After packing, the butter should be covered with a white cloth that has been scalded in boiling water. Then a covering of salt about $\frac{1}{32}$ inch deep should be put over the cloth. The purpose of this cloth is to aid in removing the salt, when the butter is taken from the jar.

[1] Hygeia Refrigerating Co., Rates and Information, Reference Booklet, 1914.

[2] Holmes, Geo. K., Cold-Storage Business Features, U. S. Dept. Agri. B. S., Bul. 93, 1913.

When prints are used, the jars should be treated by scalding as in the above case. Next, a brine should be made sufficiently strong to float an egg. This will require about one-fourth as much salt as water. In some cases it is wise to boil the water to kill the micro-organisms in it, before the salt is added. Then a white cord should be tied around each print, for the wrapper is likely to float away if not tied to it. The prints are then packed in the jar and a follower, such as a stone plate or a wooden circle, placed on the butter. Occasionally concrete followers are employed. If wood is used for this purpose, care must be observed in choosing a wood that will not impart an undesirable flavor to the butter. The next step is to place a stone or a brick on the follower to keep the butter submerged in the brine. These followers and weights must be carefully cleaned and scalded. Finally the brine should be poured over the butter. It may be necessary from time to time to add brine to keep the butter covered with the salt solution.

The print is more convenient to take from the jar than solid packed butter. Fifty one-pound prints can be packed in a ten-gallon jar. Less print butter can be packed in smaller jars, to the gallon capacity. This should be kept in a cool place. When covered carefully with brine or salt, butter may be held in the cold room where vegetables and fruit are kept.

**138. Effect of storage on price.**—The effect of storing butter on the price is difficult to estimate. Holmes asserts that 70 per cent is put in storage during June, July and August when the price is the lowest. Wilson[1] states that about 25 per cent of the butter of the United

[1] Wilson, James, Economic Results of Cold Storage, Year Book of Dept. of Agri., pp. 27–32. 1911.

States is put in storage. It is apparent that when this much of the output is held from the season of greater production to that of scarcity, the tendency is to equalize the prices; and there is no doubt that the average price for the year is lower than if the storage of butter were not possible.

# CHAPTER XII

## *MARKETING*

The first butter made in the United States was marketed mostly through the country stores, although some dairy-men shipped directly to the consumer. In those early days the quality was exceedingly variable; however, the market was not as critical as it is now. The time came when the farmers in many communities found that to market their butter to advantage, it was wise to organize a coöperative establishment. This was especially true in regions remote from cities. They recognized that the opportunity was better to make good butter in a creamery, because of the first-class equipment of the factory and the superior knowledge of the creamery butter-maker. They also recognized the effect of better and more uniform butter on its market value.

### GRADES OF BUTTER

**139. History of grading.** — Previous to the advent of creameries, there was no systematic grading of butter. In fact at the present time there is no universal system, although the same score-card is used throughout the country. As an illustration, "extras" on one market does not mean that butter in the same grade in another city is of comparable quality. It is generally known that the New York trade is more strict than the Philadelphia buyers, and that New York is far more critical than

Boston. Very often butter ranking as medium "firsts" in New York will sell as quickly as "extras" in Boston. However, the grading is much nearer to uniformity now than before the days of the creamery. At present butter is not made in so many small lots on farms as previously, but is manufactured in larger quantities in creameries. Thus it is not subject to so many variations in flavor, body, color, salt, and finish. Also the grading is more uniform because of the present method of employing experts in scoring butter as market inspectors. The teaching in grading at the various colleges of agriculture, state fairs, exhibitions of dairy-men's associations, and the monthly educational scoring of dairy products in various states, undoubtedly have an effect toward more uniformity in grading.

In the days when there were no creameries, simple terms such as "fair," "good," and "prime" were employed to describe the quality of butter. Later the words "choice," "fine," and then "fancy" were used for the best grades. A general grading was afterwards established with the terms "firsts," "seconds" and "thirds." When the creamery butter from the West came to the market it was recognized as being better than the dairy product and was placed above the grades at that time, being known as "western extras." It should be remembered that the first creamery in the United States was built in New York state (see Chapter I). However, there was a large demand in the East for cheese and milk, whereas the best outlet for the dairy in the middle-western states was by means of butter. About 1905 the word "western" was supplanted by "creamery," the term becoming "creamery extras." The reason for this change was that many creameries had been organized in the East, and the butter was selling in the same grades as the goods from the West. Later the word "creamery" was omitted, and now this grade is known as "extras." There have been a number of similar changes in the evolution of the grades of butter on the various markets. The grading has been a natural outgrowth of selling on the basis of quality.

## SCORING

In the last few years of the nineteenth century, butter and other dairy products were first placed on exhibition in this country at various agricultural fairs and at the conventions of dairy-men's associations. These were judged and given a numerical score.

**140. Score-card.** — The score-card now in general use, and which is the outgrowth of many years of butter-judging, is itemized as follows:

| | |
|---|---|
| Flavor | 45 points |
| Body | 25 points |
| Color | 15 points |
| Salt | 10 points |
| Package | 5 points |
| Total | 100 points |

If the score-card were to be revised, probably a greater proportion of the valuation would be placed on flavor.

In the first few years of grading, there was not much sympathy in the general trade for placing a score on butter. Possibly the main reason was that the dealers did not feel competent to grade butter in this way. Nevertheless, the time came when numerical values were assigned to the different grades. As an example, the following grades of the New York Mercantile Exchange are given with their valuations:

| | |
|---|---|
| "Higher scoring" | 93 or above |
| "Extras" | 92 |
| "Firsts" | 88 to 91 |
| "Seconds" | 83 to 87 |
| "Thirds" | 76 to 82 |

Besides these grades of creamery butter, there are classifications such as "renovated," "ladles," "packing stock," and "grease." As long as the evolution of grading finally has been to place butter according to score and not to group it, as when first started, the student should learn how many points should be taken off for each of the many defects. By careful study and several years of experience, one can learn to score butter properly. Some persons have better senses of taste and smell than others and naturally are better judges; nevertheless, it is possible to train the person with only average natural ability to be a good judge. A discussion follows of the items of the score-card from the viewpoint of the student who is learning how to score.

**141. Flavor** is the only point of the card that is never given a full score. Butter that has a total of 93, or a score on flavor of 38, is considered to be in the perfect class. This score shows that the flavor is plain and clean. When it is creamy and has an unusually pleasant flavor, the score may reach 42 or 43.

If the flavor is only slightly off, due to old cream, poor milk, or perhaps to absorbed flavors, such as barny or cowy odors, the score should be about 35 or 36. This would be a high "firsts." If it is rather dirty, or shows a distinct old cream flavor, it will score in the low "firsts" or in the "seconds." If it is very strong, or bitter, or musty, or stale, or if it seems to have a combination of all that may be bad, it will grade in the "thirds" or possibly lower. It is well for the student to know that on the market butter will rarely score over 39 on flavor which, if otherwise perfect, will give a final score of 94, and that it seldom scores less than 27 on flavor which, if not criticized on the other items of the score-card, would give a total score of 82.

**142. Body.** — The ideal body is firm and waxy. The average market is not nearly so critical of this factor as of the flavor. The body may be slightly greasy, or the moisture may not be properly incorporated. However, the average consumer will overlook these faults and other similar ones on body. If the butter is weak and greasy, it should be cut from $\frac{1}{2}$ to 2 points. If, in addition to these faults, the brine is milky and the grain short, 4 or 5 points should be taken off.

**143. Color.** — The color of butter must suit the trade and it must be uniform. If it is mottled or streaked, the consumer immediately complains. When the color is only a little variable, it might pass without criticism. Small streaks or mottles deserve a cut of $\frac{1}{2}$ to 1 point. If very mottled, 3 to 5 points should be taken off. The general shade of color is not usually criticized unless it is extremely high or low. When grading butter for a special market, less latitude can be granted in this regard than when judging at an exhibition, where the call of many markets may be represented.

**144. Salt.** — The salt-content of butter must be made to satisfy the consumer; therefore, the dealer in butter must be strict. In a general scoring, the product may pass as perfect if it has high or low saltiness. However, in all cases, to score perfect the salt must be dissolved. If it is not, $\frac{1}{4}$ to 4 points may be taken off. The salt should be evenly distributed; yet this is not so important as it was a few years ago, for the general tendency is to work the butter more thoroughly and thus the salt is uniformly incorporated.

**145. Package.** — The package must suit the market, and in order to sell to the best advantage it should have a neat appearance. A moldy tub or a discolored box is not attractive. The top of the butter in the tub or box should be finished neatly. The liner in either of these packages should be folded over nicely. Parehment paper should be used as liners, for it is usually free from mold and objectionable bacteria. Also, parehment is tougher than other paper. The top circle should be

Fig. 55. — The first three tubs are properly finished. The last is mussy.

placed in its proper position, since this is the part the buyer sees. Fig. 55 shows the comparison of neat and mussy tubs. In reading from left to right, tub No. 1 has the liner properly folded over one-half inch. Tub No. 2 shows the top of the butter cut off neatly, the liner folded over in the proper way, and the cloth circle in the correct position with the exception of that part which is folded back to show the butter. Tub No. 3 is the finished package with the four fasteners in the proper position. Tub No. 4 has been carelessly lined and the butter is smeary. Fig. 56 shows how the butter may be cut from the tub. All of the smaller packages, such as the one- and the one-half-pound prints, should be carefully wrapped. Soiled finger marks on the package are objectionable, especially on one that goes to the consumer. A perfect score is given when that part of the package which comes in contact with the butter is clean even though it may be somewhat mussy due to shipping. However, when carelessness is apparent, the score may be cut $\frac{1}{4}$ to 2 points. When extreme laxity is evident, all 5 points might be taken off. The character of the package plays an important part in the selling properties of most goods. It is especially true of butter.

FIG. 56. — Cutting the butter with a wire in finishing the tub.

## EXCHANGES

**146. History and development.** — In the early history of the butter industry, there were no wholesale trade organizations. In New York City the price changed five cents at a time. Every few days some of the leading butter merchants would talk over the situation and practically decide what the price should be for the next few days. In process of time the need of an organization was felt. These trade organizations not only promote good fellowship, but provide an avenue for better trading. Regarding these organizations, Potts and

Meyer[1] write: "In order to facilitate trading between the members rules and regulations have been adopted which provide (1) for the establishment of classes and grades of butter, (2) for inspection service to apply these grades, and (3) for the adjustment of disputes in trading between members. Through the officers of the organization information is obtained for the members regarding the movement, prices, demand, and supply of butter in other markets and receipts at the local market. . . . They also obtain the benefits of coöperative action in matters which are of mutual interest, such as state and city legislation, transportation and terminal facilities, and improvement of produce markets and marketing facilities." At present these exchanges meet daily.

THE PRICE

**147. How reported.** — It has already been stated that the custom before the organization of exchanges was for a few of the leading merchants to meet and to set the prices. These prices were reported to the public through the agricultural papers and by the newspapers. It is asserted that Solon Robinson was one of the first reporters of the produce markets. His work began in 1856. It is thought that the butter market was reported at about the same time by Robinson for the *American Agriculturist*, and by Clarkson Taber for the *New York Tribune*. The first produce paper was published in 1858 or 1859 by Benjamin Urner, appearing once a week. It later developed into what is now *The Producers' Price-Current*, which in 1882 became a daily publication. The various trade papers have no small part in determining

[1] Potts, Roy C., and Meyer, H. F., Marketing Creamery Butter, U. S. Dept. of Agri., Bul. 456, pp. 16–17, 1917.

the prices, for it is through them that the trade, whether far or near, learns of the supply and demand. The following are the quotations of June 30, 1917, in *The Producers' Price-Current,* which shows in what form the public receives them:

| | | | |
|---|---|---|---|
| Creamery, higher scoring than extras . . . . | $37\frac{3}{4}$ | @ | $38\frac{1}{2}$ |
| Creamery, extras (92 score) . . . . . . . . . | | @ | $37\frac{1}{2}$ |
| Creamery, firsts (88 to 91 score) . . . . . . | 36 | @ | 37 |
| Creamery, seconds (83 to 87 score) . . . . . | $34\frac{1}{2}$ | @ | $35\frac{3}{4}$ |
| Creamery, thirds . . . . . . . . . . . . . | 33 | @ | 34 |
| Creamery, unsalted, higher than extras . . . . | 39 | @ | $39\frac{1}{2}$ |
| Creamery, unsalted, extras . . . . . . . . . | 38 | @ | $38\frac{1}{2}$ |
| Creamery, unsalted, firsts . . . . . . . . . | $36\frac{1}{2}$ | @ | $37\frac{1}{2}$ |
| Creamery, unsalted, seconds . . . . . . . . | 35 | @ | 36 |
| State, dairy, tubs finest . . . . . . . . . . | 37 | @ | $37\frac{1}{2}$ |
| State, dairy, good to prime . . . . . . . . . | $35\frac{1}{2}$ | @ | $36\frac{1}{2}$ |
| State, dairy, common to fair . . . . . . . . | 33 | @ | 35 |
| Renovated, extras . . . . . . . . . . . . . | $36\frac{1}{2}$ | @ | |
| Renovated, firsts . . . . . . . . . . . . . | $35\frac{1}{2}$ | @ | 36 |
| Renovated, lower grades . . . . . . . . . . | 33 | @ | 35 |
| Imitation creamery, firsts . . . . . . . . . | $34\frac{1}{2}$ | @ | $35\frac{1}{2}$ |
| Ladles, current make, firsts . . . . . . . . | $33\frac{1}{2}$ | @ | 34 |
| Ladles, current make, seconds . . . . . . . | $32\frac{1}{2}$ | @ | 33 |
| Ladles, current make, lower grades . . . . . | $31\frac{1}{2}$ | @ | 32 |
| Packing stock, current make, No. 1 . . . . . | $32\frac{1}{2}$ | @ | 33 |
| Packing stock, current make, No. 2 . . . . . | | @ | 32 |
| Packing stock, current make, lower grades . . | 30 | @ | $31\frac{1}{2}$ |

**148. Determination of price.** — When the exchanges were first organized, among other committees was one that met daily and decided on the prices. In the course of time such methods were considered arbitrary and the Government compelled a change. The method used in New York City, and which is similar to the plan of the trade in Chicago and in some other cities, is based strictly on the sales of the product. In the exchange rooms there is a large blackboard on which the auctioneer places the names of the firms who have butter to sell, together with the number of packages, the grade, and the price. Usually there are no bids until it is apparent that all who have butter for sale and who wish to offer it in this way have


Fig. 57. — Wholesale price of butter in the United States from 1840 to 1916

made their desires known.. After the bids are all in, the reporter, W. C. Taber, a son of Clarkson Taber mentioned above, makes note of these transactions. It should be mentioned that at present The Butter and Egg Exchange, Inc., meets in the afternoon and that the New York Mercantile Exchange meets at 10.00 A.M. By eleven o'clock or before Taber has the opportunity to go to the street to learn of the sales there, after obtaining record of the transactions on the two floors. At noon he reports exactly what he has found in both exchanges and on the street.

**149. Prices from 1840 to 1916.** — It is interesting to see what the prices have been for as many years as they are obtainable. Table XXIII shows a list of the prices of the grade now known as extras. In the earlier years all the butter was made on the farms. At that time there was practically no grading; therefore, the figures are not really comparable. Fig. 57 shows in a graphical manner the ranges of the above prices from 1840 to 1916.

### INSPECTION

Most of the trade organizations have inspectors. The purpose of this officer is to settle disputes regarding the grade of certain lots of butter. This has helped fully as much as any one practice in the proper grading. It has also been a source of information in not only placing butter in its proper grade, but in actually putting a score on it. The inspector is subject to the butter committee, and, in case there is dissatisfaction with his decision, an appeal can be made to the chairman. The committee then inspects the goods.

**150. Branding inspected butter.** — To show that a lot of butter has been inspected, the New York Mercantile Exchange provides for the marketing in a definite

TABLE XXIII — THE AVERAGE ANNUAL PRICE OF BUTTER, 1840–1916 [1]

| Year | Price Cents | Year | Price Cents | Year | Price Cents |
|---|---|---|---|---|---|
| 1840 | 16.00 | 1866 | 44.50 | 1892 | 26.12 [2] |
| 1841 | 16.25 | 1867 | 32.75 | 1893 | 27.01 |
| 1842 | 17.50 | 1868 | 43.25 | 1894 | 22.88 |
| 1843 | 14.75 | 1869 | 41.25 | 1895 | 21.37 |
| 1844 | 17.50 | 1870 | 34.50 | 1896 | 18.41 |
| 1845 | 16.00 | 1871 | 32.25 | 1897 | 18.95 |
| 1846 | 16.50 | 1872 | 29.25 | 1898 | 19.54 |
| 1847 | 18.25 | 1873 | 29.75 | 1899 | 21.26 |
| 1848 | 17.25 | 1874 | 32.75 | 1900 | 22.45 |
| 1849 | 17.75 | 1875 | 30.25 | 1901 | 21.63 |
| 1850 | 16.75 | 1876 | 30.75 | 1902 | 24.80 |
| 1851 | 16.75 | 1877 | 27.25 | 1903 | 23.48 |
| 1852 | 21.25 | 1878 | 21.00 | 1904 | 21.89 |
| 1853 | 21.25 | 1879 | 29.25 | 1905 | 24.89 |
| 1854 | 19.75 | 1880 | 28.50 | 1906 | 24.89 |
| 1855 | 23.00 | 1881 | 28.25 | 1907 | 28.30 |
| 1856 | 21.25 | 1882 | 33.50 | 1908 | 27.11 |
| 1857 | 23.00 | 1883 | 28.50 | 1909 | 29.20 |
| 1858 | 19.50 | 1884 | 28.00 | 1910 | 30.07 |
| 1859 | 21.50 | 1885 | 23.50 | 1911 | 26.65 |
| 1860 | 18.75 | 1886 | 27.25 | 1912 | 31.37 |
| 1861 | 14.75 | 1887 | 24.50 | 1913 | 32.28 [3] |
| 1862 | 18.50 | 1888 | 25.00 | 1914 | 29.89 |
| 1863 | 23.25 | 1889 | 23.75 | 1915 | 29.82 |
| 1864 | 38.50 | 1890 | 21.75 | 1916 | 34.09 |
| 1865 | 39.25 | 1891 | 24.00 | | |

[1] Wholesale Prices, Wages, and Transportation, Senate Reports, 2d Session, 52d Cong., Vol. 3, part 2, pp. 73–74, 1892–93.

[2] Wholesale Price Series, U. S. Bureau of Labor Statistics, Bul. 114, 1913.

[3] Taber, W. C., Producers' Price-Current butter reporter, in letter to the author, 1917.

way. Extras are stamped with a circular brand two inches in diameter, bearing the words "New York Mercantile Exchange, Extras," the date of inspection and the name of the inspector. Likewise each grade is marked with its own specific brand of a certain shape, size, and wording.

**151. Cost of inspection.** — There is a schedule price for inspection. The Chicago Butter and Egg Board provides for a charge of $.75 for each inspection within a certain district. In another district, located farther from the headquarters of the Board, a charge of $2.00 is made for the first, with the addition of $.75 for each subsequent inspection made at the same time for the same parties. In districts farther still from the headquarters of the Board, thus requiring additional time of the inspector in transit, there is a higher cost. The New York Mercantile Exchange provides that within a certain district there shall be a charge of $.75 on lots not exceeding twenty-five tubs, one invoice. When there are twenty-five to fifty tubs, one invoice, the cost is $1.00. The ratio of the charges is less as the number of tubs increases. This exchange stipulates that a certain number of tubs shall be examined, depending on the number in the lot. The Chicago Butter and Egg Board leaves this to the judgment of the inspector.

**152. Other duties of the inspector.** — Some boards of trade give the inspector power to weigh butter. Other trade organizations have this work executed by a different officer. Some exchanges have made a special effort to secure as inspector a man of experience in manufacturing butter. Such a person, in addition to settling disputes as to grade and possibly as to weight, can advise the makers of the poor butter, whose product he examines, how they may improve their goods.

WEIGHING TUB BUTTER ON THE MARKET

**153. Customary methods.** — The various markets have different methods of weighing tub butter. Some dealers weigh each tub separately and thus obtain the gross weight. Then they strip several tubs and ascertain the average net weight of the butter. The difference of the gross and the net weight of these tubs (that are stripped) are then taken, thus giving the tare of the tub. The final weight of the butter is obtained by subtracting the average tare from the gross weight of each tub. Some wholesale merchants accept the weights marked on the tubs by the creameries. The Chicago Butter and Egg Board [1] states that not less than 10 per cent of the tubs shall be weighed. The New York [1] dealers in determining the tare of the tub usually make " test weights " as follows:

Weigh 3 tubs out of 12 or under.
Weigh 5 tubs out of 12 to 40.
Weigh 10 tubs out of 40 to 100.
Weigh 15 tubs out of 100 to 150.
Weigh 20 to 25 tubs out of a carload.

It is customary on most markets to require " up weight "; also it is not often that a butter-dealer will weigh less than full pounds.

**154. Amount of butter in tub.** — For several years many creameries have placed a certain amount of butter in each tub, such as sixty-two or sixty-three pounds. Since the net weight amendment to the Pure Food Law, more creameries have made a practice to put a uniform amount in each tub and then have stamped the net weight on the tub instead of marking it with a pencil. The creameries have to make an allowance of one-half to one

[1] Potts, Roy C., and Meyer, H. F., Marketing Creamery Butter, U. S. Dept. of Agri., Bul. 456, p. 7, 1917.

pound for actual shrinkage and difference in weight on each sixty-pound tub. Fig. 58 shows how the butter may be scraped off with a thin wooden strip when weighing a certain amount in each tub.

## THE MAIN MARKETS OF THE UNITED STATES

**155. Leading markets.** — The largest butter market in the United States is Chicago, it being near the region of the greatest production. A large part of the butter of the Chicago market is shipped to other points. New York City has next to the largest market in this country, and more butter is consumed there than in any other city. The Boston and Philadelphia prices, as well as those of many of the smaller cities of the East, follow the New York prices fairly closely. The other main markets of America are in Cincinnati, San Francisco, and Portland.

Fig. 58. — Weighing a uniform amount of butter in each tub. Sixty-two pounds is the customary weight.

**156. Elgin market.** — At one time the Elgin market of Elgin, Illinois, located in the greatest butter territory of the United States, was the chief. In fact it had such a reputation that little creameries in many states contrived to fit the word "Elgin" into their corporate names. The Elgin Board meets only once a week and only a few packages are sold each time. However, because of its past reputation, the Elgin quotations are still used by many creameries in the central states as a basis for payment. It is to be hoped that the Elgin market will soon cease operations, for it is unnecessary because of the nearness of the Chicago market, and in reality it represents only a small sale of butter.

## REQUIREMENTS OF DIFFERENT MARKETS

The requirements of the various markets differ in respect to the character of the butter and the type of package.

**157. Character of butter.** — Philadelphia demands a dry-appearing product. Very often the butter that goes to the Philadelphia trade has been badly overworked in order that the moisture might be thoroughly incorporated. The overworked and greasy body is not so objectionable to this trade as a little unincorporated water. New York and Chicago require a firm body, a pleasant clean flavor, and a mild salt. The Boston, Philadelphia, Baltimore, Washington, and many other markets are not so strict on any of these factors. The southern markets in general prefer a darker color and more salt than the northern trade. The residents of many rural districts are fond of butter that has been salted very high.

**158. Wholesale packages.** — It is very necessary for the butter-maker to cater to the demands of the trade in the style and type of package in which he puts his product. The two general types of packages used for bulk butter are the tub and the cube. In the states of the Middle West, the creameries use the 63-pound ash tub. In New England the spruce tub is preferred and the call is for butter packed in 10-, 20-, 30-, 50-, or 60-pound packages. On the Pacific Coast, the creameries employ the cube which may hold 63, 68, or approximately 80 pounds. The New Zealand cube holds 56 pounds. The cube costs only about two-thirds as much as the tub and is a better shape for two reasons: first, there is less space between the packages, so that the cubes can be placed on ships and in warehouses with more economy of space; second, the butter may be cut in prints more satisfactorily from the cubes. When the material is properly planned, the box or cube is as attractive as the tub. The tub is a little more substantial than the box; nevertheless, when properly made the box is sufficiently strong. Neither of these packages is returnable. In the early days of shipping butter, the large firkins which were used were returned, and in this way they were employed over and over again.

**159. Retail packages.** — The pound or one-half-pound brick print is the favorite form for the consumers of most markets. The New England preference is a flat print weighing one pound. This type permits of some advertising, as the butter-dealer, creamery, or dairy may stamp an appropriate monogram on each quarter of the print, and as each quarter is put on the table the monogram appears with it. This is not possible when the brick-shaped print is used. In other respects the brick print is better: first, there is not so much surface exposed to the warm air; second, it is easier to make. The one-half-pound and the pound hotel bars, as well as the two-pound prints, are desirable packages in some places. A five-pound tin is the package in which the Navy Department of the United States has most of its butter packed. There are a few companies who pack butter in similar tins when exporting it to warm countries. Other types of packages, a few of which may be seen in Fig. 59, are acceptable on some markets to a limited extent. The stone jar, when properly scalded and cooled, is one of the best packages so far as the keeping of the butter is concerned. However, it is heavy and easily broken, and because of being rather expensive has to be returned. It is, therefore, practicable only for a dairyman to use and even then to a limited extent.

It is unfortunate that there is such a lack of uniformity of retail butter packages. Many creameries have to keep different types on hand, which means additional expense. Also laborers in the creamery cannot work so fast because of changing from one type of packing to another.

**160. Parcel post.** — Not much butter is being shipped by parcel post, and probably this method of transportation will never be an important factor in the butter industry.

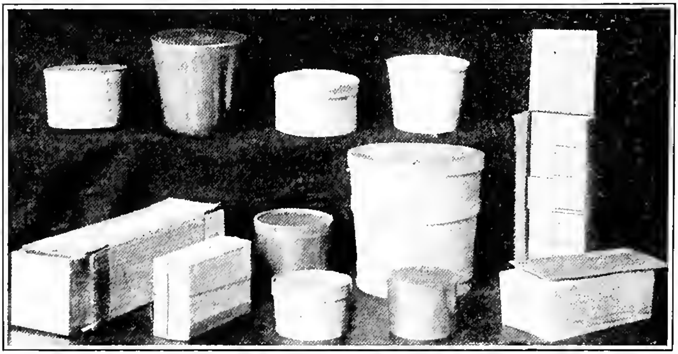


Fig. 59. — Types of packages suitable for parcel post. All are satisfactory consumer's packages.

Many different types of packages may be used. Fig. 59 shows satisfactory styles. As long as the brick print is the most desirable consumer's package, it would probably be best to choose one of the two print packages.

Both are made of corrugated paper. Inside of the one on the left of the figure there is a light tin box in which the prints may be placed after they are wrapped in parchment paper. In the other type, which is shown on the right of the figure, the prints should be wrapped in parchment and placed in a carton before they are ready to put into the box. These boxes are made in various sizes ranging from two to fifty pounds capacity. However, the larger sizes are too heavy for parcel post. The usual quantities of butter that are shipped by parcel post vary from two to ten pounds.

## SHIPPING BUTTER

**161. By railroad.** — In the butter districts of this country, a regular scheduled refrigerator dairy freight service is operated by the railroads or fast refrigerator companies. The butter is collected from creameries along the line in iced cars by "pick up" service. At junction points entire carloads are made up. The larger creameries usually ship a carload at a time. In the regions where not much butter is made, the express service is the main method of transportation. It is sometimes advisable to express to a junction on a railroad through which a refrigerator car passes. Arrangements may be made with the refrigerator car company to advance the local express charges, to be collected with the freight charges at the destination. This method of shipping costs less than the through express and has the added advantage of refrigeration the larger part of the way. It should be mentioned that it is the common custom for the butter-dealer to pay the transportation and to deduct the amount from the returns for the goods.

**162. By water.** — Water transportation is slower than by the railroad. However, it is cheaper. In the past few years several boats have been fitted with refrigerator apparatus. It is now possible to ship on the Great Lakes, and probably in a short time boats with refrigerator compartments will be going from coast to coast via the Panama Canal.

## SELLING BUTTER

**163. Methods of small creameries.** — Most butter-dealers send an agent among the creameries to solicit business. Many such merchants have held their creameries for a long time by square dealing. Some small creameries occasionally send a small shipment to another merchant on the same market, and often they send to other markets in order to determine whether their regular channel is the best. The managers of the large creameries often go on the market to ascertain the exact condition, rather than to send trial shipments to various places. It is very desirable that the creamery manager visit the market so that he may fully understand the requirements of the trade and thus be able to sell his butter for the highest possible price.

**164. Methods of large creameries.** — Most of the large centralizer creameries have their own marketing agencies. This gives them a great advantage over the smaller ones, for they learn just where to send the different grades of butter, and on account of the volume of business are able to employ very efficient salesmen. They also have a better opportunity to satisfy their trade because of the large amount and the uniformity of their goods, than the average butter-dealer who buys his product from many small creameries. Nevertheless, it should be distinctly understood that uniformly high quality is the most important consideration in the successful sale of butter. For this reason, the small creameries near the producers of the milk-fat should not be discouraged.

**165. Coöperative selling.** — In some districts creameries have profited by organizing themselves in a coöperative sales association. This organization hires a salesman who sells the entire output of the association. The butter industry in a few states has been improved by a state organization. Oregon, Washington, Minnesota, Iowa, and Michigan have state brands for butter similar to the "Lur" brand of Denmark. The purpose is to raise the standard of the quality of the butter for the respective states and to assure a high-class product to the consumer.

## DISTRIBUTORS' MARGINS [1]

**166. Wholesalers' margins.** — "The costs of market distribution were investigated in each of the cities visited, which included the larger and more important wholesale and jobbing markets in the United States. It was found that the margins taken by butter distributors in general depend upon the character of the business done; that is, whether wholesale or retail, and such factors as volume of business, extent of charged accounts, competition, and general conditions of the market. The wholesale receiver sells large lots usually at a margin of from one-fourth to three-fourths cent a pound with a fair average of one-half cent per pound. The jobber who distributes bulk packages or prints, employs salesmen, maintains delivery equipment, and extends credit to the

[1] Potts, R. C., and Meyer, H. F., Marketing Creamery Butter, U. S. Dept. of Agri., Bul. 456, pp. 27–28, 1917.

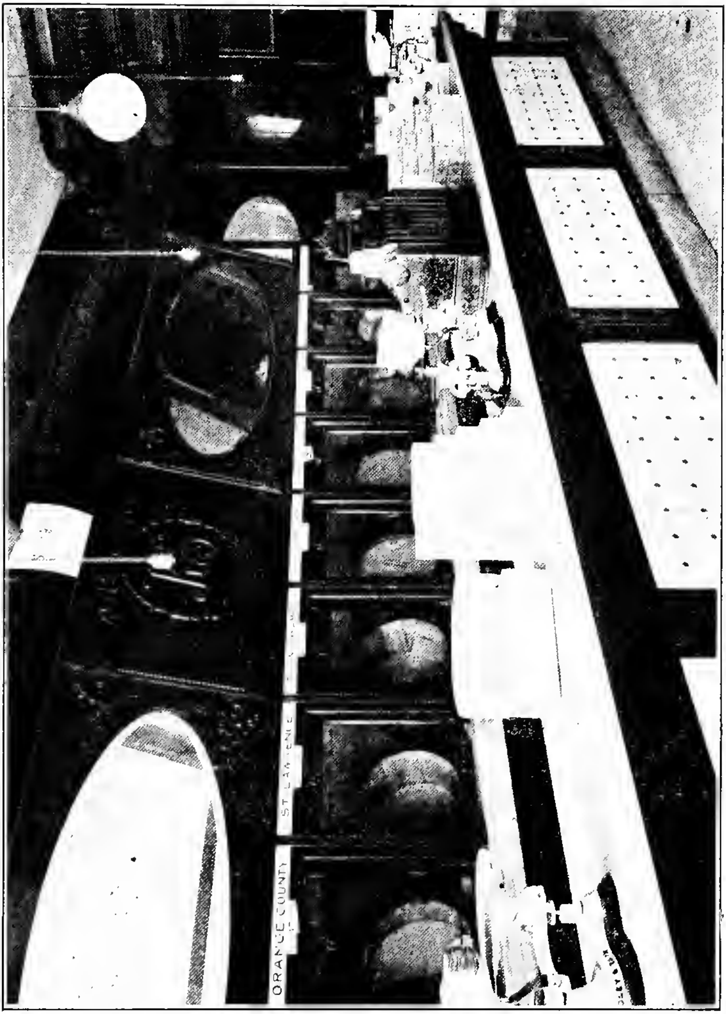



FIG. 60. — The butter counter of a large retail grocery store.

retailer, usually receives from $1\frac{1}{2}$ to $2\frac{1}{2}$ cents per pound gross margin for rendering this service. The gross margin is not all net profit, for a large amount of capital is required to conduct a wholesale or jobbing business, and the expenses are considerable. . . ."

**167. Retailer's margins.** — "The margins taken by the retailer show wider variations than those for other distributors. Butter frequently is handled by some stores on a week-end day at cost, for the purpose of attracting customers as an advertising feature. The usual margin taken by cash stores and chain stores will vary from 3 to 5 cents, depending upon the ruling price of butter. The retailer with a small butter business, who has to maintain an expensive delivery service and carry numerous credit accounts, often takes a margin of 5 to 7 cents to cover costs and profit." Fig. 60 shows the butter counter of a large retail grocery store. There are many such stores in the large cities.

# CHAPTER XIII

## *WHEY BUTTER*

WHEY butter, which is made of cream separated from the whey of cheese, is manufactured regularly in only a few cheese factories. Occasionally the whey cream is sold to centralizer creameries. At one time a company was organized in northern New York, that bought the whey cream from several cheese factories and made butter from this cream only.

**168. Fat loss in whey.** — As early as 1895, Wing [1] reported that in many cheese factories, a large amount of milk-fat was being practically wasted in the whey. He calculated that if all the whey in New York were skimmed, there would be a saving of 4,776,598 pounds of butter in one year, which at twenty cents a pound amounted to a loss of fifty cents a cow. Most of this whey was from Cheddar cheese factories. It tested about .3 per cent fat. In 1905 Farrington [2] called attention to the large loss of milk-fat in the whey of Swiss cheese, the test of which was often as high as 1 per cent. The average fat-content of the whey of Swiss cheese is about .5 per cent.

[1] Wing, H. H., Whey Butter, Cornell Univ. Agri. Exp. Sta., Bul. 85, 1895.

[2] Farrington, E. H., The Manufacture of the Whey Butter at Swiss Cheese Factories, Univ. of Wis., Agri. Exp. Sta., Bul. 132, p. 31, 1905.

**169. Cost of manufacture.** — The cost of making whey butter depends largely on the labor problem. Wing[1] states: "The manufacture of butter from the whey will not ordinarily require much increased labor. The whey can be run through the separator at the same time that the latter part of the cheese-making process is going on and the churning will take but a small amount of time and labor. The additional items of expense will be storage capacity for the whey and the separator." Doane[2] itemizes the annual expense of making 6000 pounds of whey butter as follows:

| | |
|---|---|
| Repairs | $25.00 |
| Ice | 40.00 |
| Interest on investment | 40.00 |
| Depreciation at 10 per cent | 80.00 |
| Oil | 5.00 |
| Salt | 7.00 |
| Belts | 9.00 |
| Butter paper for pound prints | 9.00 |
| | $215.00 |

"Coal, $1\frac{1}{4}$ cents per pound of butter made. Labor, $2\frac{1}{4}$ cents per pound of butter made." The total cost of manufacturing butter in this experimental creamery was a little over 7 cents a pound, and the greatest expense was labor.

Sammis[3] shows the cost of making whey butter in the following table:

[1] Wing, H. H., Whey Butter, Cornell Univ. Agri. Exp. Sta., Bul. 85, 1895.

[2] Doane, C. F., Whey Butter, U. S. Dept. Agri., B. A. I., Cir. 161, 1910.

[3] Sammis, J. L., Making Whey Butter at Cheddar Cheese Factories, Agri. Exp. Sta. Univ. Wis., Bul. 246, 1915.

TABLE XXIV — COST AND PROFIT IN SKIMMING WHEY AT LARGE AND SMALL FACTORIES

| | | | | | |
|---|---|---|---|---|---|
| Factory running months | 12 | 12 | 12 | 8 | 6 |
| Milk per day, lb. | 9,000 | 4,500 | 2,250 | 2,250 | 2,000 |
| Equipment, total cost | $685 | $607 | $411 | $381 | $209 |
| Capacity of whey separators | 5,000 | 5,000 | 3,500 | 3,500 | 1,200 |
| Cost, new | $500 | $500 | $350 | $350 | $200 |
| Whey storage tank, size gal. | 2,100 | 1,000 | 500 | 500 | — |
| Cost, new | $45 | $32 | $17 | $17 | — |
| Whey pump or steam jet | $25 | $10 | $4 | $4 | $4 |
| Piping sundries | $15 | $15 | $15 | $10 | $5 |
| Building alterations | $100 | $59 | $25 | — | — |
| Annual charges, total | $578 | $328 | $272 | $200 | $141 |
| Depreciation, 10% | $69 | $60 | $41 | $38 | $21 |
| Interest, 5% | $34 | $30 | $21 | $19 | $10 |
| Coal, gasoline, electricity | $100 | $50 | $25 | $18 | $15 |
| Oil, insurance, etc. | $15 | $8 | $5 | $5 | $5 |
| Labor | $360 | $180. | $180 | $120 | $90 |
| Gross income: | | | | | |
| Milk handled annually, lb. | 3,285[a] | 1,642[a] | 821,250 | 547,500 | 365,000 |
| Fat sold in whey cream, lb. | 8,210 | 4,106 | 2,053 | 1,370 | 913 |
| Value at 20 ¢ a lb. | $1,642 | 821 | 411 | 274 | 183 |
| Deduct expense | 578 | 328 | 272 | 200 | 141 |
| Net proceeds, total | $1,064 | $493 | $139 | $74 | $42 |
| Per pound of fat separated, cts. | 12.9 | 12.0 | 6.8 | 5.4 | 4.6 |
| Per 100 pounds milk, cts. | 3.2 | 3.0 | 1.7 | 1.3 | 1.1 |

[a] Last three figures omitted.

Sammis places the cost of making butter from whey at approximately the same price that Doane[1] named. He also calculates that the labor cost is the greatest item.

[1] Doane, C. F., Whey Butter, U. S. Dept. Agri., B. A. I., Cir. 161, 1910.

In many factories this expense is not so high, for a certain number of men must be employed regardless of whether whey butter is produced.

Arrangement is usually made whereby the farmer receives a certain proportion of the profits on the whey butter. This more than reimburses him for the milk-fat taken from the whey, thus causing the feeding value of the product to be somewhat less. Quoting Doane: "In a factory receiving a maximum flow of milk of 10,000 or more pounds a day some profit should be made after giving one-half of the gross returns to the farmer."

**170. Manufacture of whey butter.** — The first step in the making of whey butter is in the care of the milk. Generally it is considered that separation is the first part of the process.

*Separation.* — The whey should be separated as quickly as possible after it is drawn from the cheese-vat. It should be passed through a special whey separator so that the cream will test at least 50 per cent fat. This separator differs from the milk machine in having a larger opening for the skimmed product to flow from the bowl. In case of necessity, the milk separator may be employed; however, the cream must be separated the second time to be sufficiently rich in milk-fat for churning. It is wise to strain out the small pieces of curd as the whey runs into the separator. This prevents the clogging of the bowl.

*Care and ripening of cream.* — As quickly as the whey is separated, it should be pasteurized at 145° F. for thirty minutes and then cooled to a good holding temperature or to the ripening temperature. If the factory is small, the cream should probably be churned three or four times each week. A good plan is as follows: After separation Monday morning, pasteurize the cream and cool it to 50° F. and hold it at that temperature until Tuesday morning. After separating the whey on Tuesday morning, pasteurize it and mix it with the Monday batch. The next step is to add the starter. Some manufacturers like to add sufficient artificial starter to standardize the cream to a fat-content of about 30 per cent. Other butter-makers prefer to dilute the cream with skimmed-milk so that it tests about 40 per cent fat. Then they add about a 15 per cent inoculation of starter. Still other makers do not use any starter. They dilute the rich whey cream with whole milk or skimmed-milk and churn the sweet cream. Butter made from the cream that is sweet or that contains very low acidity has better keeping properties than the very sour cream goods. If thin cream is desired, it should be diluted before pasteurization, for it is not wise to add raw milk to cream in which the bacteria have been killed.

One of the sources of difficulty in securing good whey cream is the drippings of the press. Usually the whey that flows from the cheese press will test about 8 per cent milk-fat. If it is not saved, there is a large waste. However, these drippings are usually about a day old before they can be utilized and often develop a strong and old flavor. Very often they should not be used at all.

*Churning.*—The cream should be churned, washed, salted, worked, and packed in the ordinary way. Care should be observed in the employment of as low temperatures as possible, for the tendency of whey fat is to be greasy.

*Marketing.* — Most whey butter is sold in the locality of the factory. Since it does not keep quite so well as creamery or dairy butter, it is usually not shipped to distant markets. If care is observed in manufacturing whey butter, it will pass on the average market as firsts.

# CHAPTER XIV

## *RENOVATED AND LADLED BUTTER*

THE purpose of renovating or re-making butter, and of ladling or re-working it, is to make the goods more uniform in every particular and to improve the quality as much as possible.

**171. Source of raw material.** — Dairy butter is largely the raw material from which renovated and ladled products are made. Occasionally poor creamery butter is bought for this purpose. This dairy butter is usually obtained from country stores where the farmer has traded it in exchange for groceries. The practice of the grocers is to sell at retail the better grades, and to ship the poorer ones in salt or sugar barrels to a renovating or a ladling factory. This product is often transported long distances, sometimes over two thousand miles.

**172. Renovating and ladling plants.** — A few years ago there were about thirty-five butter renovating factories and many ladling plants in the United States. At present there are fewer plants for the manufacture of this product. It is easier and more profitable now for the farmers to market their cream to a creamery, than to make butter and sell it at a lower price than can be obtained for the milk-fat in the cream. The advent of the modern hand cream separator has been the main factor in the decrease in the amount of renovated and ladled butter.

**173. Over-run.** — The quantity of the finished product is usually much more than the amount of the raw material, for most dairy butter is low in moisture. These remade butters contain high percentages of moisture and salt. In fact the profit is largely secured in the increase of the final product over the original stock.

**174. Method of manufacturing renovated butter.** — The renovated product passes through a melting process; whereas the ladled butter is merely softened by warmth so that it may be easily reworked. In general, renovated butter is made in the following way; the description is taken from Shaw and Norton,[1] and covers the process used in a factory in the Central West: "The packing stock is taken to the third floor, and after removal from the containers is thrown into a large melting vat in the bottom of which are steam coils. One end of the vat is screened off, and in this screened-off section is a pump constantly in operation during the melting process, conveying the melted mixture to a battery of settling tanks each having a capacity of 500 pounds. The settling tanks are jacketed, the space between the jacket walls being filled with water which is heated with steam to maintain the proper temperature during the process of settling, which lasts from 6 to 10 hours. The clear butter oil is run from the settling tanks to the blowing tanks on the floor below. The blowing tanks also are jacketed, and have a capacity of 400 pounds of butter oil. The blowing is conducted at a temperature of 110° to 120° F., about 15 hours being usually required for an average grade of packing stock. The air is washed and heated

[1] Shaw, Roscoe H., and Norton, Raymond P., Blowing Renovated Butter Oil at Pasteurizing Temperature, Jour. of Dairy Sci., Vol. 1, No. 2, p. 28, 1917.

before coming into contact with the butter oil. The blown butter oil is passed over a continuous pasteurizer held at 160° F., and is then ready to be emulsified. The emulsion is made in a circular tank provided with paddles or dasher revolving in opposite directions. The emulsion drops to the floor below into the crystallizing vat, and the crystals removed to the ripening room in trucks, each truck holding the contents of one blower. After ripening, the crystals are worked, salt added, and the finished product packed in cartons or tubs as may be demanded by the trade." In some plants, the emulsion consists of a mixture of the purified fat or butter oil and starter. It is, therefore, practically a cream. After the emulsion passes through the ripening stage, it is churned in the ordinary way. Renovated butter must be packed and branded in a definite manner as prescribed by law (see Chapter XVII). All butter-renovating concerns do not pasteurize the raw material. However, considerable satisfaction is now felt by food experts because the tendency of many companies is toward pasteurization. The fear that the raw packing stock may contain disease micro-organisms is well grounded, for much of this butter is very carelessly handled.

**175. Method of manufacturing ladled butter.** — This product receives its name from the method of reworking. It is made of the same kind of raw material from which renovated butter is manufactured. In this process the old dairy butter is graded largely according to shade of color, although in many cases the condition of the body is a deciding factor. After the butter is graded, it is placed in a room at such a temperature that it will become soft and thus be in a good condition for reworking. Salt and water are then added and, if necessary, color is put in the mixture. The working process is then conducted by the use of ladles. The final step is the packing. Usually it is placed on the market in tubs, and most of it is sold for cooking purposes. It should be noted that this product cannot be pasteurized, so that it is probably fortunate that most of the ladled butter is so used as a culinary product.

## CHAPTER XV

### *MARGARINE*

The material long sold as oleomargarine met a determined and probably deserved opposition, particularly as it was marketed in imitation and semblance of butter. In its present form and under the conditions of its sale, it has now become a recognized product in the market and may be here considered.

**176. History.** — Margarine was first made by Mège-Mouriès, a French chemist, in 1870. Shortly before the Franco-German war, Emperor Napoleon III requested Mège-Mouriès to investigate the problem of obtaining a substitute for butter that would cost less. The Paris Health Council passed a regulation on April 12, 1872, sanctioning the new product as a substitute for butter. It also made the stipulation that this substitute was not to be sold under the name of butter. It was called margarine-mouriès. The process of Mège-Mouriès consisted in separating a portion of stearin from the best kidney fat, which is converted into a fat possessing characteristics similar to butter. Thus this method rendered the use of animal body fat possible as a butter substitute. Mouriès melted the fat in a steam vat at a temperature of 113° F. He purified it by settling and graining and then cut it in squares, tied these in small cloths, and pressed them. This gave 40 to 50 per cent stearin and 50 to

60 per cent fluid oleo oil. From the oleo oil was made oleomargarine.

**177. Method of making and composition.** — Wright[1] states: "In the best factories margarine is still made from beef fat which is finely divided by a mincing machine or 'hasher,' passed into large water-jacketed tanks, and heated to a maximum temperature of 102° F. Most of the impurities are allowed to settle with the water, and the clear yellow melted fat, having been freed from floating impurities by skimming, is run off into wooden vessels, and the stearin used for candle making then crystallizes out. The oleomargarine at this stage is quite tasteless, and has therefore to be churned up with milk, colored with annatto, and rolled with ice. Before churning the oleo is melted and then, when well emulsified by running the churn at a high speed, the other ingredients are added.

"The following is an analysis of commercial margarine.

| | |
|---|---|
| Water | 12.0 per cent |
| Stearin | 38.5 per cent |
| Olein | 25.0 per cent |
| Palmitin | 18.3 per cent |
| Butyrin, caproin | 0.3 per cent |
| Casein | 0.7 per cent |
| Salts | 5.2 per cent |
| | 100.0 per cent." |

Wilder[2] gives the formulas and cost of different grades of margarine in the following tables, — Tables XXV to XXVII, on page 222.

[1] Wright, R. Patrick, Margarine, The Standard Cyclopedia of Modern Agri. and Rural Econ., p. 193, 1910.

[2] Wilder, F. W., Butterine and Process Butter, The Modern Packing House, p. 442, 1905.

TABLE XXV — FORMULA FOR AND COST OF HIGH GRADE BUTTERINE

| MATERIALS AND QUANTITIES | COST PER POUND | TOTAL COST |
|---|---|---|
| 525 pounds No. 1 oleo oil | $0.0875 | $45.19 |
| 475 pounds No. 1 neutral lard | 0.08125 | 38.57 |
| 50 gallons 30 per cent cream | .42 | 30.24 |
| 300 pounds creamery butter | .28 | 84.00 |
| Labor and package | .01 | 15.00 |
| Salt and color | | 1.00 |
| Total | | 214.00 |

"This formula will yield 1500 pounds of butterine, therefore the cost per pound is $0.1426.

TABLE XXVI — FORMULA FOR AND COST OF MEDIUM GRADE BUTTERINE

| MATERIALS AND QUANTITIES | COST PER POUND | TOTAL COST |
|---|---|---|
| 525 pounds No. 1 oleo oil | $0.0875 | $45.19 |
| 475 pounds No. 1 neutral lard | 0.08125 | 38.57 |
| 40 gallons 30 per cent cream | .42 | 40.32 |
| Labor and package | .01 | 12.00 |
| Salt and color | — | 1.00 |
| Total | — | 137.08 |

"This formula would yield 1200 pounds butterine, therefore the cost is $0.1142 per pound.

TABLE XXVII — FORMULA FOR AND COST OF LOW GRADE BUTTERINE

| MATERIALS AND QUANTITIES | COST PER POUND | TOTAL COST |
|---|---|---|
| 350 pounds No. 2 oleo oil | $0.08 per lb. | $28.00 |
| 250 pounds cottonseed oil | .04 per lb. | 10.00 |
| 450 pounds neutral lard | .08125 per lb. | 36.54 |
| 60 gallons 3½ per cent milk | .12 per gal. | 7.20 |
| Labor and package | — | 12.00 |
| Salt and color | — | 1.00 |
| Total | — | 94.74 |

"This formula will yield 1200 pounds butterine, therefore the cost to produce and pack for shipping will be $0.0789 per pound."

The composition of the product of six large manufacturing concerns selling oleomargarine in Minnesota is given by Farrell[1] as follows:

"1. Oleo oil 40 %, lard 28 %, cottonseed oil 15 %, salt 3 %, moisture 14 % = 100 %.

"2. Cottonseed oil 46 %, oleo oil 37 %, salt 4 %, moisture 13 % = 100 %.

"3. Oleo oil 41 %, cottonseed oil 38%, lard 4 %, salt 4 %, moisture 13 % = 100 %.

"4. Oleo oil 48 %, cottonseed oil 30 %, lard 6 %, salt 4 %, moisture 12 % = 100 %.

"5. Oleo oil 22 %, cottonseed oil 49 %, lard 17 %, salt 2 %, milk solids 2 %, moisture 8 % = 100 %.

"6. Oleo oil 35 %, cottonseed oil 20 %, lard 30 %, salt 3 %, moisture 12 % = 100 %."

The fat of the first margarine was derived entirely from animals. The above analyses show that at the present time a large percentage of the oil is of vegetable origin. This product should, therefore, no longer be termed "oleomargarine," for oleo oil is now only a small part of the ingredients used in making the butter substitute.

**178. Legal control.** — Attention has been called to the stipulation made by the Paris Health Council, *i.e.* that this substitute was not to be sold under the name of butter. Wright recognizes the place of margarine as a food; however, he also points to the possibility of adulteration. The matter is summed up by Fleischmann,[2] who asserts:

[1] Farrell, J. J., The Storm Breaks, Butter, Cheese, and Egg Jour., Mar. 1, 1916.

[2] Fleischmann, W., Margarine, The Book of the Dairy, p. 319.

"It goes without saying, that attempts have been made, in order to promote its sale, to make margarine as attractive as possible. There is no reason, however, on this account, for rendering the new fat similar in external appearance to butter, or for bringing it on the market in a similar form and packed in the same way as butter. The great resemblance of the prepared animal fats to butter has always this disadvantage, that it opens the way to fraudulent practices, and has thus a tendency to destroy the honest character of the sale. The possibility of fraud was formerly increased by the universal practice of calling margarine by the name of butterine; that is, by a title which was only justified by the appearance of the margarine, but which was otherwise strained on account of the fact that not only was the chemical behavior of the margarine, but also its mechanical texture and fundamental condition, different from that of butter."

The laws controlling the manufacture and sale of margarine, therefore, have been very stringent. The Senate and House of Representatives of the United States of America [1] enacted certain laws in relation to this product on August 2, 1886, and amended them on May 9, 1902. A certain tax was placed on the manufacturer, wholesale and retail dealers. A tax of ten cents a pound was put on margarine that was colored artificially and of a quarter of a cent a pound on uncolored margarine. Provision was made for the manufacturer to pack the margarine in firkins, tubs or other wooden packages, each containing not less than ten pounds, and marked, stamped, and branded as the Commissioner of Internal Revenue prescribed, with the approval of the Secretary of the Treasury.

[1] U. S. Internal Revenue Regulations No. 9. Revised July, 1907.

It was also stated that all sales made by manufacturers and wholesale dealers must be in the original stamped package. It was stipulated that the retail dealer must sell only from original stamped packages, in quantities not to exceed ten pounds; that when sold by him, it must be packed in suitable wooden or paper packages which must be marked and branded as prescribed by the Commissioner of Internal Revenues, with the approval of the Secretary of the Treasury.

Since the enactment of this law, the manufacturers of margarine have used successfully certain ingredients to give the desired color without the use of artificial matter. Thus this butter substitute, or perhaps more properly imitation butter, has gone on the market sufficiently high in color to deceive the average purchaser, at a tax of one quarter of a cent instead of ten cents a pound.

It has been claimed that the high tax is unreasonable. However, it must be borne in mind that the spirit and purpose of this law was to permit the uncolored margarine, which is just as nutritious as that product with a higher color, to pass with a tax only sufficient to execute the law. The margarine trade has been able to sell its product to better advantage, when in such form as to deceive the public. Because of this deception, which is apparent from the following quotation, a bill was offered before Congress by Haugen[1] which it was hoped would prevent the existing unscrupulous sale of margarine. The following is a statement by Haugen when introducing the bill that has support of the National Dairy Union: "The fraudulent sale of oleo at the time the Government Bill was under consideration in 1899, disclosing the fact that manufacturers of

[1] Haugen, The Dairyman's Position, N. Y. Prod. Rev. and Amer. Cry., Apr. 12, 1916.

oleo had entered into a conspiracy to break down the state laws and had resorted to dishonorable methods in forcing their counterfeit upon the public by avoiding and disobeying the laws of the land to the extent of 5,492 dealers selling 62,825,582 pounds of oleo out of a total product of 83,130,474 pounds for the year, contrary to the laws of thirty-one states. The manufacturers went so far as to encourage and urge dealers to violate the laws of the states, and provided for a defense fund for the employment of the best legal counsel obtainable in defending illicit sales whenever prosecution was instituted. This led to the passage of the present law. The object of the proponents of the present law was, first, to bring oleo under the jurisdiction of the Federal Government by imposing a nominal tax upon the article, and second, to remove the incentive to defraud by taxing the coloring of the oleo, causing it to look like butter, or the counterfeit at the rate of ten cents per pound, which was then the difference in the cost of butter and oleo.

"The Secretary reports that the Government has been defrauded, through artificially colored oleo being sold under tax-paid stamps at one-quarter of one cent per pound instead of at the rate of ten cents due on such product by four manufacturers, the enormous sum of $17,692,410.47 since the inception of the present law. By another manufacturer, $1,503,205.30 in six years period. The five above, in the aggregate $19,195,613.77 stamp taxes, exclusive of special taxes of wholesale and retail dealers incurred."

**179. Margarine test.** — It is not always possible to detect margarine without the application of a test. A convenient household test is that of holding a small quantity in a spoon over a flame or fire. If when heated the fat does not foam and boil over, it is margarine or at least it is not butter, for the latter effervesces and foams.

**180. Butter and margarine.** — Comparing margarine and butter Wright[1] states, "Compared with butter, the chief differences in composition are the very low percentage of volatile fatty acids, the high percentage of insoluble fatty acids and the high molecular weight. There are also other practical differences in flavor, digestibility, etc. These make margarine inferior to butter in value, but as the price is also lower, good margarine serves a very useful purpose when sold under its proper name and not used for the purposes of adulteration." Margarine contains scarcely any of the growth-promoting substances which are abundant in butter. (See Chapter II.)

Dairy-men have no objection to the sale and consumption of margarine, as margarine. If the consumer wishes to pay as much or more for it than for butter, the dairy industry has no cause for complaint. However, it does object strenuously to the sale of margarine for butter.

[1] Wright, R. Patrick, Margarine, The Standard Cyclopedia of Modern Agri. and Rural Econ., Vol. 8, p. 193, 1911.

# CHAPTER XVI

## *DEFINITION OF TERMS*

Butter has become such a staple product in the market and is presented in so many forms, and the processes of manufacture have become so technical, that a special terminology has arisen. This subject may now be considered.

**181. Butter.** — "Butter is the clean, non-rancid product made by gathering in any manner the fat of fresh or ripened milk or cream into a mass, which also contains a small portion of the other milk constituents, with or without salt, and contains not less than eighty-two and five tenths (82.5) per cent of milk-fat. By acts of Congress approved Aug. 2, 1886, and May 9, 1902, butter may also contain added coloring matter.[1]" The Senate and House of Representatives of the United States passed a number of regulations regarding adulterated butter on May 9, 1902. The following paragraph referring to the moisture of butter is taken from page 87 of Regulations No. 9, revised July, 1907, United States Internal Revenue. "The definition of adulterated butter as contained in the Act of May 9, 1902, embraces butter in the manufacture of which any process or material is used whereby the product is made to contain abnormal quantities of water, milk, or cream; but the normal content of moisture permissible is not fixed by the act. This being the

[1] Standards of Purity for Food Products, U. S. Dept. Agri., Office of Sec., Cir. No. 19, June 26, 1906.

case it becomes necessary to adopt a standard for moisture in butter, which shall in effect represent the normal quantity. It is, therefore, held that butter having 16 per cent or more of moisture contains an abnormal quantity and is classed as adulterated butter." The exact amount of moisture, therefore, which constitutes adulterated butter, *i.e.* 16 per cent, is named by the United States Internal Revenue.

**182. Butter, centralizer.** — This butter is made in a creamery from cream that has been shipped long distances to this central plant. Most of this cream is separated on the farms.

**183. Butter, creamery.**[1] — "Grades of butter produced in large establishments directly from milk or cream are known as creamery butter." At large exhibitions butter made of cream from five or more herds is considered to be creamery butter.

**184. Butter, dairy.** — Dairy butter is that which has been made in a dairy, or in other words on the farm.

**185. Butter-dealer.** — A wholesale dealer or jobber of butter.

**186. Butter, gathered-cream.** — Gathered-cream butter is made in a creamery from cream that has been collected or "gathered" from many farms where it has been separated.

**187. Butter, ladled.** — "The product commonly known as ladled butter is a grade of butter made by mixing and reworking different lots or parcels of butter so as to secure a uniform product. This is known by various names to the trade. This product will not be held to be renovated butter unless in addition to being reworked it is melted and refined."[1]

[1] Regulations No. 9, U. S. Internal Revenue, p. 87, July, 1907.

**188. Butter, ranch.** — This product is made on ranches. "Ranch" butter of the western states is the same as "dairy" butter of the central and eastern states.

**189. Butter, renovated, or process.**[1] — "Regulation 1. The Act of May 9, 1902, gives to the manufacturer of renovated or process butter the option to call the product renovated butter, or to call it process butter. Regulation 2. The following explanation of the definition of renovated butter, as it occurs in the law, is adopted for guidance in connection with these regulations:

"(*a*) This grade or kind of butter may be made from one or more lots or parcels of butter which has been or have been subjected to any process by which it is melted, clarified, or refined, and made to resemble genuine butter always excepting 'adulterated' butter as defined by this act. It may or may not have common salt and harmless artificial coloring added.

"(*b*) The law defines three processes of refining butter, which, if used, make the resultant article adulterated butter, in contradistinction to renovated butter, as follows:

"First, if in any way, any acid, alkali, chemical, or any substance whatever is introduced or used for the purpose or with the effect of deodorizing or removing therefrom rancidity; second, if there is mixed any substance foreign to butter with intent or effect of cheapening in cost the product; and third, if, in any way, the product is made to contain abnormal quantities of water, milk, or cream."

**190. Butter, sweet.** — Sweet butter is the unsalted product. This term is a misnomer. Originally, sweet butter was made from sweet cream to which no arti-

[1] Regulations No. 9, U. S. Internal Revenue, p. 99, July, 1907.

ficial color had been added and in which no salt had been mixed.

**191. Butter, sweet cream.** — This is made of cream that has not been ripened or soured. This cream should not contain over .3 per cent acid. The butter may or may not contain salt and may or may not be colored artificially.

**192. Butter-trier.** — An instrument used to obtain a sample of butter to inspect. It is made of metal and is of such a shape that a long round plug may be pulled from the butter.

**193. Butter, whey.** — Whey butter is made from the cream separated from the whey of cheese.

**194. Butter, whole-milk.** — Whole-milk butter is that made in a creamery where the milk has been separated in the creamery and not on the farms.

**195. Buttermilk.** — "Buttermilk is the product that remains when butter is removed from milk or cream in the process of churning."[1]

**196. Buttermilk, artificial or commercial or cultured.** — Such buttermilk is made of skimmed-milk which may contain more than the usual amount of fat. This skimmed-milk must be ripened. If known as cultured buttermilk, it must be ripened by the introduction of certain micro-organisms.

**197. Centralizer.** — This is a factory in which centralizer butter is manufactured.

**198. Cheese.** — "Cheese is the sound product made from whole, part skimmed, or skimmed-milk, goat's milk, or the milk of other animals, with or without added cream, by coagulating the casein with rennet, lactic acid, or other suitable enzyme or acid, and with or without

[1] Standards of Purity for Food Products, U. S. Dept. Agri., Off. of Sec., Cir. 19, June 26, 1906.

the further treatment of the separated curd with ripening ferments, special molds or seasoning." [1]

**199. Cheesery or cheese factory** is an establishment in which cheese is made.

**200. Commission merchant.**—A commission merchant is similar to a butter-dealer in that he sells at wholesale. A commission merchant in the true sense sells the butter for the shipper and charges a commission for the transaction of the business. Approximately 5 per cent of the wholesale price is the usual commission. At present there are not many commission merchants.

**201. Cream.**—"Cream is that portion of milk, rich in milk-fat, which rises to the surface of milk on standing, or is separated from it by centrifugal force, is fresh and clean and contains not less than eighteen (18) per cent of milk-fat." [2]

**202. Creamery.** — A creamery is a factory in which creamery butter is produced.

**203. Dairy.** — A dairy is a place, usually a farm, where milk-producing cows are kept. The word is sometimes erroneously applied to the place (room, kitchen or building) in which dairy products are manufactured.

**204. Homogenized milk or cream.** — "Homogenized milk or cream is milk or cream that has been mechanically treated in such a manner as to alter its physical properties with particular reference to the condition and appearance of the fat globules." [1]

**205. Margarine.** — "That for the purposes of this act certain manufactured substances, certain extracts, and certain mixtures and compounds, including such

[1] Definitions and Standards, The Dairy Record, Vol. 19, No. 1, June 6, 1917.

[2] Standards of Purity for Food Products, U. S. Dept. Agri., Off. of Sec., Cir. No. 19, June 26, 1906.

mixtures and compounds with butter, shall be known and designated as 'Oleomargarine,' namely: All substances heretofore known as oleomargarine, oleo, oleomargarine-oil, butterine, lardine, suine, and neutral; all mixtures and compounds of oleomargarine, oleo, oleomargarine-oil, butterine, lardine, suine, and neutral; all lard extracts and tallow extracts; and all mixtures and compounds of tallow, beef-fat, suet, lard, lard-oil, vegetable-oil, annatto and other coloring matter, intestinal fat, and offal fat made in imitation or semblance of butter, or when so made calculated or intended to be sold as butter or for butter." [1]

**206. Milk.** — "Milk is the natural food of the young of Mammalia. It is secreted in the mammary glands of the female parent during a more or less extended period after parturition." [2]

The following is the definition of milk in terms of the law: [3] "Milk is the fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and ten days after calving, and contains not less than eight and one-half (8.5) per cent of solids not fat, and not less than three and one-quarter (3.25) per cent of milk-fat."

**207. Milk-fat.**[2] — "Milk-fat, butter-fat, is the fat of milk and has a Reichert-Meissl number not less than twenty-four (24) and a specific gravity not less than

$$0.905 \frac{40° \text{ C.}}{(40° \text{ C.})}."$$

[1] Regulations No. 9, U. S. Internal Revenue, p. 23, 1907. Sec. 2, Acts of Aug. 2, 1886, and May 9, 1902.

[2] Pearson, R. A., Cyclopedia of American Agriculture, Vol. III.

[3] Standards of Purity for Food Products, U. S. Dept. Agri., Off. of Sec., Cir. No. 19, June 26, 1906.

**208. Milk plant.** — A place where liquid milk is the major product handled.

**209. Over-run.** — The increase in butter over and above the butter-fat paid for is over-run. It may be defined as the sum of the moisture, salt, and casein minus the losses in manufacture.

**210. Pasteurization** is the process of heating a liquid to such temperature and for such a period of time that nearly all the micro-organisms in it are killed. It includes the cooling of the liquid. There are two systems of pasteurization in dairying: first, the continuous method, which consists of heating the milk or cream to 160° F. to 185° F. for an instant and in cooling immediately; second, the holder method, which heats the milk or cream to 145° F., holding it at this heat for thirty minutes, and cooling it immediately to the desired temperature.

**211. Patron.** — A person who sells his milk or cream to a dairy concern.

**212. Receiver.** — A receiver is a wholesale dealer or jobber; when selling butter, he is a butter-dealer.

**213. Skimmed-milk.** — "Skimmed-milk is milk from which a part or all of the cream has been removed and contains not less than nine and one-quarter (9.25) per cent of milk solids." [1]

**214. Starter** is a medium containing desirable bacteria for the ripening or souring of dairy products.

**215. Sterilization** is the process of killing all the micro-organisms. In the handling of dairy products, this is accomplished by heat, usually with steam. It should be noted that for want of a better term this word is often

[1] Standards of Purity for Food Products, U. S. Dept. Agri., Off. of Sec., Cir. No. 19, June 26, 1906.

used erroneously in connection with cleansing dairy apparatus. It is not always possible to sterilize a utensil with steam unless it is placed under a pressure of ten pounds for thirty minutes. This gives a temperature of 110° C. The expression "thoroughly scalding" is suggested for the process of holding a dairy utensil in boiling water for a minute or two, or of rinsing carefully with boiling water, such as flushing a vat or steaming a can.

**216. Thoroughly scalding** is the process of heating with steam or hot water to such a temperature that nearly all the micro-organisms are killed. It is not sterilization.

# CHAPTER XVII

## *TESTING*

TESTING in connection with the manufacture of butter consists in the use of the Babcock test for determining the quantity of milk-fat in whole milk, cream, skimmed-milk, butter, and buttermilk; moisture and salt tests for butter; and acidity tests for milk and cream. The most essential test is the determination of milk-fat, for this is the main constituent of butter. Creameries buy milk and cream on the basis of their fat-content. The fat test for butter is not in general use. When employed, the purpose is usually to determine whether the composition of butter is within the requirements of the law. One reason why the Babcock test, which is the simplest one for fat, is not used for testing butter, is that the technique is not as simple as that of the moisture test. Simplicity is essential for a layman, such as a creamery operator.

The holding of samples for any test is important. If they are to be kept for one or two days or for a longer period, they should be put in glass bottles with ground glass stoppers so that interchange of moisture between the samples and the air may not take place.

**217. Important factors in Babcock test.** — The Babcock test for milk-fat consists in: (1) Obtaining a representative sample; (2) taking the proper amount for a test; (3) the addition of the proper amount of sulfuric acid to destroy the solids not fat; (4) proper centrifuging to force the heavier substances in the acid solution to the bottom of the test bottle, thus crowding the lighter constituent, the fat, into the graduated neck; (5) careful addition of water to the liquid, when forcing the fat into the neck of the bottle; (6) proper reading.

**218. Handling of composite samples.** — Composite samples should be held in glass bottles with ground glass stoppers as mentioned above. A preservative such as corrosive sublimate (mercuric chloride) should be used in sufficient quantities to prevent the souring of the milk. It is good practice to shake the sample each time a portion is added in order to distribute the preservative throughout. A rotary motion should be used in this agitation, since it is desirable that a minimum amount of milk or cream be splashed on the sides of the bottle. When this happens, milk or cream clings to the sides of the bottle above the surface of the sample and is likely to become dry and leathery; thus it is in bad condition to prepare for testing. Coloring matter should be used in the preservative as a warning that poison is present. All specially prepared preservatives for composite samples have this added color. The mercuric chloride is of course very poisonous.

**219. Sampling sour milk and cream.** — Milk so sour that it is curdled cannot be sampled properly without special precaution. Milk that is sour but not curdled may be correctly sampled. However, it should be tested soon after it is sampled. Sour cream is hardly as difficult to sample as sour milk; nevertheless it is more readily handled when it is sweet.

**220. Sampling frozen milk and cream.** — According to Ross and McInerney,[1] partly frozen milk should never

[1] Ross, H. E., and McInerney, T. J., The Babcock Test, with Special Reference to Testing Cream, Cornell Univ. Agri. Exp. Sta., Bul. 337, p. 35, 1913.

be sampled for testing, since such sample will not be representative. It is said that such milk should be melted and carefully remixed before any is taken for a test, but in melting the ice a temperature of not over 85° F. should be employed. Too high temperature is likely to melt the fat and cause a separation in the form of an oil. When this happens, it is almost impossible to remix it evenly with the milk.

If milk is allowed to stand several hours before freezing, the fat will rise to the surface and form a cream line. If this line freezes, the ice will be rich in fat. If the milk is agitated while freezing, the ice formed will be low in fat, since freezing tends to squeeze the fat out of the ice. Thus the liquid portion contains a greater proportion of fat than the ice. If the creamery-man samples frozen milk, he is likely to pay for more fat than he actually receives. In the following table, Ross and McInerney[1] compare the percentages of fat found in samples of partly frozen whole milk:

TABLE XXVIII — PERCENTAGE OF FAT FOUND IN MILK IN VARIOUS CONDITIONS AS TO FREEZING

| Sample | Percentage of Fat | | |
|---|---|---|---|
| | In Original Milk | In Partly Frozen Milk | |
| | | Liquid part | Ice |
| 1 | 2.9 | 3.1 | 2.6 |
| 2 | 3.9 | 4.2 | 3.2 |
| 3 | 4.7 | 5.0 | 3.7 |
| 4 | 1.8 | 1.9 | 1.6 |
| 5 | 2.3 | 2.5 | 2.2 |
| 6 | 4.7 | 5.0 | 4.1 |
| 7 | 3.7 | 4.4 | 3.0 |
| 8 | 3.2 | 3.5 | 3.3 |
| 9 | 3.6 | 3.8 | 3.2 |
| 10 | 4.2 | 4.3 | 3.9 |

[1] Ross, H. E., and McInerney, T. J., The Babcock Test, etc., Cornell Univ. Agri. Exp. Sta., Bul. 337, p. 35, 1913.

It should be noted that the smallest difference between the liquid part and the ice is .2 per cent and the greatest 1.4. Probably the variation in frozen cream is much greater.

**221. Sampling whole milk.** — When testing a single batch of whole milk, it must be agitated thoroughly before a sample is taken. In taking a composite sample in the usual way in creameries, it is a question whether it pays to take the time to agitate the milk after it has been poured into the weigh-can, for it seems that if the portion placed in the composite sample is lower in fat than the average of the batch of milk from which it is taken on one day, it may be a little higher the next day. Thus at the end of fifteen days, which is the usual time in creameries between tests, the composite test would be the same whether the daily batches were thoroughly agitated or not stirred at all. In this relation Potts[1] first discusses the limit of error in reading in relation to the error of sampling. He says it is impossible in our present test-bottles for whole milk to read closer than .1 per cent, that a sample may really test .05 per cent higher or lower in fat than it is read, and that likewise another sample may test .05 per cent lower or higher than it is read. Therefore, there might be a difference of .1 per cent due to reading the first sample too high and the second sample too low. In like manner in testing cream in the six-inch test-bottles graduated to read to 50 per cent, it would be necessary to allow .5 per cent as a reading error. The following figures show the results of different methods of obtaining composite samples in comparison with a daily sample and test. Composite sample A was taken with a little dipper

[1] Potts, A. E., Sampling of Milk, Thesis in Cornell Univ. Library, 1913.

which was attached to the stirring-rod or agitator; composite sample B with a metal tube which drew very nearly an aliquot portion; composite sample C rather carelessly with a McKay sampler. The McKay sampler bends fairly easily and soon begins to leak; therefore, the samples procured with it were taken in the usual rapid way of creamery practice.

TABLE XXIX — SUMMARY OF SEVEN DAY COMPOSITES

| Samples | Pounds of Milk | Pounds of Fat | Average Fat Test of Milk | Number Patrons Receiving More by Composite than by Daily | Number Patrons Receiving Less by Composite than by Daily | Pounds Fat More by Daily than by Composite |
|---|---|---|---|---|---|---|
| Daily | 27,029 | 1187.094 | 4.391 | — | — | — |
| Composite A | 27,029 | 1176.411 | 4.352 | 23 | 37 | 10.683 |
| Composite B | 27,029 | 1179.340 | 4.363 | 22 | 38 | 7.754 |
| Composite C | 27,029 | 1185.150 | 4.384 | 32 | 28 | 1.944 |

It should be noticed that the readings of the average fat test of the milk are very close. This milk was delivered by sixty patrons. There were 420 daily and sixty composite tests made. Potts shows further figures which record results similar to the above. The samples were obtained from sixty-six patrons in the same manner as in the above case, excepting that the experiment continued fourteen instead of seven days.

Here again the readings of "average fat test of milk" are seemingly very nearly the same. They would all be read 4.00 per cent fat on a milk test-bottle. It might seem that better results would be obtained in a seven-day than in a fourteen-day composite sample. However, it should be noted that these are the results of only two series of experiments. It may also appear that there is a loss of fat to the farmer by the composite method of sampling milk. On the other hand, it should be noted that all the tests in both tables are within the limit of error in reading. The most interesting item to be noticed in these tables is the close comparison of the different methods of composite sampling.

TABLE XXX — SUMMARY OF FOURTEEN DAY COMPOSITES

| Samples | Pounds of Milk | Pounds of Fat | Average Fat Test of Milk | Number Patrons Receiving More by Composite than by Daily | Number Patrons Receiving Less by Composite than by Daily | Pounds Fat More by Daily than by Composite |
|---|---|---|---|---|---|---|
| Daily | 80,638 | 3325.625 | 4.131 | — | — | — |
| Composite A | 80,638 | 3251.851 | 4.039 | 10 | 56 | 73.774 |
| Composite B | 80,638 | 3220.397 | 4.00 | 12 | 54 | 105.228 |
| Composite C | 80,638 | 3255.241 | 4.044 | 13 | 53 | 70.384 |

Kent [1] compared the daily and the composite testing for a period of thirteen days. There were fifty-two patrons. Three samples were taken as follows from the milk delivered by each patron: a daily sample, a composite sample for which the daily portions were obtained with a small dipper, and a composite sample for which the daily portions were secured with a Scoville sampling tube. The average daily test was 4.01 per cent, the dipper

[1] Kent, F. L., Testing Milk and Cream, Oregon Agri. Exp. Sta., Bul. 70, 1902.

composite sample test 3.95 per cent, and the composite sample taken with the Scoville sampler tested 4.00 per cent. Thus the daily test was again slightly higher than the others, but it was well within the limit of error in reading. These small differences might be explained in the following way: There is a natural tendency to read a test high in the same way that it is natural to give a small over-weight or slight over-measure when weighing or measuring butter or any other article. As long as there were seven-, fourteen-, and thirty-day periods respectively, there would be seven, fourteen, and thirty times as many readings to make in the daily as in the composite samples. Thus there might easily be a difference of the above amounts of fat due to this one reason.

**222. Testing whole milk.** — The following are the steps for testing whole milk for fat: 1. Agitate the sample thoroughly in order to obtain a representative portion.

2. With the regular milk pipette, measure out 17.6 c.c. of milk and put it into the test-bottle.

3. With an acid measure add the sulfuric acid (commercial $H_2SO_4$, Sp. G. 1.82 to 1.83) to the milk in the test-bottle, being careful to hold the bottle in such a way that the acid will run down the sides of the neck and the bowl rather than to allow it to go directly into the milk. When the acid is added in this way it will go to the bottom of the bottle and rise under the milk; thus the fat is not so likely to be scorched as when the acid is poured immediately into the milk. The test-bottle should be revolved slowly when the acid is being added in order to carry down any milk that may adhere to the neck of the bottle. The exact amount of acid to add depends largely on the temperature of the acid and of the milk. If the temperatures are high, less acid is necessary than

when they are normal. On the other hand, when the temperatures are low, a slightly larger amount of acid may be used.

4. Shake the test-bottles until the milk and acid are thoroughly mixed. It is difficult to secure a clear test if the agitation of the acid and milk has not been thorough. A rotary motion should be used so as not to fill the neck of the bottle with coagulum.

5. Place the test-bottles in the centrifuge and revolve it at the required speed as indicated by the directions on the machine.

6. After centrifuging for five minutes, stop the machine and fill each to the shoulder with warm or hot water as the conditions may require. The temperature of the water will depend on that of the machine and of the room. If the centrifuge is very hot, due to poor steam exhaust, the water should probably not be above 110° to 120° F. In the hot summer season, when the milk and the acid are warm, the temperature of this water should be about 110° F. and not boiling.

7. Revolve the centrifuge at the required speed.

8. At the end of two minutes of centrifuging at full speed, stop and fill the test-bottles with hot water. The fat should be raised toward the top of the graduation in the neck of the bottle. Care must be taken to prevent the overflowing of the test-bottles.

9. Revolve the centrifuge for one minute at the required speed.

10. Read the tests, which should now have clear distinct lines. The fat should be a straw-yellow color and the liquid under the fat should be as clear as crystal. The tests should be read as they are taken from the centrifuge and before they are cooled. The reading should

include the fat within the top of the meniscus and what would constitute a straight line at the bottom of the fat.

11. Record the readings.

**223. Sampling cream.** — Cream is more sticky than whole milk. It clings to the agitators, cans, bottles, and the like, in such a way that it is hard to sample. This is especially noticeable when the cream is sour and the body is heavy and sticky. There has been more or less discussion concerning some of the essentials in sampling cream. Recently Scoville[1] made investigations on this subject under the heading of "Difference in Sampling Cream when Cold and Thick or Warm and Fluid." He states that some of the cream was very nearly a solid mass when received at the creamery. In such condition it was impossible to stir properly, so a sample was taken with a McKay sampling tube which had been warmed in hot water. This tube took a column of cream from the top to the bottom of the can, and when the tube was warmed it discharged practically all the cream. He calls attention to the fact that this is a practice followed in some creameries and that the question arises as to its accuracy, whether it is possible to secure an accurate sample in this manner or whether the serum on standing settles to the bottom, thus making the test read high. The experimental cream that Scoville used was obtained from a station which was separating a very heavy cream. Each can was sampled after stirring as well as possible while the cream was cold and heavy. Then it was warmed gradually in warm water to a temperature of approximately 85° F. During this time the cream was stirred carefully so as not to churn it, until it became less thick

[1] Scoville, R. I., Some Factors Affecting the Over-run in Creameries, A Thesis in Cornell Univ. Library, p. 18, 1916.

and more fluid, at which time another sample was taken. Both samples were obtained with a McKay sampling tube. The following table shows the results:

TABLE XXXI — THE EFFECT OF WIDELY VARYING TEMPERATURES ON SAMPLING CREAM

| Number of Determinations | Average Temperature of Cold Cream | Average Temperature of Warm Cream | Average Test of Cold Cream | Average Test of Warm Cream |
|---|---|---|---|---|
| | | | *Per Cent* | *Per Cent* |
| 83 | 56.5° F. | 85.5° F. | 50.66 | 50.86 |

One peculiar fact these figures show is that the test of the warm cream is slightly higher than that of the cold. In theory the cold cream should test more than the warm, as it is logical to think that the cream in the bottom of the can would be thinner than on the surface, for cold cream is difficult to agitate. If there is thin cream at the bottom of the can and if the McKay sampling tube should leak this from the lower end, the test would be a little higher.

Scoville also published data on sampling cream that stood twenty-four hours. This was always sour, fairly cool, and was quite thick. The following is a summary of his figures:

TABLE XXXII — A COMPARISON OF SAMPLING CREAM AFTER STANDING TWENTY-FOUR HOURS

| Number of Determinations | Average Test of Cream Taken with McKay Tube before Stirring | Average Test of Cream Taken with McKay Tube after Stirring | Average Test of Cream Taken with Dipper after Stirring |
|---|---|---|---|
| | *Per Cent* | *Per Cent* | *Per Cent* |
| 35 | 41.69 | 41.55 | 41.88 |

These tables show that there is very little difference in the test of the cream, whether thoroughly agitated, partially mixed or not stirred at all. The latter table also shows that there is very little difference in the test of the cream when the sampling is made with a McKay sampling tube, which is supposed to obtain very nearly an aliquot sample, and the little, easily handled, inexpensive sampling dipper.

The question of the advisability of composite sampling of cream is still unsettled. Hunziker [1] thinks that it is not satisfactory largely from the standpoint of creamery records, because the amount of fat in the cream should be known every day. From the viewpoint of accuracy, this method of sampling cannot be criticized if made properly. The sample jar or bottle must be air-tight. Ground glass stoppers are absolutely essential. Lee and Hepburn [2] have probably done the most extensive work on the composite sampling of cream. Their comparisons of daily and composite tests were on the cream of seventy-seven patrons, and their work covered a period of one year. Their results show a marked tendency for variation between composite and individual sampling for short periods, but that the distribution of this variation is such as to occasion very small amounts of difference when figured on seasonal periods. Their figures indicate that composite samples tend to test slightly higher than individual ones in summer, and lower in winter. The yearly average shows practically no difference between the composite and individual samples.

[1] Hunziker, O. F., Testing Cream for Butter Fat, Purdue Univ. Agr. Exp. Sta., Bul. 145, p. 552, 1910.

[2] Lee, C. E., and Hepburn, N. W., Comparison of Methods of Sampling Cream for Testing, Ill. Agri. Exp. Sta., Bul. 153, pp. 547 and 574, 1912.

Scoville [1] also found that there is very little difference in the amount of fat in the cream when sampled individually or compositely. The following table shows the results of his work. Each composite sample was composed of portions taken from two to six cans of cream:

TABLE XXXIII — A COMPARISON OF INDIVIDUAL AND COMPOSITE SAMPLING OF CREAM

| NUMBER OF COMPOSITE SAMPLES | NUMBER OF INDIVIDUAL SAMPLES | COMPOSITE SAMPLE | INDIVIDUAL SAMPLE |
|---|---|---|---|
| | | Pounds Fat | Pounds Fat |
| 20 | 83 | 3,183.50 | 3,169.71 |

This table shows a difference of 13.79 pounds of fat during the twenty days or a little over .4 per cent of the entire amount of fat in favor of the patrons. This is the opposite of what Lee and Hepburn [2] found, for, according to Lee's readings, the composite fell below the daily test .27 per cent and, according to Hepburn, the composite samples showed .16 per cent less fat than in the daily sample.

The composite sampling of cream seems to be as accurate as testing the daily or individual samples, and it is evidently as satisfactory as the composite method of sampling whole milk. Again, the time-saving feature of composite testing should be emphasized. It is true that in many creameries it would not be possible to keep good daily records without a daily test of each patron's cream,

[1] Scoville, R. I., Some Factors Affecting the Over-run in Creameries, A Thesis in Cornell Univ. Library, p. 21, 1916.

[2] Lee, Carl E., and Hepburn, N. W., Comparison of Methods of Sampling Cream for Testing, Ill. Agri. Exp. Sta., Bul. 153, p. 574, 1912.

whereas in other factories the record keeping would be even more simple if the composite method were in force.

**224. Testing cream.** — The testing of cream for fat by the Babcock method is similar to that of testing milk. Some of the steps require modification. The procedure should be as follows:

1. Agitate the sample thoroughly in order to obtain an aliquot portion to test. If the cream is cold, it should be warmed to 80° or 85° F.

2. Weigh 9 grams of the cream into the test-bottle. The bottle that is now in common use is graduated to read to 50 per cent and the reading is obtained directly if 9 grams of cream are used. It is necessary to have delicate scales and they must be maintained in a sensitive condition. Only one bottle should be weighed at a time. Many creameries use scales that weigh as high as twelve bottles at once. Scales that carry so many bottles are not as delicate as the smaller ones, and there is greater opportunity for error when several bottles are balanced at one time. The purposes of weighing instead of measuring cream as practiced with milk are: (*a*) cream is so sticky that it cannot all be discharged from the pipette; (*b*) the specific gravity is variable, for it may test 15 or 16 per cent or may contain 60 per cent fat or more; (*c*) cream contains variable quantities of air. Therefore, all cream samples should be weighed. They should never be measured.

3. Add cold or warm water or do not add any, depending on conditions and the results of experience. If the centrifuge becomes very warm on account of poor exhaust of steam, or in very warm weather, cold water may be used. Ordinarily the water should be sufficiently warm to melt the fat in the neck of the cream test-bottle so as to

carry it down into the acid solution. The amount of water necessary to dilute the cream depends on the percentage of fat in the cream, and on the method usually followed by an operator. Often a creamery operator will add approximately 9 c.c. of water to 9 grams of cream. Many creamery-men do not add water; thus less acid is necessary, which is a saving of expense and time. Ordinarily at least a few cubic centimeters of water should be put into the cream.

4. Add the sulfuric acid. The amount necessary depends largely on the quantity of water used in step 3, and on the temperatures of the cream and acid. Usually 9 grams of cream and 9 c.c. of water require about 2 or 3 c.c. less acid than whole milk, or 14 or 16 c.c. If no water is added, approximately 8 c.c. of acid is sufficient. There should be enough acid added to bring the color of the solution and cream to a chocolate brown shade.

Steps 5, 6, 7, 8, 9, and 10 are the same as steps 4, 5, 6, 7, 8, and 9, under "Testing whole milk," par. 222.

5. Place the test-bottles in a specially constructed tank or bath for maintaining uniform temperatures, after the water in the bath has first been regulated to the proper heat. According to Hunziker,[1] the temperature of the fat when read should be 135° F. Ross and McInerney [2] state that the temperature of the fat at this time should be between 140° and 150° F. for at least three minutes. This means that the tempering water should be raised as high as the top of the fat column in the test-bottles and that

[1] Hunziker, O. F., Testing Cream for Butter Fat, Purdue Univ. Agri. Exp. Sta., Bul. 145, p. 591, 1910.

[2] Ross, H. E., and McInerney, T. J., The Babcock Test with Special Reference to Testing Cream, Cornell University Agri. Exp. Sta., Bul. 337, p. 41, 1913.

the bottles should remain in the water at 140° F. for at least three minutes.

6. Add the meniscus-remover, which is a light oil such as the best grades of separator oils. The original oil used was glymol, known commonly under the name of white mineral oil. This oil should be colored to aid in reading. Alkanet root, which gives a red color, is very satisfactory for this purpose. Approximately .5 c.c. of the meniscus-remover should be added to each test-bottle while it is still in the tempering bath and just before it is time to read. Care must be observed in adding the meniscus-remover. If allowed to drop directly on the fat, the force of the fall will cause it to penetrate into the fat. It should be allowed to run down the neck of the bottle and from there it will spread over the fat and produce a distinct and flat line of division between the fat and the oil. A cream test should never be read without the meniscus-remover.

7. Read the fat from the bottom of the column as noted under "Testing whole milk" to the distinct line of demarcation at the top, which is between the fat and the meniscus-remover. The reading of each test should be made immediately after taking the test-bottle from the tempering bath, for the temperature of the fat will soon drop below 140° F. when held at room heat.

8. Record the readings as each test is read.

**225. Sampling skimmed-milk and buttermilk.**—These products are easily sampled, for the fat globules in them are so small that they do not come to the surface readily. The most accurate way to obtain these samples is to take them from the tank into which ether has been run. However, in general practice they may be satisfactorily sampled by occasionally taking a portion, in case of the skimmed-milk, as it flows from the separator, or in the case of buttermilk, as it is drawn from the churn. A drip sample is often the most convenient method of obtaining skimmed-milk to test. This is taken as follows: a small pail is hung under a hole in the lower side of the skimmed-milk spout of the separator; a portion of the skimmed-milk will drip through this hole into the pail.

**226. Testing skimmed-milk and buttermilk.** — The testing of these products is similar to that of testing whole milk, with the exception of steps 3 and 6. In testing whole milk, a measure of 17.5 c.c. of acid is used as noted in step 3, while in testing skimmed and buttermilk about 2 c.c. more acid is necessary, because there is a greater amout of solids not fat to be destroyed. When testing whole milk, the centrifuge is run for five minutes during the first run as directed in step 6. According to Ross and McInerney,[1] skimmed-milk should be centrifuged ten minutes during the first run. This should also be true of buttermilk. The centrifuge should be operated the same periods of time in the second and third runs as in testing whole milk. The reason for a longer time being required in centrifuging skimmed and buttermilk is that the fat globules which remain in these products are small and are not readily brought into the neck of the test-bottle. It must be remembered that special bottles should be used in testing skimmed and buttermilk, and that when they are placed in the centrifuge, the funnel tubes and the graduated necks should be put on the same plane. This permits the fat to rise more readily in the graduated neck than if the bottles were placed in some other position.

[1] Ross, H. E., and McInerney, T. J., The Babcock Test with Special Reference to Testing Cream, Cornell Univ. Agri. Exp. Sta., Bul. 337, p. 35, 1913.

**227. Sampling butter.** — The fat-content of butter is variable. Lee, Hepburn, and Barnhart [1] show that the variation in the fat-content from one churning in which ten samples were taken was 83.15 per cent in the lowest test and 84.57 per cent in the highest. In another churning, from ten samples, the percentage of fat varied from 80.82 in the lowest to 83.58 in the highest. It is apparent, therefore, that carefulness in the sampling of butter for a fat test is essential. It is well when obtaining a sample from the churn to take at least twelve portions. In sampling butter from the churn, a hardwood spatula may be used. The top of the butter should be cut back with a ladle, thus freeing it of loose moisture that may have dropped on it from the churn. Then the portion may be taken with the spatula. If the butter is in tubs and it is desired to sample the entire churning from these tubs, the sample may be taken with a trier if the butter has first been chilled. The trier plug should extend diagonally from one side at the top to the opposite side at the bottom of the tub. The top two inches of the plug should be returned to the hole so that the package may not be defaced. Each tub of the churning should be bored. If this method of sampling is followed in daily practice, too much butter is used and the buyer is likely to complain. The method of sampling for the daily record employed in the Cornell University creamery laboratory is to remove a small portion with the wooden spatula from each tub, or from each printerful. Thus from ten to forty portions are taken for a single sample from one churning. The portion is secured from the top of the tub or printerful after the butter is cut with a wire and rolled up to be

[1] Lee, Carl E., Hepburn, N. W., and Barnhart, Jesse M., Univ. of Ill. Agri. Exp. Sta., Bul. 137, p. 322, 1909.

removed. If only one tub or other package is to be examined and an especially accurate test is desired, it is advisable to take two or three plugs at least, extending from one side of the package at the top diagonally to the opposite side at the bottom.

The sample should be put in a glass bottle with a ground glass stopper. This must be closely observed in order to prevent evaporation of moisture. It is essential that the bottle should have a large opening to permit easy stirring of the butter when it is being prepared for testing. It is also important that the shoulder of the bottle is not so deep that the butter may collect under it in the preparatory process.

**228. Testing butter.** — The following are the steps in testing butter for fat:

1. Prepare the sample by holding the jar in a pail of water at a temperature of 110° to 120° F. until the butter is the consistency of thick cream. During this time the sample should be agitated. A hardwood spatula is a convenient tool for this purpose. The stirring should be sufficient to make a uniform mass of the butter, and when a portion is taken for the test it will be representative of the sample. If care has been exercised in warming the sample, so that it is not too soft, it will not be necessary to cool it during the latter part of the agitation. Time may be saved if the operator is watchful and does not permit the fat to become too soft.

2. Weigh the proper amount of butter from this prepared sample on sensitive scales in a special butter or cream test-bottle. If a cream bottle is used, 4.5 grams of butter should be taken. It is advisable to warm the neck of the test-bottle with dry heat so that the butter will slide into the bottle.

3. Add about 13.5 c.c. water when 4.5 grams butter are used. The temperature of this water should be 100° to 120° F. so as to melt the fat.

4. Add sufficient acid to give the solution a very light shade of brown color, as there is very little solids not fat, to cause a change in color.

The remaining steps are the same as for testing cream. It must be remembered, when reading the test, that if it has been made in a 9-gram cream bottle and 4.5 grams of butter were used, the reading must be multiplied by 2.

### MOISTURE TEST OF BUTTER

The amount of moisture in butter is important only in the final product. It is not of special concern in the whole milk, cream, and the like. Inasmuch as the moisture test is simple and as heretofore the fat test of butter has been somewhat difficult of technique in the hands of the layman, the moisture has been the constituent controlled by law.

**229. Sampling.** — The sampling of butter for moisture tests should be carried out as outlined above for "sampling butter" for the milk-fat determination (par. 227). In this test also it is very essential that the sampling be made properly, for the moisture in butter is variable. According to researches by Guthrie and Ross [1] of fifty-one packages, nine, or 17.6 per cent, showed a difference of 1 per cent or more of moisture in adjacent samples, and in eleven packages or 21.6 per cent there was a difference of 1 per cent or more between the lowest and the highest moisture tests. Lee, Hepburn, and

[1] Guthrie, E. S., and Ross, H. E., Distribution of Moisture and Salt in Butter, Cornell Univ. Agri. Exp. Sta., Bul. 336, p. 21, 1913.

Barnhart[1] found that there is a variation in the moisture-content, ranging from 0.1 to 1.0 per cent, between different samples representing the same butter. The average variation was about 0.5 of one per cent. This serves to show that the operator should be careful to take many portions in securing a sample.

**230. Testing.** — The following are steps in testing butter for moisture:

1. This is the same as step 1 in testing butter for milk-fat, par. 228.

2. Weigh the desired amount of butter from this prepared sample into a special cup that has been thoroughly dried. The usual quantities are 10 or 20 grams. Under the average conditions, it is best to weigh 10 grams in the light aluminum cup which is about 2½ inches high by about 2½ inches in diameter at the top. Such a cup heats and cools quickly. The best scale for the creamery is the moisture-test torsion balance.

3. Place the cup in an oven, such as a hot water or electric oven, or put it on an asbestos pad over an alcohol or gas flame, or hold it over a low naked flame. In the average creamery, a low flame in an alcohol burner is the most satisfactory. This flame may be naked or an asbestos pad may be used, as conditions warrant. It is best not to shake the sample very much when being heated. If shaken too much, it is more likely to effervesce or bubble over than when shaken only occasionally.

4. The end point has been reached in the heating process when the color becomes chocolate brown. The casein on the surface should be in small portions at this stage and

[1] Lee, Carl E., Hepburn, N. W., Barnhart, Jesse M., A Study of Factors Influencing the Composition of Butter, Univ. Ill. Agri. Exp. Sta., Bul. 137, p. 314, 1909.

when heated over a low flame no bubbles of moisture and air should leave the fat. The determination of the completion of the drying process is not difficult and a butter-maker may soon learn by experience to recognize it.

5. Put the cup in a desiccator or set it on a dry place until the cup and fat have cooled. In the average creamery where there is no desiccator, the cup should be put on a dry shelf and a flat piece of paper placed on the top of the cup. This paper should be sufficiently wide completely to cover the cup and thus practically prevent any moisture of the air from getting into the cup. A thin aluminum cup will cool in about five minutes. It should be weighed soon after cooling, unless it is in a desiccator where the air is thoroughly dry. The reasons why the fat and cup must be cooled are that the specific gravity of the butter and cup increases as the temperature drops, and thus they become heavier. A current of warm air also goes up from the hot cup and butter, which causes them to weigh lighter than when they are cool and no current of air rising from them. When running a preliminary churn test, the final reading may be obtained when the cup and butter are hot. When this is done, a correction must be made. In case a light aluminum cup is used, the reading is likely to be .3 per cent higher when the sample is hot than when it is cool. Thus a moisture test that would read 14.5 per cent when just taken from the flame would read 14.2 per cent when cool. This latter reading would be the correct one. The reading of the preliminary churn test when hot saves time, and it is sufficiently accurate to be satisfactory at this stage of the manufacture of butter. If a heavier cup is used, the butter-maker may ascertain by a little experimental work what the correction should be.

6. Weigh the dried butter. If the scales are graduated to read the results directly in percentage, it is easy to obtain the final reading. If the scales are not so graduated, computation must be made.

7. Record the results.

### SALT TEST OF BUTTER

The salt test is not used in many creameries. However, in the largest and best organized ones it is constantly employed, for the butter-maker wishes to obtain a uniform salt-content from churning to churning and also desires to make the over-run as large as possible.

**231. Sampling.** — The same precaution should be observed in sampling for the salt test as in the fat or the moisture test. The variation of salt within a single package of butter is greater than many persons realize. According to Lee, Hepburn, and Barnhart,[1] in the two churnings referred to above, when there were ten samples taken in churn A, the variation in salt was 1.56 to 2.06 per cent, and in churn B, 1.97 to 2.68 per cent. Guthrie and Ross[2] report that in 36.2 per cent of the fifty-one packages examined there was a difference of .2 per cent salt in adjacent samples, and 46.8 per cent of the packages contained a difference of .2 per cent salt between the lowest and the highest tests. When moisture tests are made, the same sample may be used for the salt determination. If a moisture test has not been made, the sample should be taken as described under "sampling butter," par. 227.

[1] Lee, Carl E., Hepburn, N. W., and Barnhart, Jesse M., Univ. of Ill. Agri. Exp. Sta., Bul. 137, p. 322, 1909.

[2] Guthrie, E. S., and Ross, H. E., Distribution of Moisture and Salt in Butter, Cornell Univ. Agr. Exp. Sta., Bul. 336, p. 21, 1913.

**232. Testing.** — The following are steps in testing butter for salt:[1]

1. Prepare the sample as directed under "testing butter," par. 228, if no moisture test has been made.

2. Weigh 10 grams of butter from the prepared sample or use that remaining after driving off the moisture. This latter sample must have weighed 10 grams if the following directions are followed.

3. Obtain water at 100° to 140° F. in a 300 c.c. measure. The purpose of the addition of water is to secure all the salt of the butter in solution. From the standpoint of Troy's method and of quick reading, it is essential to employ exactly 300 c.c. of water.

4. Remove the butter from the weighing or moisture cup to the container, in which the butter and water may be thoroughly mixed. A 500 c.c. glass bottle with a ground glass stopper is very satisfactory for this purpose. A rubber policeman is convenient in removing the butter from the cup.

5. Pour a portion of the warm water secured in step 3 into the weighing cup in order to melt some of the fat remaining from step 4. Put this into the container with the butter, and continue pouring the warm water into the cup and flushing out the butter until all is loosened from the sides and bottom of the cup. Usually the rubber policeman is most convenient at this stage of the process, for friction is necessary to loosen some of the fat.

6. After the 10 grams of butter, or that remaining from a 10-gram moisture sample, and the 300 c.c. of water are in the container, the contents must be thoroughly shaken

[1] Troy, H. C., Method developed and used by Troy in the testing laboratories at Cornell University.

to distribute the salt throughout the solution. The agitation should continue about one minute.

7. Allow the sample to stand until the fat rises to the surface. This may require two to five minutes.

8. With a 17.6 c.c. Babcock pipette, draw a pipetteful of the clear liquid and put it in a titration container which may preferably be a white cup or an Erlenmeyer flask.

9. Add three or four drops of the potassium chromate ($K_2CrO_4$) which acts as an indicator.

10. Titrate this solution with tenth-normal silver nitrate ($AgNO_3$) until a very light brown color appears. It should be remembered that the solution must be agitated constantly during titration. It must also be kept in mind that the first permanent brownish color is the end point.

11. In obtaining the final reading, it must be borne in mind that each cubic centimeter of tenth-normal silver nitrate that is titrated into the salt solution is equal to 1 per cent salt.

12. Record the results.

**233. Notes on the chemistry of the salt test.** — The first reaction in this test is as follows: $AgNO_3$ (silver nitrate) + $NaCl$ (sodium chloride, salt) = $AgCl$ (silver chloride) + $NaNO_3$ (sodium nitrate). When all the chlorine from the salt in the butter solution has been satisfied and an excess of silver nitrate is added, another chemical reaction occurs between the silver nitrate and the potassium chromate, which is used as an indicator. This reaction is as follows: 2 $AgNO_3$ (silver nitrate) + $K_2CrO_4$ (potassium chromate) = $Ag_2CrO_4$ (silver chromate) + 2 $KNO_3$ (potassium nitrate). The silver chromate is the substance that gives the reddish brown color indicating that all the salt is neutralized.

The reading is calculated as follows: The molecular weight of silver nitrate ($AgNO_3$) is 170 grams; the molecular weight of sodium chloride is 58.5 grams. Applying the rule that the molecular weight of one substance is to the molecular weight of another as the actual weight of the first substance is to the actual weight of the second when the molecules are chemically equal, the result is as follows: 170 (molecular wt., $AgNO_3$) : 58.5 (molecular wt., NaCl) : : .017 : $X$. There are .017 gram $AgNO_3$ in 1 c.c. of the N/10 solution. In the calculation, $X$ is equal to .00585 gram, which is the amount of salt that 1 c.c. of N/10 silver nitrate solution will neutralize. In this determination, 10 grams of butter were put in 300 c.c. of water. A Babcock pipetteful of this solution was titrated. This pipette delivers 17.5 c.c. of liquid. Assuming that in the titration 4 c.c. of N/10 silver nitrate was used to neutralize the salt, then .00585 gram $\times$ 4 c.c. = .0234 gram of salt in one pipetteful of the solution. The quantity of salt in the 300 c.c. solution is reckoned as follows: 300 $\div$ 17.5 c.c., the amount in one pipetteful, = 17.14 pipettefuls; 17.14 $\times$ .0234 = .4 gram of salt in the 300 c.c. of solution. This means that the 10 grams of butter contained .4 gram of salt, .4 $\div$ 10 = .04 of a gram. This .04 gram $\times$ 100 = 4.00 per cent salt. Thus it is seen that when 10 grams of butter are melted in 300 c.c. of water and a Babcock pipetteful is used for titration, the final reading may be obtained without any calculation. Each cubic centimeter of the N/10 silver nitrate used is equal to 1 per cent salt.

### ACIDITY TEST OF MILK OR CREAM

The acidity of milk products is formed largely by lactic acid. This acidity is a fairly good criterion of measure of the number of bacteria in dairy products, and thus of their qualities. Often when there is a question whether certain milk or cream should be accepted by a creamery, the quick determination of the acidity will settle the problem. The acidity test in the manufacture of butter is used only on milk and cream.

**234. Sampling.** — The ordinary precautions in sampling milk or cream should be observed in obtaining samples for an acidity test.

**235. Testing.** — Following are steps in testing milk or cream for acidity.

1. Measure a Babcock pipetteful of milk or cream into a titration cup or Erlenmeyer flask, add about 15 or 20 c.c. of water. In case of cream, use water at a temperature of 100° to 120° F. to make the cream more fluid.

2. Add two or three drops of phenolphthalein. This is an indicator colorless in an acid solution and pink when the solution is alkaline.

3. Titrate with N/10 alkaline solution until a pink color remains. Care must be observed in titrating, for it is easy to go past the end point.

4. Read by dividing the number of cubic centimeters of N/10 alkaline solution required to neutralize the acid in the milk or cream by 2. Then each cubic centimeter of the quotient is equal to .1 per cent. Very often a special pipette is used which has a capacity of one-half of the Babcock pipette. In such case the reading is obtained directly. Each cubic centimeter is equal to .1 per cent acid.

**236. Notes on the chemistry of acidity.**—The chemical reactions of acidity are clearly explained by Ross:[1] "It is a chemical fact that equal volumes of acids and alkalies of the same chemical strength will exactly neutralize one

[1] Ross, H. E., A Dairy Laboratory Guide, p. 44, 1914.

another. In 1 c.c. of a normal solution of lactic acid there is .09 gram of lactic acid. According to the above rule 1 c.c. of any normal alkali solution would just neutralize .09 gram of lactic acid.

"In actual practice a solution weaker than a normal solution is usually employed, because a normal solution is so strong that any small variation in the amount used makes a big variation in results. A common solution used is $\frac{1}{10}$ normal (expressed N/10). One c. c. of N/10 alkali solution would neutralize .009 gram of lactic acid. An example will illustrate how the percentage of acid in milk is calculated. Suppose it took 6 c.c. of N/10 alkali solution to neutralize the acid in 20 grams of milk. What is the per cent of acid? One c.c. of N/10 alkali will neutralize .009 gram of lactic acid. Six c.c. will neutralize $6 \times .009 = .054$ gram of acid. $.054 \div 20 = .0027$. $.0027 \times 100 = .27$ per cent acid in the milk. Formulated, the above example is expressed as follows:

$$\frac{.009 \times 6}{20} \times 100 = .27\,\%.$$

If the milk for the acid test is measured in cubic centimeters, it should be reduced to grams by multiplying by the specific gravity of milk. The acid is obtained in terms of grams and we cannot divide grams by cubic centimeters and obtain per cent."

Usually the milk or cream is measured, since the acidity does not have to be determined exactly. For this reason one Babcock pipetteful is considered to be 18 grams, which is true of whole milk but not quite accurate in case of cream. The computation is as follows: Suppose that it took 8 c.c. of N/10 alkali solution to neutralize the acidity in one pipetteful or approximately 18 grams of cream.

$\frac{.009 \times 8}{18} \times 100 = .4$ per cent acid in the cream. This can be obtained quickly by dividing the amount of alkali by the arbitrary number 2 and by reading the quotient in tenths as follows; 8 c.c. ÷ 2 = .4 per cent acid. If 9 grams, or only half of 18 grams, of cream were used, the result would be obtained directly by reading each cubic centimeter of alkali as .1 per cent. In this way, the reading is rapid, with only a little mental calculation.

## GENERAL NOTES OF TESTING

The most important factor in testing is accuracy. All chemistry operations, of which testing dairy products is one, demand carefulness.

**237. System.** — One of the essential considerations in running a test is system. All sample bottles should be plainly labeled. When all the samples are obtained, each should be arranged in consecutive order. Then the test-bottles should be clearly marked and arranged in order. When this is done, if a mistake is made, such as forgetting to label a test-bottle, its position would be sufficient to identify it. There should be a special place for the recording of each test. A student in the laboratory can plan for a systematic recording of the tests. It might be possible for him to prepare his notebook when the centrifuge is running. In a creamery there should be special printed sheets for such records. The above suggestions will aid in increasing the speed as well as the accuracy of the testing operation.

**238. Conveniences for testing.** — A few conveniences might be used to increase the speed of testing, such as the following: (1) A warming tank with a rack in which to place samples that should be heated before being tested. (2) A prepared solution for cleaning the test-bottles. This may be made as follows: Mix hot water, "gold-dust" or other good glass cleaner, and lye to destroy the casein formation quickly. This solution may be used several weeks before it is discarded. The container of the cleaning solution should be sufficiently large to admit a test-bottle rack, and if possible means should be provided to heat it. (3) Test-bottle racks that are easily handled and sufficiently large to hold the same number of bottles that the centrifuge will contain. (4) Handy acid measures, such as the little glass dipper which is especially convenient for measuring acid into cream test-bottles because of their large necks, or the bottle with the measure on the side that is filled by tipping the bottle. This latter measure may be used easily in filling milk or cream test-bottles. (5) A brass or a copper collar for each composite sample bottle on which is placed the patron's number. The metal should be fairly thin and soldered around the neck of the bottle. This is easy and simple, and a certain identification of the sample. For daily cream samples small jars with aluminum tops are convenient. The patron's number may be placed easily on these tops and later the numbers may be readily erased. (6) A brass or copper collar for each test-bottle on which is stamped a number. This saves practically all the time required to place the sample or patron's number on each test-bottle. The test-record sheet should have a column for the patrons' numbers and one for those of the test-bottles. The time saved would be the difference between that required to erase the old numbers on the test-bottles and in placing the new numbers on them; and in simply writing the numbers of the bottles opposite those of the samples on the record sheets.

# INDEX

Acidity in butter, 163.
neutralizing, 84, 87.
test, chemistry of, 261.
test of milk or cream, 260.
Alvord, Henry E., 126.

Babcock, S. M., 87.
Babcock test, 236.
when developed, 5.
Bacteria, and how carried, 35.
conditions of growth, 40.
growth of, at different temperatures, 183.
in butter, 177.
pathogenic, in butter, 97.
pathogenic, in margarine, 98.
pathogenic, in skimmed-milk, 99.
Baker, G. D., 179.
Barnhart, Jesse M., 8, 143, 252, 255, 257.
Berg, W. N., 93, 95, 180.
Body, when scoring, 192.
Bowen, John T., 106.
Branding inspected butter, 198.
Breed, Robert S., 99, 100.
Briscoe, Chas. F., 96, 98.
Brown, C. A., Jr., 169.
Brown, C. W., 166, 170, 172, 179, 181, 182.
Bryant, Ruth, 177.
Bull, William, 3.
Burrill, D. H., 125.
Butter, acidity, 163.
amount in tub, 201.
branding inspected, 198.
centralizer, definition, 229.
comparison with margarine, 17.
composition, 7.
creamery, definition, 229.
Butter, dairy, definition, 229.
dealer, definition, 229.
definition, 228.
exports, 5.
flavors, 160.
food value of, 14.
gathered cream, definition, 229.
grading, 188.
inspection of, 198.
introduced in Europe for food, 3.
ladled, 216.
ladled, definition, 229.
ladled, method of manufacture, 218.
moisture test, 254.
packing, 153.
printing, 155.
production in U. S., 5.
ranch, definition, 230.
renovated, 216.
renovated or process, definition, 230.
renovated, method of manufacture, 217.
salt test, 257.
sampling, 252.
shipping by railroad, 206.
shipping by water, 207.
storage of, 181.
stored for many years, 2.
sweet, definition, 230.
sweet cream, definition, 231.
testing, 253.
-trier, 231.
used as an ointment, 1.
weighing tub on the market, 201.
whey, 211.
whey, definition, 231.
whole-milk, definition, 231.

Buttermilk, artificial, commercial, or cultured, definition, 231.
definition, 231.
sampling, 250.
testing, 251.

Carefulness, 27.
Centralizer, definition, 232.
Cheese, definition, 232.
Cheesery or cheese factory, definition, 232.
Chemistry, acidity test, 261.
of salt test, 259.
Churn, cleaning, 24.
cleaning a musty churn, 25.
Churning, effect of abnormal micro-organisms, 135.
effect of amount of cream in churn, 134.
effect of condition of milk-fat, 129.
effect of milk-fat globules, 133.
effect of richness of cream, 128.
effect of ripeness of cream, 128.
effect of speed of churn, 135.
effect of temperature, 126.
factors in, 126.
history of, 123.
steps in, 135.
Churns, large, 124.
simple, 123.
Color, amount to use, 136.
artificial, 149.
faded, 152.
how to add, with salt, 137.
mottles, 149.
natural, 148.
when scoring, 192.
Commission merchant, 232.
Composite samples, 237.
Cooling, effect of stirring, 46.
milk, methods, 44.
milk, reasons for, 40.
tanks, 44.
Cooper, W. F., 129.
Cooper, W. H., 95, 101, 102, 103.
Cost, effect of storage, 185.
Cream, acidity test, 260.
care of, 35.
Cream, control of fat content, 68.
definition, 232.
factors affecting test, 73.
ripening, 108.
ripening in a creamery, 116.
sampling, 244.
separation, 52.
testing, 248.
when ripe, 121.
Creameries, size of, 4.
Creamery, definition, 232.
equipment, 29.
first one built in U. S., 3.
influence of buildings, 33.
influence of surroundings, 33.
operators, 28.
poorly arranged, 32.
well-arranged, 30.
Cuddie, D., 168.
Curd, amount in butter, 11.
composition of, 11.

Dairy, definition, 231.
school, first one organized, 5.
Davis, Brooke J., 93, 95, 168, 180.
Davis, Marguerite, 15, 16.
Dean, H. H., 175.
Definition of terms, 228.
Distributors' margins, 208.
Doane, C. F., 212, 213.
Dotterrer, W. D., 99, 100.

Eckles, C. H., 10, 130, 131, 132, 133, 134, 148, 172.
Elgin, market, 202.
Enzymes in butter, 180.
Ewing, P. V., 129.
Exchanges, history of, 194.

Farrand, Bell, 179.
Farrell, John J., 102, 103, 223.
Farrington, E. H., 95, 101, 211.
Fat loss in whey, 211.
Flavor, basic, 160.
effect of acidity on storage butter, 174.
effect of individuality of the cow, 172.
effect of pasteurization, 171.

Flavor, effect of salt, washing, 173.
fishy, 166.
metallic, 168.
rancid, 169.
when scoring, 191.
Flavors, absorbed, 160.
acid, 163.
developed, 161.
history of acidity, 164.
of butter, 160.
salted versus unsalted, 163.
Fleischmann, 8, 56, 57, 223.
Freak, G. A., 129.
Frost, W. D., 177.
Frozen milk and cream, sampling, 237.

Gaessler, W. G., 95, 101, 102, 103.
Giltner, W., 179.
Godfrey, J. H., 95.
Grading butter, history of, 188.
milk and cream, 84.
Gray, C. E., 166, 172, 176, 182.
Growth-promoting substances, 15.
Guthrie, E. S., 72, 143, 153, 154, 169, 171, 173, 175, 254, 257.

Hammer, B. W., 95 102, 103.
Hart, E. B., 150.
Hastings, E. G., 100.
Haugen, 225.
Hayward, Harry, 1.
Hepburn, N. W., 143, 246, 247, 252, 255, 257.
History, of acidity, 164.
of butter, 1.
of churning, 123.
of exchanges, 195.
of grading butter, 188.
of grading milk and cream, 85.
of margarine, 220.
of neutralizing acidity, 85.
of pasteurization, 90, 91, 92.
of printing, 155.
of separation, 55.
of starter, 109.
of starter cans, 112.
Holmes, Geo. K., 185.
Homogenized milk or cream, definition, 231.
Hunziker, O. F., 53, 93, 131, 132, 133, 144, 246, 249.
Hutchinson, Robert, 14.

Inspection, cost of, 200.
of butter, 198.
Inspector, other duties, 200.

Jensen, A., 92.
Jensen, O. A., 174.

Kent, T. L., 241.
Kieffer, P. H., 170.
Kiethley, J. R., 167, 176, 182.
Kirchner, W., 63, 64.

Ladled butter, 216.
method of manufacture, 218.
Ladling butter plant, 216.
Larsen, C., 56, 57, 165, 172, 174.
Lazer, H., 98.
Leach, A. E., 10.
Lee, Carl E., 8, 95, 101, 143, 151, 246, 247, 252, 255, 257.
Lumsden, Leslie L., 98.
Lund, T. H., 165.

MacNeal, W. J., 96, 98.
Macnish, James, 125.
Margarine, 220.
and butter, 227.
comparison with butter, 17.
definition, 233.
history, 220.
method of making and composition, 220.
test, 226.
Margins of distributors, 208.
Market, Elgin, 202.
requirements, 203.
Marketing, 188.
Markets by the U. S., 202.
McCollum, E. V., 15, 16, 17.
McKay, G. L., 56, 57, 87, 166, 172, 174, 182.
McMerney, T. J., 41, 44, 46, 237, 238, 249, 251.

Melick, C. W., 174.
Mendel, L. B., 15, 16, 17.
Meyer, H. F., 195, 201, 208.
Meyers, John H., 164.
Michels, John, 130.
Milk, acidity test, 260.
  care of, 35.
  definition, 233.
  -fat, composition of, 8.
  -fat, definition, 233.
  plant, definition, 234.
Miller, L. F., 165.
Mills, H. C., 131, 132, 133, 144.
Mohler, John R., 96.
Moisture, control, 144.
  creamery men should control, 146.
  in butter, 142.
  incorporation, 144.
  natural amount in butter, 146.
  test of butter, 254.
  variation in butter, 143.
Mortensen, M., 95, 101, 102, 103, 106.
Mottles, 149.

Neatness, 27.
Neutralizing acidity in cream, 84, 87, 88.
Norton, R. P., 8, 11, 217.
Nuttall, W. H., 129.

Operator, essential consideration, 51.
Osborne, T. B., 15, 16, 17.
Over-run, definition, 234.
  factors that affect, 147.
  in the creamery, 147.
  on the farm, 147.

Package, preparation of, 142.
  when scoring, 193.
Packages, for storage, 142.
  retail, 154.
  retail, market requirement, 204.
  wholesale, 153.
  wholesale, market requirement, 203.
Packing butter, 141.
Palmer, Leroy S., 130, 131, 148.
Parcel post, 205.
Pasteurization, 90.
  and cooked flavor, 102.
  comparison of holder and continuous methods, 102, 103, 104.
  cost of, 106.
  definition, 234.
  effect on buttermilk test, 101.
  effect on flavor, 92.
  of sour cream, 105.
  of thin cream, 105.
Pasteurizer, operation of, 102.
Patrick, G. E., 164, 175.
Patron, definition, 234.
Pearson, R. A., 233.
Pickerill, H. M., 154.
Potteiger, C. R., 95, 168.
Potts, A. E., 239.
Potts, R. C., 195, 201, 208.
Price, determination of, 196.
  effect of storage, 186.
  how reported, 195.
Prices, butter and other foods, 14.
  from 1840 to 1916, 198.
Printing butter, 155.
  proper weight, 157.
Protein, composition of, 12.
Prucha, M. J., 37.

Rahn, Otto, 115, 166, 170, 172, 179, 182.
Raitt, J. A., 143, 145.
Rasmussen, Fred, 147.
Reakes, C. J., 168.
Receiver, definition, 234.
Reid, A. H., 155.
Reid, H. A., 168.
Renovated butter, 216.
  method of manufacture, 217.
  raw material, 216.
Renovating butter plant, 216.
Richmond, H. D., 8.
Ripening cream, demand of trade, 121.
  in a creamery, 116.
  on a farm, 119.
  relation of temperature and inoculation, 120.

Ripening temperatures, 120.
  when cream is ripe, 121.
Rogers, L. A., 93, 95, 96, 153, 167, 168, 176, 177, 178, 180,182.
Rosenau, M. J., 90, 100, 177.
Ross, H. E., 41, 44, 46, 101, 143, 237, 238, 249, 251, 254, 257, 261.
Russell, H. L., 87, 90, 100, 101.

Salt, amount in butter, 11.
  amount to use, 141.
  blisters, cause, 152.
  composition of, 11.
  how to add, to butter, 140.
  test, chemistry of, 259.
  test of butter, 257.
  what to do if dissolves slowly, 140.
  when scoring, 192.
Sampling, butter, 252.
  cream, 244.
  frozen milk and cream, 237.
  skimmed-milk and buttermilk, 250.
  sour milk and cream, 237.
  whole milk, 239.
Sammis, J. L., 151, 212.
Sayre, W. S., 179.
Scalding utensils, 21.
Score-card, 190.
Scoring butter, 190.
Scoville, R. I., 244, 247.
Selling butter, 207.
  coöperative, 208.
  methods of large creameries, 207.
  methods of small creameries, 207.
Separation, advantages of centrifugal method, 78.
  by centrifugal force, 55.
  by gravity, 53.
  continuous, 56.
  efficiency of different methods, 53.
  intermittent, 55.
  principle of, 52.
Separator, factors in buying, 78, 79.
Separator, location of, 80, 81, 82.
  when first sold in U. S., 5.
Separators, the operation of, 67.
Shaw, R. H., 8, 10, 11, 131, 132, 133, 134, 172, 180, 217.
Shipping, by parcel post, 205.
  by railroad, 206. es,
  by water, 207. es,
Shiver, F. S., 130. es,
Shrinkage, in wholesale packages, 153.
Skimmed-milk, definition, 234.
  factors affecting, 72–77.
  killing pathogenic bacteria in, 99.
  sampling, 250.
  testing, 251.
Smith, F. H., 129.
Smith, L. M., 166, 170, 172, 182.
Sour milk and cream, sampling, 237.
Spitzer, Geo,, 131, 132, 133, 144.
Starter, apparatus, 111.
  artificial, 111.
  cans, history, 112.
  definition, 234.
  how often to propagate, 115.
  kind of milk for, 118.
  making the transfer, 118.
  natural, 110.
  steps in propagation, 112.
  when first sold in U. S., 5.
  when to use, 108.
Sterilization, definition, 234.
Stewart, R. F., 155.
Stocking, W. A., Jr., 37, 40.
Storage, buildings, 183.
  business, 183.
  cost, 185.
  effect on price, 186.
  home, 185.
  of butter, 181.
  temperatures, 181.
Supplee, G. C., 72.

Taber, W. C., 199.
Test ware, cleaning, 26.
Testing, 236.
  butter, 253.

Testing, conveniences for, 263.
cream, 248.
skimmed-milk and buttermilk, 251.
whole milk, 242.
Thom, Chas., 180.
Thompson, S. C., 8, 11, 167, 176, 182.
Thoroughly scalding, definition, 234.
Troy, H. C., 14, 258.

Utensils, cleaning and care of, 18.
relation to clean milk, 37.

Valerius, T. L., 126.
Van Slyke, L. L., 150.

Washburn, Henry J., 96.
Washing utensils, 19.
Water, amount in butter, 11.
Weeter, H. M., 37.
Weighing tub butter on the market, 201.
Weigmann, H., 162.
Wells, C. A., 129.
Whey, fat loss, 211.
Whey butter, 211.
churning, 215.
cost of manufacture, 212.
manufacture of, 214.
marketing, 215.
White, B. D., 170.
Whole milk, sampling, 239.
testing, 242.
Wilder, F. W., 221.
Willmann, J., 91.
Wilson, James, 186.
Wing, H. H., 211, 212.
Working butter, how to do it, 141
purpose of, 141.
when completed, 141.
Wolff, A., 162.
Woll, F. W., 11.
Workmanship, 31.
Wright, R. Patrick, 221, 227.

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