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STILLWATER, OKLAHOMA

COMMERCIAL BUTTERMILK

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Bulletin No. 156 *January, 1926*

To All Who Are Interested in the Manufacture of Commercial Buttermilk

The manufacture of commercial buttermilk is not difficult, although it demands strict adherence to specific details. A satisfactory product can not be produced without clean milk which has been properly heated and cooled; nor can sanitation in every respect be neglected.

A thorough knowledge of the product is essential, but a thorough knowledge will not produce results without the proper combination of efficient buttermilk equipment, proper methods of temperature control and, last but not least, an ideal culture. Best cultures are those which have been grown for years without the necessity of renewal through the use of a commercial starter, and it is only through attention to the above factors that such can be accomplished.

Sincere appreciation is expressed to the following firms for cooperation in furnishing samples of lactic cultures or for suggestions, thus making this work possible.

Many of these firms suggest special procedures considered most desirable for their particular strain of lactic bacteria in either liquid or dry form. The bulletin is prepared with this in mind and the hope that consumption of fermented milks may be stimulated as well as the quality of the product improved.

Cit-Ro-Lac Products Company, 1245 Lawrence Avenue, Chicago, Illinois.

Anderson's Chemical Company, Litchfield, Minnesota.

Aschman-Johnson Laboratories, 200 Sixth Avenue, Pittsburgh, Pennsylvania.

Levring and Company, St. Louis, Missouri.

Parke-Davis and Company, Detroit, Michigan.

Chr. Hansen's Laboratory, Inc., Little Falls, New York.

Elov Ericsson Company, 1098 Lexington Avenue, St. Paul, Minnesota.

Dairy Laboratories, 2300 Locust St., Philadelphia, Pa.

Commercial Buttermilk

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MILK

Milk is composed of various constituents in proportion about as follows (Farrington):

Water	87.4%
Fat	3.7%
Milk sugar	5.0%
Casein	2.5%
Albumin	.7%
Ash	.7%
	100.0%

Each of the above serves a particular purpose in the body. The water, a diluent and solvent, supports the other substances in solution, in the colloidal state or in suspension and makes them more readily available for use in the body. Casein and albumin, the principal nitrogenous compounds, are utilized in the body in the building and repair of tissue. Ash consisting principally of compounds of lime, phosphorus, potassium and a small amount of iron, is chiefly important in the formation of bone, teeth and muscle. Milk fat is used by the human system as a source of energy. It has a high fuel value, and may be stored up in the body as fat. Like all other constituents of milk, it is readily digested. Milk sugar, one of the solids in solution, is especially valuable in aiding the establishment of a desirable bacterial flora in the intestinal tract, thus assisting in the prevention of putrefaction.

CASEIN AND MILK SUGAR

From the standpoint of buttermilk manufacture, we are interested chiefly in the casein and sugar of milk.

Casein

All milk contains the product, casein. Chemically casein is known as a colloid which, for our purpose, may be considered as a substance so finely divided that it remains suspended in a fluid, neither rising nor settling. So small are the particles that they can be observed only under the high power of the ultra-microscope. It is this product, casein,

*Note: The writer wishes to extena thanks to Messrs. I. M. Cox, Antonio Lopez Gonzales, W. H. Bishop and J. D. DeWet, senior students, for their conscientious assistance in performing many of the experiments reported in this bulletin.

which forms the "curd" of sour milk, and gives to milk its white color. It is the principal constituent of cheese.

Milk Sugar or "lactose" is a product peculiar to milk. In appearance it resembles cane sugar, but is less sweet and dissolves less readily in water. It is present in milk to the extent of about 5% and is entirely in solution. It derives its name from the term, "lacteal fluid," meaning milk, and the ending, "ose" indicating sugar, as in malt*ose*, dextr*ose*, levul*ose*, sucr*ose*, etc. Through action of certain lactic-acid-forming bacteria, milk sugar is split into dextrose and galactose, the latter in turn being readily converted into lactic acid, the product producing most of the acidity of sour milk, thus:

$$\underset{\text{(lactose)}}{C_{12}H_{22}O_{11}} + H_2O + \text{bacterial action} = \begin{matrix} \underset{\text{(dextrose)}}{C_6H_{12}O_6} \\ \underset{\text{(galactose)}}{C_6H_{12}O_6} \text{ produces } 2\ \underset{\text{(lactic acid)}}{C_2H_4OH\ COOH} \end{matrix}$$

BACTERIA

General Discussion

Bacteria are minute, single celled organisms belonging to the plant kingdom. So small are they, that many millions would be required to cover a space the area of a pin head. They are found almost universally in the dust of the air, water, and soil. Most of them have no means of locomotion but are carried from place to place in various ways. Under favorable conditions they grow rapidly, usually reproducing by a method known as "fission," the cell constricts in the middle, and finally divides, forming two separate and distinct organisms. The whole process requires but a short period, approximately twenty minutes. With these facts in mind, the rapid souring of milk under conditions favorable for bacterial growth due to the combined action of myriads of bacteria which ferment milk sugar into lactic acid, is readily understood.

Classification According to Their Effect on Health

According to their effect on health, bacteria may be divided into three general classes:

1. Advantageous.
2. Detrimental.
3. Harmless.

Luckily, comparatively few belong to the second class which includes all disease producing organisms; i. e., pathogenic bacteria. The first class is therefore the one in which we, as manufacturers of buttermilk, are interested; and it is to this class that lactic-acid-producing-bacteria belong.

Classification According to the Quantity of Lactic Acid Produced

Bacteria which change milk sugar into lactic acid may, for the purpose of this bulletin, be classified as follows:

A. Those that produce a large amount of lactic acid.
B. Those that produce a medium or small amount of lactic acid.

Bacteria Producing a Large Amount of Lactic Acid

Bacillus Bulgaricus

To this class belong the organisms known as bulgarian bacteria, commonly called *Bacillus bulgaricus, Bacterium bulgaricum* or *Lactobacillus bulgaricus,* isolated from a sour milk beverage used in Bulgaria and eulogized by Metchnikoff (6) in his writings on the "Prolongation of Life" and by Douglas (7) in his treatise entitled "The Bacillus of Long Life."

Characteristics of Bacillus Bulgaricus

The optimum or best temperature for the growth of this organism appears to lie between the temperature ranges of 45° C. to 49° C. (about 110° F. to 120° F.) Between these limits it is capable of rapid growth and the production of much larger quantities of lactic acid than the more common type of lactic acid forming bacteria. Fisher (5) reports an acidity of 3.85% developed under laboratory conditions. Other workers obtained similar results. However, the average acidity produced lies between 1% and 2%.

Although this acidity may appear relatively low, it is exceedingly high when considered from the standpoint of palatability. For this reason, milk soured with the bulgarian organism is usually treated as a special product, and in many cases is used purely for medicinal purposes.

Bacteria Producing a Medium or Small Amount of Lactic Acid

Streptococcus Lacticus

To this class belong the organisms known as *Streptococcus lacticus,* (plural, *Streptococci lacticus*), also called *Bacterium lactis acidi,* (plural, *Bacteria lactis acidi.*) These organisms produce lactic acid in the same manner as the bulgarian bacteria. However, they are incapable of producing as large a quantity as the former, the acidity seldom exceeding .9%. According to Sigurd Orla-Jensen, (4) who has classified the lactic bacteria, these organisms grow at temperatures varying from 50° F. to 104° F. Below or above either of these limits the growth is poor. The organisms readily gain predominance in milk kept at room temperatures, growing rapidly at 60° to 68° F., and produce lactic acid ranging in amounts from approximately .50% to .80%. Hammer (1) likewise finds these organisms to grow over a wide range. Ordinarily they grow most satisfactorily at temperatures ranging between 86° and 97° F. although these latter temperatures are not conducive to best results in the manufacture of commercial buttermilk, as will be pointed out a little later. The *Streptococcus lacticus* organisms grow equally as rapidly as those of the bulgarian type, and cultures containing them as the predominating organism are used more frequently in the manufacture of commercial buttermilk than the latter, chiefly because they produce lactic acid in a lesser amount, thus rendering the product more generally desirable as a beverage.

Associated Bacteria

In the study of many commercial starters used in the preparation of commercial buttermilk, Hammer (1) has succeeded in isolating two types of organisms which are associated with the *Streptococcus lacticus* bacteria. These organisms he named *Streptococcus citrovorus* and *Streptococcus para-citrovorus.* The former he found to be present "in the product put out by most manufacturers," although in one case *Streptococcus para-citrovorus* was almost always found. The presence of either or both of the associated organisms in commercial starters Hammer found to be necessary for the development of the ideal flavor and aroma desired in a good quality of buttermilk. The *Streptococcus citrovorus* organism he found to develop most satisfactorily at temperatures of 21° C. to 23° C, (about 70° F. to 74° F.) while the *para-citrovorus* bacteria appear to make satisfactory growth at 37° C. (about 97° F.), or even at room temperatures. In studying the growth of *Streptococcus para-citrovorus* at different temperatures, Hammer and Baker (2) have found considerable variation, "some organisms growing well at a certain temperature and others growing poorly or not at all." The paragraph closes by noting a "rather gradual variation with all degrees of response on the part of the organisms."

THE BEST TEMPERATURE FOR THE GROWTH OF COMMERCIAL STARTERS

From his studies of commercial starters, Hammer (1) makes the following statement relative to the temperature most desirable for growth of the bacteria: "Although *Streptococcus lacticus* grows well at a considerable range of temperature, 21° C. to 23° C. is undoubtedly the best for the propagation of starters. One reason why this temperature is best is because the proper balance between the different organisms concerned is most easily maintained here." The conclusion may be readily reached, that commercial starters are best incubated at temperatures varying from about 68° F. to 72° F. in order to secure the proper flavor and aroma and the most desirable growth of organisms associated therewith. It must always be remembered that the *Streptococcus lacticus* organisms usually composed over 75% of the bacterial flora of commercial cultures, and that their chief purpose is to develop a sufficient amount of acid to cause curdling of the milk, which is followed by the production of a desirable flavor and aroma due to the action of the associated organisms.

THE DISTINCTION BETWEEN BULGARIAN AND COMMERCIAL BUTTERMILK

Because of the wide spread advertisement of bulgarian buttermilk the term has been commonly applied to the more common product, with the result that commercial buttermilk has occasionally been sold under the name of "Bulgarian buttermilk." As a matter of fact, the so-called commercial buttermilk and the bulgarian product are distinct.

as has already been pointed out. The buttermilk with which we are most familiar, therefore, is the product made through the use of starters containing chiefly the types of bacteria (*Streptococcus lacticus* and associated organisms), which produce the lesser amount of lactic acid, and correspondingly milder flavor.

COMMERCIAL CULTURES

There are on the market at the present time cultures of bacteria commonly used in the preparation of commercial buttermilk. These cultures occur in two forms:

1. Dry
2. Liquid

The dry culture, occurring either in the form of powder or tablets, consists of myriads of bacteria which have been mixed chiefly with milk solids or prepared media, dried and compressed into small tablets or pulverized and put up for commercial purposes in small glass vials holding about one ounce. The liquid cultures, on the other hand, are composed chiefly of sterilized milk into which has been inoculated the necessary types of bacteria for the production of buttermilk.

Advantages and Disadvantages of the Two Types

The dry culture has the following advantages:

1. It keeps longer than the liquid product, usually from two to six weeks.
2. It is more readily handled; and, being in the dry form, is less apt to become contaminated during handling.

Its chief disadvantage lies in the fact that the bacteria contained are not as vigorous as those commonly found in the liquid cultures. For this reason it is usually necessary to make two or three propagations of the dry culture before the bacteria are invigorated to the same extent that they would be had they been grown in liquid. Another disadvantage offered is that it is seldom put up as pure and free from contaminating organisms as the liquid culture. Regarding the keeping qualities of the latter, it is generally conceded that it should be used within one week after being received. However, the writer has found, on one occasion, that a liquid culture kept for over a year and was usable at the end of that time. However, liquid cultures should be used within the specified period, as they rapidly become weakened and will not yield a good starter.

CLASSES OF BUTTERMILK

Buttermilk may be divided into two classes:

1. Natural buttermilk.
2. Commercial buttermilk.

The process of making the first is well known and the factors which influence its quality are the same as those influencing the quality of cream from which it is derived. Much more complicated is the

manufacture of the commercial product which depends for its desirable qualities on such factors as:

1. The material from which it is made.
2. The process of manufacture.
3. The temperature control.

Difference Between the Two Classes of Buttermilk

In many ways the two buttermilks are similar, yet with sufficient differences to characterize them as distinct products. Buttermilk from the churn; i. e., the natural product, usually contains a considerable amount of fat, depending upon such factors as:

1. The fat content of the cream.
2. The acidity of the cream.
3. The temperature of the cream when churned.
4. The rapidity of churning.

Accordingly, the fat globules readily rise to the surface and collect in a separate layer. In the commercial product made chiefly from skim milk, the quantity of butterfat is much less and the particles being so finely divided, do not readily rise to the surface, but remain evenly distributed throughout the skim milk.

The second greatest difference and perhaps the most important, lies in the bacterial flora of the two products. The natural buttermilk being obtained from cream of various qualities may, and frequently does, contain undesirable bacteria which have a detrimental effect on its healthfulness, flavor, and other desirable qualities. On the other hand, the commercial product, made chiefly from skim milk which has been highly heated, cooled and inoculated with the commercial culture of bacteria, contains, unless it be subsequently contaminated, only the specific organisms with which it was inoculated. For this reason, it is generally considered a more healthful product, and may be made more uniform from day to day since the factors of its manufacture are controlled.

The third variation lies in the viscosity of the two products, buttermilk from the churn being somewhat thin and watery in appearance, while the commercial product when properly made, is quite thick and creamy. This variation is due to the greater quantity of solids not fat which the latter contains and the characteristics of the culture used in its preparation.

CLASSES OF COMMERCIAL BUTTERMILK

Like buttermilk in general, the commercial product may itself be divided into two classes:

1. Naturally ripened commercial buttermilk.
2. Artificially ripened commercial buttermilk.

The former results from the spontaneous souring or natural ripening of sweet skim milk or whole milk which, after curdling, is broken up into very fine particles. The artificially ripened buttermilk is made as already specified: by heating milk, cooling to the proper temperature and inoculating with a commercial culture. As soon as curdled it is

cooled and the curd broken. Obviously the artificially ripened product is more to be desired than that ripened naturally; and it is only with the latter that this bulletin deals.

COMMERCIAL OR CULTURED BUTTERMILK

Economic Importance

It is difficult to arrive at definite figures regarding the economic importance of commercial buttermilk. During the past few years the consumption has increased at a tremendous rate. Indications are that increased consumption will continue until buttermilk becomes one of the leading manufactured dairy products in any municipality.

Little do we realize its importance until an examination is made of the statistics collected by the United States Department of Agriculture, Bureau of Dairying. The investigations covered the ratio of milk and cream handled, to the quantity of buttermilk manufactured in over two hundred plants located in different parts of the country, so that statistics obtained were quite representative. Accordingly there follows the statistical data as gathered and published by the bureau (9).

Table No. 1.—Average Daily Sales of Cultured Buttermilk Compared With Milk and Cream in Various Sections of the United States

Group of States	Number of Plants	Total Amount of Milk and Cream Handled Daily Gallons	Total Amount of Cultured Buttermilk Handled Daily Gallons	Ratio of Cultured Buttermilk to Milk and Cream Output Percent	Variation in Ratio Among Plants
South Atlantic	20	78,390	5,369	6.8	.0—90.0
Pacific	23	108,055	4,683	4.3	1.4—16.6
East South Central	13	25,250	6,843	27.1	8.1—66.6
West South Central	10	28,145	2,945	10.5	3.8—22.5
Mountain	9	11,749	468	4.0	.0— 4.5
New England	15	45,540	548	1.2	.0—13.3
West North Central	24	88,151	5,543	6.3	.3—16.0
Middle Atlantic	54	563,030	13,235	2.4	.0—12.9
East North Central	38	196,582	8,188	4.2	.0—14.9

Table No. 2.—Average Daily Sales of Cultured Buttermilk Compared With Milk and Cream in Ten Cities

City.	Number of Plants	Total Amount of Milk and Cream Handled Daily Gallons	Total Amount of Cultured Buttermilk Handled Daily Gallons	Ratio of Cultured Buttermilk to Milk and Cream Output Percent	Variation in Ratio Among Plants
Birmingham	3	8,200	3,800	46.3	22.0—90.0
Dallas	5	11,400	2,250	19.7	13.7—25.0
Richmond	3	12,800	1,800	14.1	10.2—17.4
Washington, D. C.	6	29,100	1,740	6.0	3.2—11.0
Philadelphia	10	115,422	4,186	3.6	2.2— 7.4
Detroit	7	90,000	3,780	4.2	2.5— 7.0
Chicago	14	176,750	7,320	4.1	3.0—11.0
Minneapolis	12	56,280	4,212	7.5	3.7—11.5
Los Angeles	3	55,000	2,255	4.1	2.8— 5.2
Seattle	4	15,820	720	4.6	3.7— 7.4

As a result of these studies, the bureau emphasizes the following points. There is a greater consumption in the South than in the North, while the eastern portion of the country, chiefly the New England States, consumes and also produces a somewhat smaller amount as compared with the consumption of sweet milk. However, even in New England, at least "one plant reports 13.3% of output in the form of cultured buttermilk so that it would seem that other dealers in this section might well take advantage of their opportunities for increasing sales along this line." A thorough study of the tables given, especially Table Number 2, will bear out the fact that cultured buttermilk is fast becoming a primary beverage among the populace.

Factors Contributing to the Popularity of Commercial Buttermilk

We may list the factors which contribute to the popularity of commercial buttermilk as follows:

1. It sells for a good price and is not difficult to make. It quenches the thirst on a hot day more efficiently than most of our soft drinks.

2. Its use in cases of typoid fever and in the treatment of other diseases has been advocated for some time by leading physicians, so that its value in this respect has been established.

3. It is a valuable food containing all the constituents of milk with the possible exception of fat.

4. Due to prohibition, its gain in favor has been rapid since it serves in an admirable way to quench the thirst of those who were addicted to strong drink.

5. By popular advertising largely due to the publication of works indicating its value in the prolongation of life, it has been kept continually before the public.

DIETETIC VALUE

Buttermilk varies in composition according to the raw product from which it is derived. Hence, the food value depends largely upon its chemical composition. The relationship between raw milk and its by-products used in the preparation of buttermilk may be observed from the following table:

	Whole Milk	Skim Milk	Buttermilk From Sour Churned Cream
1. Water	87.4%	90.3%	90.6%
2. Fat	3.7%	.1%	.1%
3. Casein	2.5%	2.9%	3.6% (casein and albumen)
4. Milk sugar	5.0%	5.2%	4.4%
5. Albumen	.7%	.7%	.....
6. Ash	.7%	.8%	.7%
7. Lactic acid			.6%
	100.0% (Farrington)	100.0%	100.0% Van Slyke

In many instances skim milk is the principal product from which commercial buttermilk is made. Therefore, it is apparent that fat is

the chief material in which it is deficient. On the other hand, whole milk or equal parts of whole milk and skim milk are occasionally used in its preparation and render the product more valuable from the nutritive standpoint. But whether the product be manufactured from skim or whole milk, its dietetic value in either case is exceedingly high.

According to the United States Department of Agriculture, Bulletin 363, skim milk has a high nutritive value which is seldom appreciated. As a matter of fact, the product is especially valuable in preparing infant foods because of its high percentage of protein material and carbohydrates. When containing fat it is all the more valuable.

Much has been written regarding the food value of buttermilk. Among the first was the work of Metchnikoff (6) followed a little later by that of Douglas (7), both of whom sought to show the probable role of *Bacillus bulgaricus* in the prolongation of life when imbibed through the use of sour milk. While the ability of bulgarian or the commoner type of lactic acid organisms to assist in extending the span of life is open to extensive criticism, the fact remains that in those countries where sour milk is regularly consumed the span of life does appear to be somewhat lengthened. Whether it be due chiefly to climatic conditions, daily habits or action of desirable lactic bacteria or to a combination of all three, is not for us to decide. The truth remains, and we can do little less than abide by its acceptance.

In the treatment of certain infant ills the use of both bulgarian and ordinary commercial buttermilk has been highly successful. Likewise, its value in correcting intestinal disorders in adults has been widely advertised while its employment as the sole food in cases of typhoid fever has been attended with marked success.

In an interesting research to show the effect of lactic acid on undesirable bacteria Fisher (5), experimenting with cultures of both bulgarian and ordinary lactic bacteria, found that "Pathogenic bacteria introduced into milk cultures containing 1% lactic acid were effectively checked and destroyed." His work dealt with cultures of *Bacillus coli; B dysenteria* and *B typhosus.* While other experiments according to Fisher "seem to indicate that this germicidal action of lactic acid does not extend to the control of the organisms already in the intestine" he did find "that intestinal putrifaction decreased markedly when at least two quarts of *bulgaricus* milk were used and the other food reduced proportionately."

We now know that, contrary to previous opinion, neither bulgarian nor ordinary lactic bacteria can be transplanted and grown in the intestinal tract through the use of bulgarian or cultured buttermilk. However, they do have a beneficial effect on health. Finally, the curdling of milk is looked upon by many as highly advantageous in that it approximates the first step of digestion and in many cases appears to be retained more easily than whole milk. Undeniably, buttermilk is a health drink.

Financial Aspects

Buttermilk serves as a ready means of selling surplus milk and turning skim milk into a valuable product.

From the standpoint of the milk dealer the year might well be divided into three seasons:

1. The period of shortage.
2. The normal period.
3. The surplus period.

The latter, resulting from the stimulus of fresh, green spring pasture on production, presents a problem of no small scope and its systematic solution frequently settles the question of profit or loss. Considered from this angle, commercial buttermilk might be looked upon as a "safety first" product.

Surplus coming as it does during the season of lowest prices, must be disposed of usually through separation, the skim milk in many cases being considered a total loss and allowed to flow down the sewer.

In a small plant where the writer was first called upon to experience the trials of a milk plant worker, thirty ten-gallon cans of skim milk were lost daily in this way. A total waste! The problem was readily handled chiefly through the production of commercial buttermilk and cottage cheese, and the waste was converted into a profitable enterprise.

Although the price of buttermilk varies considerably, depending upon such factors as locality and composition, ten cents a quart appears to be a relatively fair average. On this basis the following interesting calculation may be made, figuring no losses.

100 lbs. of 4% milk contains	4 lbs. fat
100 lbs. of 4% milk containing 4 lbs. fat yields about	20 lbs. of 20% cream
100 lbs. milk minus 20 lbs. cream equals	80 lbs. of skim milk
Value of 20 lbs. cream at 40 cents per qt. retail figuring approximately 2.15 lbs. per qt.	$3.72
Value of 80 lbs. or approximately 36 qts. of buttermilk at 10 cents per qt. equals	$3.60
Total value	$7.32
Cost of milk at $2.40 per 100 lbs. and culture at 5 cents per day equals	$2.45
Difference	$4.87

While incidental expenses of manufacture and mechanical losses would entail further deductions, a reasonable and substantial profit may well be expected.

THE QUALITIES OF GOOD COMMERCIAL BUTTERMILK

Good buttermilk possesses the following qualities: It has a mild, rather sweet, acid flavor. It should be viscous and creamy in appearance, pouring from a bottle much the same as thick gravy. After curdling, it should break up readily into a fine, flocculent, smooth, homogeneous mixture which contains no lumps and does not whey

off when held in storage at a low temperature for two days or longer. For judging the quality of commercial buttermilk, the writer has prepared the following score card with criticisms of the different items:

Item	Perfect Score
Flavor and odor	45
Viscosity	25
Appearance and color	15
Visible dirt	10
Bottle and cap	5
Total	100

In the first place, the item of flavor and odor has been allowed 45 points because buttermilk is consumed largely for its palatability, medicinal value, and general tasty qualities. Since any undesirable qualities are usually associated with an undesirable flavor and odor, it seemed imperative that this item be given a high rating. Furthermore, bacteria are responsible for the production of the ideal flavor and odor while foreign types of organisms adversely affect this quality. Flavor and odor, therefore, are a partial indication, at least, of the desirable qualities in buttermilk.

Regarding viscosity, it is readily observed that a lack of this quality is directly associated with wheying off, watery and flat flavor and a dull color and appearance. A score of 25 was allowed for this item because it was believed that approximately one-fourth of the defects appearing in commerical buttermilk are associated with poor viscosity.

Appearance and color being so closely associated, it was deemed inadvisable to separate the two. As all good buttermilk has a creamy rich, thick, smooth, soft, velvety appearance and poor buttermilk a dull, watery, flaky, thin, dead, whitish appearance, it is believed advisable to assign fifteen points to this item on the score card.

The same criticisms for visible dirt and bottle and cap should be considered as are found on the score card for market milk. In the mind of the writer there is no excuse for the sale of buttermilk containing sediment in the bottom of the bottle and much sediment should be considered as indicating carelessness in its preparation.

Manufacturing Commercial Buttermilk on a Commercial Scale

Distinction Between Sterilization and Pasteurization

Scientifically speaking, sterilization means the complete destruction of bacteria or other organic life contained in any product, while pasteurization refers to the process of destroying as much organic life as possible, thus rendering the product free from undesirable organisms. In other words, pasteurization means simply par-boiling, and from a commercial standpoint, has been defined as a process of heating milk to a temperature of 145° F. for 30 minutes followed by immediate cooling. Higher temperatures have been employed for shorter periods, but do not apply to the generally accepted definition of commercial pasteurization.

Sterilization, on the other hand, might require several hours of continued boiling or a higher temperature for a shorter period. The difficulty attending sterilization on a commercial basis is therefore readily apparent, although we use the term quite generally and freely, applying it to the process of heating milk.

For the manufacture of commercial buttermilk we are interested only in heating the milk to such a temperature that the bacterial content is reduced to a minimum, thus enabling the manufacturer to artificially induce in the product the type of fermentation he desires. Therefore, to avoid confusion, only the term "heating" will be used.

Importance of Sanitation

The greatest difficulty attending the manufacture of commercial buttermilk lies in the possible contamination of the product, through unclean utensils, carelessness on the part of the manufacturer, or dirty glassware in which milk for the mother culture is prepared. All frequently serve to contaminate the product and result in an off flavor, gassy, and undesirable culture or buttermilk. It is therefore essential that all utensils coming in contact with the milk or cultures be thoroughly steamed and kept scrupulously clean.

MOTHER STARTER

Products Used for Mother Starter

Various dairy products have been suggested for the preparation of mother cultures and each possesses certain distinct advantages and disadvantages.

1. Skim milk.

   Advantages:
   1. It is inexpensive.
   2. It is less likely to injury by high temperature.
   3. It is readily obtained.

   Disadvantages:
   1. It is frequently less sanitary than whole milk.

2. Whole milk.

   Advantages:
   1. It is usually cleaner than skim milk since it does not pass through a separator of doubtful sanitation.
   2. It is usually fresher than skim milk.
   3. Because it is usually kept cool until ready for use, the bacterial content may be less than in skim milk.

   Disadvantages:
   1. It is more expensive than skim milk.
   2. It is more readily injured by high temperatures on account of its content of fat.

3. Cream.

   Advantages:
   1. It may be used when other materials are unobtainable.
   2. Its addition to the bulk increases the fat content materially and results in a richer commercial buttermilk with higher food value.

   Disadvantages:
   1. It is more expensive than skim milk or whole milk.
   2. It is more readily injured by high temperatures on account of its content of fat.
   3. The fat content may partially hide the ideal lactic flavor of the mother culture.
   4. Because of its low percentage of solids not fat it is not so desirable a media for the growth of bacteria.

4. Milk Powder.

   Advantages:
   1. It may be readily obtained in practically all localities.
   2. It can be stored and kept for considerable periods and used when desired.

   Disadvantages:
   1. It necessitates more work to prepare it in the form of milk or skim milk.
   2. It has a heated flavor which partially hides the desirable lactic taste.
   3. It may readily become contaminated if not carefully handled.

5. Whey.

Advantages:

1. It is easily sterilized and is not injured by high temperatures.
2. It is cheap since in most plants it is considered a waste product.

Disadvantages:

1. It contains no casein; consequently does not curdle and does not furnish the manufacturer with an index of the type of bacteria which it contains.
2. It is readily contaminated with yeasts and in general is less sanitary than other dairy products.

From all standpoints skim milk has been found to be the most acceptable and has been used in nearly all experiments reported in this bulletin.

The Mother Starter

There are on the market many cultures of lactic bacteria manufactured by numerous firms. These cultures are generally termed "commercial starters" or "lactic ferments" and consist, as already stated, of lactic-acid-producing-bacteria with possibly one or both types of the associated organisms. In other words, we may consider them as pure cultures of desirable milk fermenting organisms. It is customary for plants to secure these starters twice monthly, although in some cases they are obtained weekly. Each vial of the commercial starter contains a sufficient number of organisms to curdle a quart bottle of milk in from eighteen to twenty-four hours, depending upon whether the starter is of the dry or liquid type.

When the quart bottle of milk has been heated, cooled to the proper temperature, and inoculated with the commercial starter it is allowed to curdle. This curdled milk is then termed "mother starter," "mother culture," or simply "startoline." This startoline is carried forward from day to day by small transfers from the previous day's bottle until, because of contamination it becomes necessary to renew it with another commercial starter.

Utensils for the Mother Starter

Experiments conducted by the writer prove the manufacture of off flavored mother starter or buttermilk may be brought about through the use of unsatisfactory utensils, cans, or metal vessels containing rust spots or from which the tin coating has become worn exposing copper or iron surfaces which invariably produce a metallic flavor. For this reason the use of glass or heavy enameled-ware has been found to be the most satisfactory.

Quart milk bottles or fruit jars serve admirably as vessels in which to heat milk. The jar, however, has the disadvantage of having a screw or clamp cap and is therefore somewhat difficult to keep clean around the top. The quart milk bottle makes a satisfactory container if only small amounts of mother starter are required. Sterile caps,

parchment paper tied over the top with a string, or an ordinary drinking glass placed over the mouth will permit thorough heating and prevent contamination from the dust of the air. When it is desired to manufacture mother starter in larger quantities, some special device providing for the heating of a greater volume of milk must be provided.

Preparation of the Mother Starter

For a mother starter, milk may be placed in one of the vessels already described, heated to 190° F. for 30 minutes, and then cooled to the desired temperature, which varies from 68° to 80° F. If a dry commercial starter is used in preparing the "mother" a temperature of 80° is more desirable for the first inoculation since bacteria in the dry state are not as vigorous as those contained in the fresh liquid culture. A temperature of 75° F. will prove satisfactory for the first inoculation with liquid culture.

Second and Succeeding Propagations

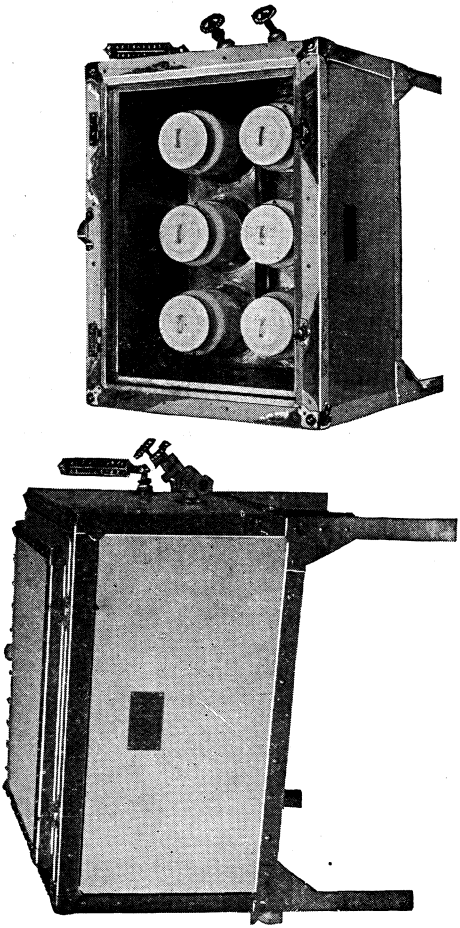
Milk for the second and succeeding day's manufacture of the "mother culture" should be heated as already recommended, but may be cooled to a lower temperature, preferably 68° F. to 70° F. in the summer and 70° F. to 72° F. in the winter. For inoculating each succeeding quart of "startoline" about two or three per cent of the previous day's culture thoroughly broken up by vigorous agitation, should be used.

It is impossible to give explicit directions for the amount of culture to be added daily. However, a good rule to remember is that the smaller the amount required to curdle the milk in a certain definite time, the better the mother culture will be, as it indicates the addition of vigorously active bacteria. It is well to shake the bottle once or twice during the first hour to make sure that the added culture has become well distributed throughout.

Controlling the Temperature of Incubation

Many devices have been suggested for the proper regulation of temperature such as an insulated box provided with an electric light. While in many cases such equipment has served as a poor substitute, it would appear inadvisable to recommend anything other than thoroughly efficient equipment, especially since buttermilk has gained so prominent a place in commercial dairying.

For the experiments reported in this bulletin a standard electrical bacteriological incubator or the sterilizer-incubator shown in the cut on page 18 were employed. Through their use temperature requirements have been readily controlled and no difficulty has been experienced in carrying ideal mother cultures from day to day without contamination. It was only after attempting to manufacture buttermilk under make shift methods mentioned above, which resulted in a product of variable quality, that a decision was reached to buy the above equipment, which has given satisfaction and made it possible to carry a pure



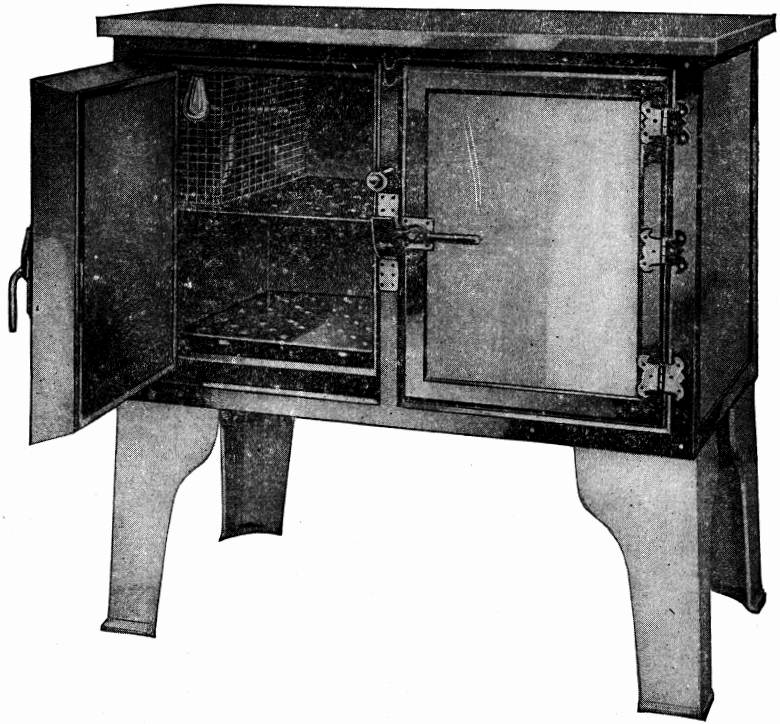
Combined Sterilizer and Incubator. (Through the courtesy of Cit-Ro-Lac Products Company, 1245 Lawrence Avenue, Chicago, Illinois.)

mother culture for as long as desired without resorting to the use of a new commercial starter.

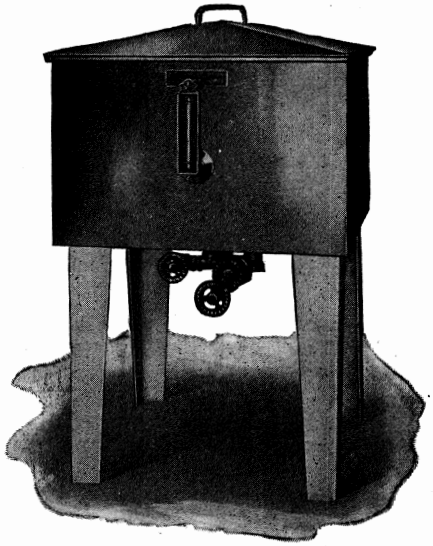
The Appearance of an Ideal Mother Starter

The ideal mother starter, when properly curdled, has the following qualities:

1. The curd is smooth and uniform.
2. The surface of the curd should appear very slightly concave and may be covered by a thin film of whey.
3. The curd should be free from gas holes or gas streaks, cracks or openings of any kind, and the surface should be clean cut and free from raggedness.



Mojonnier Culture Controller



Sterilizer for Mojonnier Culture Controller

Mojonnier Culture Controller and Sterilizer. (Through the courtesy of Mojonnier Brothers Company, 4601 W. Ohio Street, Chicago, Illinois).

4. A mother starter prepared in a quart milk bottle should be sufficiently firm for the bottle to be tilted at an angle of about 45° and in some cases entirely inverted without the curd giving way.

When the curd is in this condition, it should be set in the ice box or cold room and held at a temperature not exceeding 45° F. until ready for use. It is advisable not to break up the mother starter until just previous to use.

Reasons for Not Breaking the Mother Starter

The lactic acid bacteria commonly employed in the preparation of commercial buttermilk are incapable of producing under ideal conditions, more than about 1% acid. Experiments have shown that they begin to die out when an acidity of about .75% is reached. As has already been specified, they produce lactic acid by fermenting milk sugar. In the curdled mother starter the milk sugar around each organism has possibly been converted into lactic acid and no more is produced. Hence, if the culture be broken up, bacteria may be distributed to a fresh supply of unchanged milk sugar and the acidity of the culture thus increased until the bacteria become weakened or entirely killed.

The Propagation of the Mother Starter to Use

When commercial starters are first received at the plant in either the dry or liquid state, the bacteria are not as vigorous as they will become after succeeding propagations. For this reason it is advisable to use the dry culture only after the third propagation, the liquid culture being usually satisfactory after the first transfer. It is inadvisable to keep the mother starter more than two days without making a new transfer and for most satisfactory results daily propagations should be made.

Summary of the Preparation of the Mother Starter

1. Use sterilized glass containers or enameled ware in which to heat the milk.
2. Heat the milk to 190° F. and hold for 30 minutes.
3. Cool to 80° F. if a dry starter is used and to 75° F. if a liquid culture is employed.
4. For each succeeding propagation, heat the milk as already described and cool to 68° to 70° F. in summer and 70° to 72° F. in winter.
5. When properly curdled set the culture in the ice box without breaking until ready to use.
6. Just previous to using break up the culture by vigorous agitation.
7. Use about two or three per cent per quart of each day's mother starter for the succeeding day's starter.

Manufacture of Commercial Buttermilk On a Large Scale

Products Used for Making Commercial Buttermilk in Bulk

Three chief products may be used for the preparation of the bulk buttermilk.

1. Skim milk.

Skim milk for preparing the bulk product has the same advantages as it has for the preparation of mother culture, and likewise the same disadvantages. It is used more extensively, perhaps, than any of the other products in that it is the by-product obtained from handling surplus milk in the factory, and must be disposed of in the most profitable manner. It makes an excellent product, highly palatable and of ideal viscosity when handled properly. Its palatability may be increased by the addition of a small amount of cream.

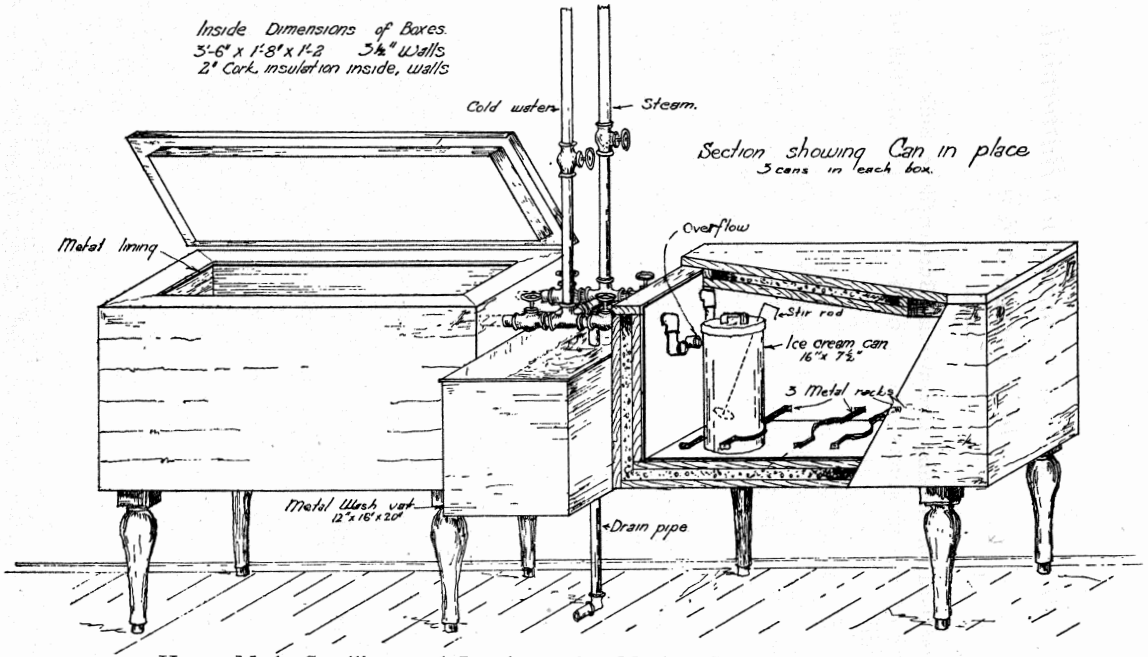
2. Whole milk.

Whole milk has the same advantages and disadvantages as listed under whole milk for mother starter. As a rule, whole milk is seldom used as the sole product for the preparation of commercial buttermilk. However, it frequently forms 50% of the commercial product, being diluted with skim milk buttermilk. Buttermilk made from partially skimmed milk therefore contains approximately 2% fat, and is highly pleasing, palatable, and rich in flavor.

3. Skim milk powder.

A number of firms, as a result of necessity, have attempted to manufacture the bulk product using skim milk powder. The powder is dissolved in water at the rate of one pound of powder to nine pounds of water. A special starter can or pasteurization vat, the coils of which are provided with mixing blades, is best for this purpose. The water should be at a temperature of about 80° F. when the powder is added, and thoroughly agitated while bringing the temperature up to 100° F. As soon as the powder is thoroughly dissolved, the milk should be stirred and heated to a temperature of 180° F., then cooled immediately to 69° to 70° F., and inoculated with two to five percent of mother starter, depending upon the rapidity with which curdling is desired. The manufacture of high grade buttermilk from skim milk powder is still open to much criticism. Skim milk powder has a flavor unto itself and when reheated, takes on a more pronounced cooked flavor.

COOLING and STERILIZING APPARATUS -



Home Made Sterilizer and Incubator for Mother Starter Similar to One in Use by Beatrice Creamery Company at Oklahoma City, Oklahoma. This Piece of Apparatus can be Built at Small Cost.

Utensils in Which to Manufacture the Bulk Product

For the manufacture of the bulk product three principal classes of containers are available:

1. Thoroughly tinned ten-gallon milk cans.
2. Tinned copper vats.
3. Glass lined vats.

For the manufacture of buttermilk in small quantities, ten-gallon milk cans usually suffice. When the product is manufactured on a large scale, tinned copper vats (buttermilk machines) or glass lined vats are the most desirable. Some of these latter machines are manufactured to operate at two speeds, the slow speed being employed during mixing, heating and cooling, and a high speed when breaking up the curd. In the use of ten-gallon milk cans or tinned copper vats it is essential that the tin surface be free from blemishes and rust spots or exposed copper surfaces, otherwise a metallic flavor may result.

It must be remembered in the manufacture of all commercial buttermilk that the high acidity of the product gradually destroys the tinned coating of metal vats, exposing the copper surfaces, making retinning necessary at comparatively frequent intervals, whereas in the use of glass enameled vats this difficulty is overcome.

MAKING THE PRODUCT

Heating the Milk

It is assumed that an ideal starter or startoline is at hand. That being the case, it is necessary to heat the milk to a temperature of 180° to 190° F., preferably the latter, cooling immediately to 68° to 70° F. in summer and 70° to 72° F. in winter.

The Quantity of Mother Starter to Add for Curdling the Product

The amount of mother starter used depends upon a number of factors such as:

1. The vigor of the starter.
2. Temperature of setting.
3. Rapidity with which curdling is desired.

A large percentage of mother starter while shortening the time of curdling, frequently results in a strongly flavored product which may be somewhat lumpy. Specific information regarding the most desirable quantity of starter to use is therefore difficult to give. If the temperature can not be accurately controlled, variations in the quantity of mother starter will be required, a colder temperature necessitating the use of a larger amount and a warmer temperature somewhat less.

Occasionally as high as ten percent starter has been used in plants when it was desired to culture the product in the early morning and bottle it late in the afternoon. As a rule, buttermilk is cultured with sufficient mother starter to curdle it for use in fifteen to eighteen hours, in other words, over night, and the smallest amount of starter necessary to efficiently produce this result and impart the desired

qualities to the commercial product is the proper amount to use. It can best be determined by experience. In most of the experiments reported in this bulletin from two to three percent of finely broken mother starter was used in making the bulk product and was found to give highly satisfactory results.

Stirring the Bulk Product After Adding Mother Starter

During the first hour after the mother starter has been added, the product should be agitated three or four times in order that thorough mixing may be obtained, otherwise, the mother starter may settle to the bottom and produce uneven curdling.

Controlling the Temperature

During the ripening period of the bulk product, the temperature should be accurately maintained.

In many plants custom has decreed that the bulk milk be set at a temperature of 85° F. or thereabouts with the expectation that it will drop to the desired temperature during the ripening period. This procedure occurs largely in plants which have inadequate means of temperature control and, although satisfactory results are frequently obtained, it is not conducive to the manufacture of a uniformly high grade product. The vigor of the culture, the quality of the product and the acidity developed are only efficiently controlled when temperatures of incubation are carefully regulated.

Cooling and Breaking the Bulk Product

When the bulk buttermilk has been prepared in a ten-gallon milk can, as frequently occurs in plants inefficiently equipped, it is advisable to cool the product by placing it in the ice box and allowing it to remain overnight before breaking up the curd, thus rendering it more viscous with less possibility of wheying off. This process has been regularly tried at the college creamery and has given satisfaction. Neither did the acidity materially increase during the period of overnight cooling.

When the product is made in commercial buttermilk vats, a somewhat different process is necessary. Experiments conducted by the writer in the college creamery and information secured from a plant* which cooperated in this work have shown that most satisfactory results are obtained when the curdled milk is broken up at the temperature of incubation, in other words, 68° to 72° F. Agitation should be only sufficient to produce a uniform, smooth, creamy, homogeneous product. Too vigorous agitation invariably produces foam and wheying off at either high or low temperatures as shown by the experiments reported in this bulletin. During the breaking up process the buttermilk may be cooled quickly to the desired temperature of holding, 40° to 50° F.

Acidity and Palatability

While commercial buttermilk manufactured from a single culture of a lactic ferment may contain as high as .90 to .95 or even 1.00% acid,

*D. H. Ewing Sons, Louisville, Ky.

the most desirable acidity to develop from the standpoint of palatability was found to be .80 to .85%. This was concurred in by those judges who tasted the product for flavor.

Summary of the Preparation of the Bulk Buttermilk

1. Use ten-gallon milk cans or commercial buttermilk vats.
2. Heat the milk to 190° F. and cool immediately to 68° to 70° F. in summer and to 70° to 72° F. in winter.
3. Add two to three percent of smooth startoline.
4. Agitate the milk three or four times during the first hour to thoroughly distribute the startoline.
5. Let stand until curdled with temperature properly controlled.
6. If prepared in a ten-gallon milk can, cool the curd before breaking up. If made in a commercial buttermilk vat, begin breaking up at the temperature of incubating, (68° to 72° F.), cooling continuously to 40° to 50° F. with just sufficient agitation to produce a smooth product.

Experiments Conducted on Commercial Buttermilk

The following experiments were conducted on commercial buttermilk to determine certain factors affecting its quality.

THE EFFECT OF METALS ON FLAVOR

The metals with which buttermilk most frequently comes in contact are tin, aluminum, copper and zinc. Occasionally the product develops a strong metallic flavor undesirable from a commercial standpoint. Since it is sometimes prepared in ten-gallon milk cans or tinned copper vats from which the tinned coating has become worn, it was deemed advisable to determine what effect, if any, such conditions might have on flavor.

Six gallons of skim milk were divided into four lots, and each lot was placed in a heavily enameled culture can in a Petersen Combined Sterilizer and Incubator. The milk was then heated to 190° F. for one hour, cooled to a temperature of 86° to 90° F., and held at this temperature during the curdling period, in order to produce as much acidity as possible, and thus increase the probability of a metallic flavor.

When each lot was inoculated with 3.8% mother starter prepared under the usual factory conditions, a strip of one of the above mentioned metals cut in a size two by four inches, was suspended in each can with a string until after the milk had curdled. The acidity was noted and the buttermilk tested for flavor and other qualities as listed in the data.

Conclusions

From the results obtained the following conclusions may be reached:

1. Direct contact of buttermilk with copper and zinc produces a distinct metallic flavor.
2. Tin and aluminum had no noticeable effect on flavor.
3. In experiments on butter, Hunziker (8) shows that metals such as copper and iron may be dissolved by the acid in buttermilk from the churn and form chemical combinations such as copper lactate. Since commercial buttermilk is considerably higher in acid than buttermilk obtained directly from the churn, the metallic flavor may be especially pronounced, as shown by the above experiment.
4. Metallic flavored buttermilk may be avoided or entirely prevented by: 1. Using well tinned cans or vats free from rust spots or exposed copper surfaces, or by employing glass lined vats or heavy enameled ware. 2. Thoroughly washing and drying vats and utensils used for handling buttermilk. If buttermilk must be made in rust spotted cans or vats with exposed copper surfaces it should be removed as soon as possible or cooled to prevent the formation of more acid which is conducive to metallic flavor.

Effect of Metals on Flavor of Commercial Buttermilk

Date	Percent Acidity	Characteristic of Culture	Flavor	Odor	Approximate Time to Curdle (hours)	Amount Culture Used	Setting Temp. F.	Metal Used
1-29-23	.813	Smooth no gas	Excellent	Good	12	½ pint	86°	Tin
	.9	Smooth no gas	Metallic	Good	12	½ pint	86°	Copper
	.9	Smooth no gas	Very acid	Good	12	½ pint	86°	Aluminum
	.813	Gassy visible whey	Metallic	Rancid	12	½ pint	86°	Zinc
1-27-23	.875	Smooth no gas	Metallic	Good	12	½ pint	86°	Copper
	.9	Smooth no gas	Excellent	Good	12	½ pint	86°	Tin
	.85	Gassy visible whey	Metallic	Rancid	12	½ pint	86°	Zinc
	.85	Smooth no gas	Excellent	Good	12	½ pint	86°	Aluminum
1-30-23	.825	Smooth no gas	Metallic	Good	12	½ pint	86°	Copper
	.910	Smooth no gas	Excellent	Good	12	½ pint	86°	Tin
	.875	Smooth no gas	Excellent	Good	12	½ pint	86°	Aluminum
	.870	Smooth no gas	Metallic	Good	12	½ pint	86°	Zinc
1-31-23	.975	Smooth no gas	Strong acid	Good	12	½ pint	86°	Aluminum
	1.00	Smooth no gas	Strong acid	Good	12	½ pint	86°	Tin
	.95	Smooth no gas	Metallic	Good	12	½ pint	86°	Zinc
	.95	Smooth no gas	Metallic	Good	12	½ pint	86°	Copper
2-1-23	.9	Smooth no gas	Good	Good	12	½ pint	86°	Aluminum
	.975	Smooth no gas	Metallic	Good	12	½ pint	86°	Zinc
	.95	Smooth no gas	Strong metallic	Good	12	½ pint	86°	Copper
	.95	Smooth no gas	Good	Good	12	½ pint	86°	Tin
2-2-23	.975	Wheying off	Good	Fair	12	½ pint	90°	Aluminum
	.975	Wheying off	Metallic	Fair	12	½ pint	90°	Zinc
	1.00	Wheying off	Metallic	Fair	12	½ pint	90°	Copper
	1.00	Wheying off	Good	Fair	12	½ pint	90°	Tin

DO METALS PRODUCING METALLIC FLAVORS CAUSE COMMERCIAL BUTTERMILK TO WHEY OFF?

Since it was found that copper and zinc produced a metallic flavor in commercial buttermilk it was deemed advisable to determine what effect, if any, they might have on its tendency to whey off.

Accordingly, commercial buttermilk was prepared in a manner identical to that used to determine the effect of metals on flavor. Two metal strips of copper and zinc were suspended in the milk as soon as cultured and set at a temperature of 86° F. A high acidity was developed as shown in the table of results and the curd was broken up in a small glass hand churn. Two pint bottles were then filled with the commercial buttermilk, two samples being taken of each can containing the copper and the zinc strips. One pint bottle was placed in the ice box at a temperature of 50° F. and the other was set away at room temperature, observations being made for any tendency on the part of the buttermilk to whey off. Control samples containing no metal strips were also prepared in each case and samples taken therefrom. The results obtained are shown in the following table:

Conclusions

From the practical standpoint all samples appeared identical with the control, although there was some controversy with regard to the firmness of the curd, it being finally concluded that the samples containing metal strips did not develop as firm a curd as the curd of the product in which no metal had been suspended. This may have been caused by variation in the acidity and more experiments should be run to definitely settle the point in question.

The Effects of Metals on the Wheying Off of Commercial Buttermilk

Metal	Percent Acidity of Buttermilk	Characteristics of Buttermilk	Odor of Buttermilk	Approximate Time to Curdle (hours)	Approximate Percent of Culture Used for the Inoculation	Setting Temp. °F.)	Remarks
Copper	.85	Firm; no whey	Good	12	4%	86	Copper and zinc were slightly less firm than control.
Zinc	.9	Firm; no whey	Good	12	4%	86	
Control	.875	Very firm; no whey	Good	12	4%	86	
Copper	.813	Firm; no whey	Good	12	4%	86	Copper and zinc were slightly less firm than control.
Zinc	.9	Firm; no whey	Good	12	4%	86	
Control	.85	Very firm; no whey	Good	12	4%	86	
Copper	.95	Firm; no whey	Good	12	4%	86	Copper and zinc were slightly less firm than control.
Zinc	.975	Firm; no whey	Good	12	4%	86	
Control	.95	Very firm; no whey	Good	12	4%	86	

EFFECT OF DIFFERENT TEMPERATURES OF HEATING MILK ON THE FLAVOR AND PHYSICAL CHARACTERISTICS OF COMMERCIAL BUTTERMILK

Apparently much confusion exists with regard to the different temperatures which may be employed in heating milk for the manufacture of commercial buttermilk. An examination of publications sent out by various firms manufacturing commercial starters have been found to recommend temperatures varying anywhere from 150° F. for one hour to 200° F. for thirty minutes. The great discrepancy in the temperatures advocated may be observed from the following table:

Firm Number	Heating Milk for Commercial Buttermilk	
	Temperature	Minutes
1	190 to 200	30
2	180 to 190	30 to 40
3	190	20
4	190	30
5	180 to 200	30 to 40
6	150 to 160	90
7	190 to 200	0 to 5
8	180	0
9	190	60
10	170	60
11	170 to 190	40

In order to determine what temperatures and time of holding were most desirable for heating the milk, four samples were secured and each sample heated to the different temperatures for the time specified, as shown in the table of results. The samples were cooled to a temperature of from 68° to 74° F., and to each was added approximately 2% of good fresh mother starter. After curdling, the curd was broken up for five minutes in a glass hand churn, the handle of the churn being turned at a definite rate of speed. Studies were then made of the product for the appearance of the curd, the acidity, and other factors as noted in the table of results.

The viscosity of the product was determined in two ways, as follows:

1. A clean piece of glass was tilted at a definite angle, 23°, 40 minutes, and upon its surface were scratched two lines at a distance of 12 inches apart. A definite amount (2 cc) of the buttermilk was run onto the glass at the first mark and the time taken in seconds that it required to flow to the second mark.
2. A 50 cc pipette was filled with the buttermilk and the time required to empty was taken in seconds.

An examination was made of the curd under the microscope and differences in its appearance noted. In studying the table of results slight variations will be observed in the acidity of the curdled product, although this was kept as nearly uniform as possible by temperature

control, and the amount of inoculation. With the exception of series one and two of the experiments, four commercial starters obtained from different firms were used in the preparation of both the mother culture and the commercial product so that results obtained should be significant.

It was thought best for the sake of clearness to summarize each series of the experiment, this to be followed by a general summary and conclusions for all.

Conclusions to Series One

Series One was a preliminary experiment. Since four different cultures were used, variations were to be expected in the results. However, the following facts may be listed.

1. At temperatures higher than 145° F. applied for longer than thirty minutes, a distinctly flat or slightly cooked flavor was apparent.
2. When examined under the microscope the curd of milk which had been heated to 145° F. was coarser and less evenly distributed than that from milk to which higher temperatures had been applied.
3. The curd of milk which had been heated to 185° to 200° F. for one hour was very easily broken up and quite viscous.
4. The higher temperatures appeared to produce greater viscosity in the cultured buttermilk.

Conclusions to Series Two

1. Temperatures higher than 145° F. for thirty minutes imparted to the buttermilk the slightly cooked, flat or off-flavor which was not considered ideal.
2. The curd of buttermilk prepared from milk heated to temperatures above 145° F. was softer and more easily broken up in practically all cases. The curd particles under the microscope appeared more uniform, better distributed, and freer from air spaces than those of the product which had been heated to temperatures of 145° F. or 160° F.

Conclusions to Series Three

Series Three demands the same conclusions as given for Series Two, with the exception that in milk heated to 190° F. and immediately cooled without holding no cooked flavor was apparent. Exceptional viscosity was also exhibited by buttermilk prepared from milk heated to temperatures higher than 145° F., the viscosity increasing as the temperature increased. The acidities were comparatively the same in the different lots of buttermilk.

Because of the undesirable results obtained with milk heated to 145° F., it was decided to discard this temperature as being unsuitable for the manufacture of the commercial product. Accordingly, temperatures of heating of 160°, 170°, 180° and 190° F. were used in series four, five, six and seven of the experiment, these temperatures being employed for periods varying from 0 to 30 minutes.

Conclusions to Series Four, Five, Six and Seven

Temperatures of 160° to 190° F. applied for thirty minutes were unnecessary from the standpoint of good quality in commercial buttermilk. Since it requires a considerable period to raise the temperature of milk to 190° F. unless flash pasteurized it is unnecessary to hold it at this temperature for any period, as the product has been rendered practically bacteria-free by the time this temperature is reached. Hence, heating to 190° F., followed by immediate cooling is satisfactory. The viscosity of the cultured product increased as the temperature increased in practically all cases. The ease of breaking also appeared to increase as the temperature of heating increased. An acidity of .8% to .85% was considered the most desirable from the standpoint of palatability.

General Summary and Conclusions

As a result of the seven series of experiments the following conclusions may be drawn:

1. Heating to a temperature of 180° to 190° F. followed by immediate cooling is best for the practical sterilization of milk for commercial buttermilk making.
2. An acidity of .8% to .85% was most desirable from the standpoint of palatability, according to the opinions of those who tasted the product.
3. The viscosity of the buttermilk increases as the temperature of heating increases and is chiefly dependent on the vigor of the culture used, the temperature of incubation and the acidity developed.

Effect of Different Temperatures of Heating Milk on the Qualities of Commercial Buttermilk—Series 1

Number	Temperature of Heating	Time of Heating Minutes	Approximate Per cent of Mother Culture Added	Temperature of Incubation	Character of Curd Before Breaking	Viscosity of Milk		Ease of Breaking Curd	Appearance Under Microscope	Acidity	Time of Agitating Curd to Break It	Temperature at Which Curd was Broken Up	Name of Culture	Flavor and Odor
						Running From a 50 cc Pipette	Flowing Over Glass							
I	145° F.	30	2	68° F.	Excellent; smooth, no gas, no whey	5 sec.	21 sec.	Very easy	Uniform particles but of medium size somewhat clumped	.86%	5 min.	68° F.	A	Very good
II	160° F.	60	2	68° F.	very slight whey on surface, no gas, ideal curd	40 sec.	40 sec.	Relatively hard	Very fine particles; uniform size	.88%	5 min.	68° F.	B	Strong, flat
III	185° F.	60	2	68° F.	Slight whey on surface; smooth curd; ideal	39.6 sec.	36 sec.	Easy	Rough looking; not so fine or even as No. II	.86%	5 min.	68° F.	C	Flat, slightly cooked
IV	200° F.	60	2	68° F.	Very smooth; no bubbles; slight whey on surface; ideal curd	Lost	40 sec.	Exceptionally well broken after 4 or 5 turns of handle	Very fine; smooth particles; air bubbles present	.74%	5 min.	68° F.	D	Good, slightly flat

Effect of Different Temperatures of Heating Milk on the Qualities of Commercial Buttermilk—Series 2

Number	Temperature of Heating	Time of Heating (minutes)	Temperature of Incubation (degrees F.)	Approximate Percent of Mother Culture Added	Character of Curd Before Breaking	Viscosity (seconds)		Ease of breaking Curd	Appearance Under Microscope	Acidity	Time of Agitating Curd to Break It (minutes)	Temperature at Which Curd was Broken Up (degrees F.)	Name of Culture	Flavor and Odor
						Running from 50 cc Pipette	Flowing Over Glass							
1	145	30	70	2	Fair	18	30	Very easy	Particles slightly larger than at other temperatures. Curd particles appeared to be separated by air spaces. Particles of curd could be easily distinguished	.7	5	70	A	Good
	160	30	70	2	Slight film of whey on top; ideal curd	20	28	Very easy	Curd particles clumped and clumps close together, but separated by air spaces. Curd particles appeared about the same size as 145° particles	.77	5	70	A	Slight strong
	175	30	70	2	Very good; no whey	14	26	Very easy	Curd particles homogeneous. Particles finer than previous temperatures. No clumping visible. Entire mixture uniform	.66	5	70	A	Cooked
	190	30	70	2	Appeared slightly rough	20	32	Fairly easy breaking	Curd particles homogeneous. Particles much finer than at 145° or 160° F. No clumping visible. Whole mixture uniform. Similar to 175° F. sample	.69	5	70	A	Cooked;

II	145	30	70	2	Slight film of whey on top; rough	18	28	Hard breaking	Clumps appeared separated by air spaces. Particles in clumps appeared about same as 145° F. above	.76	5	70	B	Good
	160	30	70	2	Slight film of whey on top; poor	20	32	Medium	Clumps were very close together but between individual clumps were many smaller curd particles rather than air spaces	.80	5	70	B	Slight acid. Cooked.
	175	30	70	2	Slight film of whey on top	22	40	Easy	Same as 175° above	.81	5	70	B	Slight acid. Cooked.
	190	30	70	2	Slight amount of whey on top; fair curd	20	30	Medium	Same as 175° above	.75	5	70	B	Cooked.
III	145	30	70	2	Slight amount of whey on top; fair curd; rough	30	42	Hard	Same as 145° of Culture 1	.73	5	70	C	Good
	160	30	70	2	Slight whey on top; medium	18	22	Easy	Same as 160° of Culture II	.75	5	70	C	Strong flavor; slight cooked
	175	30	70	2	*								C	
	190	30	70	2	Slight whey on top; medium	Lost	32	Easy	Same as 175° of Culture II	.75	5	70	C	Cooked

*Did not curdle.

Effect of Different Temperatures of Heating Milk on the Qualities of Commercial Buttermilk—Series 3

Number	Time of Heating (minutes)	Temperature of Heating °F.	Approximate % of Mother Culture Added	Temperature of Incubation °F.	Character of Curd Before Breaking	Viscosity of Milk: Running From a 50 cc Pipette	Viscosity of Milk: Flowing Over Glass	Ease of Breaking Curd	Appearance Under Microscope	Acidity %	Time of Agitating Curd to Break it (minutes)	Temperature at Which Curd was Broken up	Name of Culture	Flavor and Odor
I	30	145	2	72	Smooth—Slight whey	35	11	Hard		.74	5	72	A	Milk, slight bitter
	30	160	2	72	Smooth—No whey	35	3	Medium hard		.68	5	72	A	Flat; slight bitter
	30	170	2	72	Smooth—Slight whey	50	36	Medium hard		.80	5	72	A	Medium; slight bitter
	0	190	2	72	Smooth—Ideal	52	200	Fairly easy		.80	5	72	A	Slightly bitter
II	30	145	2	72	Ideal	40	13	Hard		.76	5	72	B	Slightly bitter
	30	160	2	72	Uneven	45	39¾	Medium easy		.76	5	72	B	Slightly bitter
	30	170	2	72	No whey Ideal	45	58	Medium hard		.80	5	72	B	Fair
	0	190	2	72	Ideal	85	Too viscous	Medium hard		.78	5	72	B	Fair and mild
III	30	145	2	72	Ideal	35	13	Easy		.76	5	72	C	Fair and mild
	30	160	2	72	Ideal	35	19	Medium		.73	5	72	C	Fair and mild
	30	170	2	72	Smooth	40	35	Hard		.75	5	72	C	Clean lactic; mild
	0	190	2	72	Even Ideal	65	Too viscous	Medium hard		.80	5	72	C	Clean lactic; mild
IV	30	145	2	72	Smooth	20	25	Medium hard		.77	5	72	D	Slight bitter
	30	160	2	72	Broken	30	25	Easy		.80	5	72	D	Slight bitter
	30	170	2	72	Smooth; even	45	80	Easy		.79	5	72	D	Slight bitter
	0	190	2	72	Smooth	65	Too viscous	Hard		.76	5	72	D	Slight bitter

In all samples the particles appeared more homogenious, finer and more compact when the milk had been heated to temperatures above 160° F.

Note: In case of 190°, "too viscous" means the product was too viscous to flow a distance of 12". It was *ideal* viscosity. 190° was not maintained for any definite period. The milk was cooled at once. The other temperatures were applied 30 min.

Note: Determining viscosity by the pipette proved unsatisfactory. Its use was continued only because it indicated a smooth or lumpy product.

Effect of Different Temperatures of Heating Milk on the Qualities of Commercial Buttermilk—Series 4

Number	Time of Heating	Temp. of Heating	% Culture Added	Temp. of Inc.	Character of Curd Before Breaking	Viscosity (seconds)		Ease of Breaking	Acidity %	Time of Breaking (minutes)	Temp. of Breaking	Name of Culture	Odor	Flavor
						Running from 50 cc pipette	Flowing over glass							
I	30	160	2%	72	Curd soft, ideal	35	40	Easy	.85	5	72	A	Ideal	Good
	30	170	2%	72	Ideal	50	Too viscous	Fairly easy	.77	5	72	A	Good	Very good Pleasant
	30	180	2%	72	Very little whey; medium hard	70	Too viscous	Medium easy	.78	5	72	A	Good	Very good Pleasant
	30	190	2%	72	Ideal Hard	71	41	Hard	.85	5	72	A	Good	Very good Pleasant
II	30	160	2%	72	Soft, whey, loose curd	40	32	Very easy	.86	5	72	B	Good	Very sharp Fair
	30	170	2%	72	Soft, whey, loose curd	45	60	Medium easy	.83	5	72	B	Good	Very sharp Fair
	30	180	2%	72	Medium soft, whey	51	102	Fairly easy	.81	5	72	B	Good	Good
	30	190	2%	72	Medium soft; no whey	48	45	Fairly easy	.80	5	72	B	Good	Very good Pleasant
III	30	160	2%	72	Fairly soft; no whey	45	45	Fairly easy	.83	5	72	C	Good	Very good Pleasant
	30	170	2%	72	Ideal	80	140	Fairly easy	.85	5	72	C	Good	Very good Fair
	30	180	2%	72	Ideal	85	180	Medium hard	.82	5	72	C	Good	Very good Pleasant
	30	190	2%	72	Ideal	90	130	Fairly easy	.85	5	72	C	Good	Excellent
IV	30	160	2%	72	Fairly firm	62	40	Fairly hard	.92	5	72	D	Good	Acid fair Strong
	30	170	2%	72	Fairly firm	84	40	Fairly easy	.85	5	72	D	Good	Fair
	30	180	2%	72	Very good	100	100	Medium hard	.88	5	72	D	Good	Quite acid Fair
	30	190	2%	72	Good	85	65	Fairly easy	.96	5	72	D	Good	Slightly metallic acid

Note: "Too viscous" means the product was too viscous to flow a distance of 12".

Effect of Different Temperatures of Heating Milk on the Qualities of Commercial Buttermilk—Series 5

Number	Temperature of Heating (degrees F.)	Time of Heating (minutes)	Approximate Per Cent of Mother Culture Added	Temperature of Incubation (degrees F.)	Character of Curd Before Breaking	Viscosity (seconds)		Ease of Breaking Curd	Acidity %	Time of Agitating Curd to Break it (minutes)	Temperature at Which Curd Was Broken up (degrees F.)	Name of Culture	Odor	Flavor
						Running from 50 cc pipette	Flowing over glass							
I	160	20	2%	70	Good	45	20	Very easy	.87	5	70.5	A	Good	Fair
	170	20	2%	70	Fair	60	35	Very easy	.85	5	70.5	A	Good	Fair
	180	20	2%	70	Fair	58	50	Very easy	.85	5	70.5	A	Good	Slightly flat
	190	20	2%	70	Soft	82	74	Very easy	.83	5	70.5	A	Good	Very good
II	160	20	2%	70	Medium firm	41	15	Medium easy	.89	5	70.5	B	Good	Very good
	170	20	2%	70	Medium soft	50	25	Easy	.91	5	70.5	B	Good	Very good
	180	20	2%	70	Very soft	55	43	Easy	.89	5	70.5	B	Good	Very good
	190	20	2%	70	Soft	65	55	Very easy	.82	5	70.5	B	Good	Very good
III	160	20	2%	70	Fairly firm	50	20	Slightly hard	.87	5	70.5	C	Good	Sharp; fair
	170	20	2%	70	Not so firm as 160°	63	17	Very easy	.83	5	70.5	C	Good	Slightly flat
	180	20	2%	70	Firm Good texture	75	48	Easy	.86	5	70.5	C	Good	Good
	190	20	2%	70	Slightly open but firm	70	52	Easy	.875	5	70.5	C	Good	Good
IV	160	20	2%	70	Firm	65	20	Hard	.99	5	70.5	D	Good (old)	High acid; Poor
	170	20	2%	70	Ideal	80	50	Fairly hard	1.05	5	70.5	D	Good (old)	Poor
	180	20	2%	70	Ideal	90	55	Medium Hard	1.04	5	70.5	D	Good (old)	Poor
	190	20	2%	70	Ideal	100	70	Hard	1.04	5	70.5	D	Good (old)	Poor

Effect of Different Temperatures of Heating Milk on the Qualities of Commercial Buttermilk—Series 6

Number	Temperature of Heating (Deg. F)	Time of Heating. (minutes)	Approximate Per Cent of Mother Culture Added	Temperature of Incubation (degrees F.)	Character of Curd Before Breaking	Viscosity (seconds)		Ease of Breaking	Acidity %	Time of Agitating Curd to Break it. (minutes)	Temperature at Which Curd Was Broken up (degrees F.)	Culture	Odor	Flavor
						Running from a 50 cc pipette	Flowing over Glass							
I	190	10	2	70	Good	55	65	Fairly easy	.84	5	70	A	Sharp	Acid
	180	10	2	70	Loose	45	54	Fairly easy	.83	5	70	A	Good	Acid
	170	10	2	70	Loose	35	10	Fairly easy	.83	5	70	A	Good	Slightly sharp acid
	160	10	2	70	Loose	30	10	Fairly easy	.78	5	70	A	Good	Fair Acid
II	190	10	2	70	Good	58	Too viscous Did not run	Fairly easy	.86	5	70	B	Very Sharp	Acid
	180	10	2	70	Fair	40	30	Fairly easy	.78	5	70	B	Pleasant	Slightly acid
	170	10	2	70	Loose	40	15	Very easy	.76	5	70	B	Pleasant	Very slightly acid
	160	10	2	70	Loose	25	5	Exceedingly easy	.72	5	70	B	Good	Sharp Metallic
III	190	10	2	70	Firm	55	122	Easy	.83	5	70	C	Good	Slightly acid
	180	10	2	70	Fair	52	Too viscous	Easy	.82	5	70	C	Good	Slightly acid
	170	10	2	70	Good	40	22	Hard	.84	5	70	C	Good	Slightly acid
	160	10	2	70	Poor	25	5	Fairly easy	.80	5	70	C	Good	Slightly acid
IV	190	10	2	70	Good	60	Too viscous; did not run	Very easy	.80	5	70	D	Good	Slightly acid
	180	10	2	70	Good	62	Too viscous; did not run	Very easy	.80	5	70	D	Good	Slightly acid
	170	10	2	70	Fair	58	Too viscous	Fairly easy	.83	5	70	D	Good	Slightly acid
	160	10	2	70	Loose	28	10	Very easy	.79	5	70	D		Metallic

Note: "Too viscous" means the product was too viscous to flow a distance of 12".

Effect of Different Temperatures of Heating Milk on the Qualities of Commercial Buttermilk—Series 7

Number	Time Held 0 min.	Temperature of Heating	Percent of Culture Added	Temperature of Incubation	Character of Curd	Viscosity (seconds)		Ease of Breaking Curd	Acidity %	Time of Breaking	Temperature at Which Curd Was Broken up (degrees F.)	Name of Culture	Odor	Flavor
						Running from 50 cc pipette	Flowing over glass							
I	0	190	2	74° F.	Ideal	130	Too viscous	Easy	.98	5	74	A	Stale	Slightly flat
	0	180	2	74° F.	Good body	120	Too viscous	Hard	.95	5	74	A	Stale	Quite acid
	0	170	2	74° F.	Loose	50	120	Easy	1.08	5	74	A	Stale	Quite acid
	0	160	2	74° F.	Very loose	45	129	Very easy	1.09	5	74	A	Stale	Very acid
II	0	190	2	74° F.	Good body	90	120	Easy	.94	5	74	B	Good	Acid (pleasant)
	0	180	2	74° F.	Fair	75	62	Fairly hard	.96	5	74	B	Stale	Very slightly metallic
	0	170	2	74° F.	Loose	50	15	Easy	1.13	5	74	B	Good	Bitter and acid
	0	160	2	74° F.	Loose	45	20	Very easy	1.00	5	74	B	Good	Quite acid
III	0	190	2	74° F.	Ideal	120	110	Easy	1.08	5	74	C	Good	Excellent
	0	180	2	74° F.	Very loose	95	28	Easy	.98	5	74	C	Good	Good lactic
	0	170	2	74° F.	Very loose	90	15	Easy	1.00	5	74	C	Good	Good lactic
	0	160	2	74° F.	Very loose	65	10	Easy	1.10	5	74	C	Good	Good lactic
IV	0	190	2	74° F.	Very loose	95	65	Easy	1.06	5	74	D	Good	Good lactic
	0	180	2	74° F.	Good	77	60	Hard	1.00	5	74	D	Good	Good lactic
	0	170	2	74° F.	Fair	45	20	Very easy	1.12	5	74	D	Fair	Fair lactic
	0	160	2	74° F.	Very loose	40	12	Very easy	1.18	5	74	D	Fair	Fair

Note: "Too viscous" means the product was too viscous to flow a distance of 12".

THE EFFECT OF AGITATION AND TEMPERATURE ON THE CHARACTERISTICS OF BUTTERMILK

To determine the effect of temperature of breaking the curd on wheying off, flavor and odor, viscosity, and other characteristics of the buttermilk, mother cultures were grown at temperatures varying from 68° to 85° F., they being prepared from commercial starters and carried along daily. The bulk milk used in these experiments for the preparation of the commercial product was heated to a temperature of 190° F. for one hour and then cooled to the desired temperature for inoculation. The amount of mother culture added to the bulk milk varied from about 1.00% to 12.00%, as noted in the experiments. The variations in the temperature of incubation and in the amount of mother culture used for inoculation varied the acidity of the resulting buttermilk.

When the milk had curdled, it was divided into two lots, Lot 1 being broken up at the temperature of ripening, while Lot 2 was either cooled or warmed, and then broken up. In both lots the curd was first broken with a hand agitator, great care being taken to avoid foaming. One-half pint was then poured into a half-pint milk bottle and the breaking up process continued in an automatic Dazey churn, samples being drawn after 5, 10, 15, 20 or 25 minutes of agitation, as shown in the table of results. The samples were then held in storage at a temperature of 54° F. and observations made immediately, and again after 24 and 48 hours, to determine whether wheying off was noticeable. In each series of the experiment, with the exception of number one, where whole milk was used, the product was made from skim milk. Two different cultures were employed in performing the experiments, culture A being used in Series 1 and 2 and culture B in Series 3.

Conclusions

The results of the experiment show that:

1. Vigorous agitation to the point of foaming produced wheying off in cultured buttermilk.

2. When buttermilk is made in a can and broken up by hand agitation, there is little danger of foaming to the extent of wheying off.

3. Breaking the curd for 10, 15, 20 or 25 minutes invariably produces wheying off if the agitation be vigorous and in the case of whole milk buttermilk caused churning.

4. Cooling the buttermilk to a temperature of between 60° and 68° F. retarded the possibility of wheying off.

5. If commercial buttermilk is manufactured from whole milk and the curd broken up with sufficient agitation to cause churning, wheying off invariably results.

6. Warming buttermilk to a temperature of 75° F. and 90° F. before breaking up the curd made the product appear thin and wheying off invariably resulted.

7. When the buttermilk, as treated above, was held in storage, any tendency to whey off was increased as the period of storage increased.

8. Too vigorous agitation produced wheying off, regardless of the acidity of the buttermilk.

9. For the manufacture of good buttermilk, the curdled product should be broken up without undue agitation, beginning the process of breaking up at a temperature of 65° to 70° F. and cooling rapidly to the temperature of storage, 45° F., or lower.

The Effect of Agitation and Temperature on the Characteristics of Buttermilk—Series I

Culture	Temperature of Growing Mother Culture (degrees F.)	Approximate Amount of Culture Added, %	Temperature of Milk When Inoculated, ° F.	Temperature at Which Milk was Ripened, ° F.	Acidity of the Resulting Buttermilk	Characteristics and Viscosity of the Resulting Buttermilk	Flavor and Odor	Characteristics of the Buttermilk After Curd Had Been Broken Up — Time in Minutes						Hours of Storage	Temperature at Which Cultured Buttermilk Was Broken Up, ° F.	Temperature at Which Buttermilk Was Stored	Kind of Milk Used in Experiments
								0	5	10	15	20	25				
A	62	12	62	62	.80	Good Heavy	Good	Good Good Good	Good Good Few bubbles	Foam Foam Wheyed off	Foam Foam Wheyed off			0 24 48	62	54	Skim milk
A	62	12	62	62	.80	Good Heavy	Good	Good Good	Good Wheyed off badly	Foam Wheyed off Wheyed off	Foam Wheyed off Wheyed off	Churned Wheyed off Wheyed off	Churned Wheyed off Wheyed off	0 24 48	62	54	4% whole milk
A	62	12	62	62	90	Good Heavy	Good	Good Good Good	Good Wheyed off Wheyed off	Foam Wheyed off Wheyed off	Slightly churned Wheyed off Wheyed off	Churned Wheyed off Wheyed off	Churned Wheyed off Wheyed off	0 24 48	62	54	4% whole milk
A	68	12	68	68	.81	Good Heavy	Good	Good Good Good	Good Wheyed off Wheyed off	Thin Foam Wheyed off Wheyed off	Churned Wheyed off Wheyed off	Churned Wheyed off Wheyed off	Churned Wheyed off Wheyed off	0 24 48	68	54	4% whole milk
A	68	12	68	68	.84	Good	Good	Good Slightly thin Slightly thin	Churned Churned Churned	Churned Wheyed off Wheyed off	Churned Wheyed off Wheyed off	Churned Wheyed off Wheyed off	Churned Wheyed off Wheyed off	0 24 48	68	54	4% whole milk
A	75	12	75	75	.87	Good	Good	Good Good Good	Wheyed off Wheyed off Wheyed off	Wheyed off Wheyed off Wheyed off	Good Good Good	Good Good Good	Good Good Good	0 28 48	55	54	4% whole milk

The Effect of Agitation and Temperature on the Characteristics of Buttermilk—Series II

Culture	Temperatures of Growing Mother Culture, ° F.	Approximate Amount of Culture Added, %	Temperature of Milk When Inoculated (°F.)	Temperature at Which Inoculated Milk was Ripened, ° F.	Acidity of the Resulting Buttermilk %	Characteristics and Viscosity of the Resulting Buttermilk	Flavor and Odor	Characteristics of the Buttermilk After Curd Had Been Broken Up — Time in Minutes: 5	10	15	20	Hours of Storage	Temperature at Which Curdled Buttermilk was Broken Up, ° F.	Temperature at Which Buttermilk was Stored	Kind of Milk Used in Experiments
A	75	1	65	75	.94	Good	Acid	Good	Good	Wheyed off	Wheyed off	0	75	54	Skim milk
								Good	Good	Wheyed off	Wheyed off	48			
								Slight whey	Slight whey	Wheyed off	Wheyed off	96			
								Good	Good	Good	Wheyed off	0	60	54	Skim milk
								Good	Good	Good	Wheyed off	48			
								Slight whey	Slight whey	Slight whey	Wheyed off	96			
A	75	2	65	75	.88	Good	Slightly acid	Good	Good	Slight foamy	Wheyed off	0	75	54	Skim milk
								Good	Good	Slight foamy	Wheyed off	48			
								Slight whey	Slight whey	Wheyed off	Wheyed off	96			
								Slight whey	Slight whey	Wheyed off	Wheyed off	0	60	54	Skim milk
								Slight whey	Slight whey	Wheyed off	Wheyed off	48			
								Slight whey	Slight whey	Wheyed off	Wheyed off	96			
A	75	3	65	75	.70	Fair	Fairly good	Foam	Curd breaking	Wheyed off	Wheyed off	0	75	54	Skim milk
								Foam	Curd breaking	Wheyed off	Wheyed off	48			
								Foam	Wheyed off	Wheyed off	Wheyed off	96			
								Good	Good	Wheyed off	Good	0	60	54	Skim milk
								Good	Good	Wheyed off	Good	48			
								Slight whey	Wheyed off	Wheyed off	Wheyed off	96			

A	75	5	65	75	.80	Fair	Good	Slight whey	Slight whey	Slight whey	Wheyed off	0	75	54	Skim milk
								Slight whey	Slight whey	Slight whey	Wheyed off	48			
								Slight whey	Slight whey	Slight whey	Wheyed off	96			
								Good	Good	Good	Good	0	60	54	Skim milk
								Slight whey	Slight whey	Slight whey	Wheyed off	48			
								Slight whey	Slight whey	Slight whey	Wheyed off	96			

The Effect of Agitation and Temperature on the Characteristics of Buttermilk—Series III

Cultures	Temperature of Growing Mother Culture, ° F.	Approximate Amount of Culture Added, %	Temperature of Milk When Inoculated, ° F.	Temperature at Which Inoculated Milk was Ripened, ° F.	Acidity of the Resulting Buttermilk %	Characteristics and Viscosity of the Resulting Buttermilk	Flavor and Odor	Characteristics of the Buttermilk After Curd Had Been Broken Up — Time in Minutes: 5	10	15	20	Hours of Storage	Temperature at Which Curdled Buttermilk was Broken Up, ° F.	Temperature at Which Buttermilk Was Stored	Kind of Milk Used in Experiments
B	90	4	90	90	.90	Poor	Good but acid	Slight foam	Foam	Foam	Foam	0	90	54	Skim
								Wheyed off	Wheyed off	Wheyed off	Wheyed off	24			
								Wheyed off	Wheyed off	Wheyed off	Wheyed off	48			
								Good	Good	Good	Good	0	65	54	Skim
								Good	Good	Good	Good	24			
								Very slight whey	Good	Good	Good	48			
B	90	4	90	90	.90	Fairly good	Good but acid	Good	Good	Good	Foam and breaking	0	90	54	Skim
								Good	Good	Good	Foam and breaking	24			
								Wheyed off	Wheyed off	Wheyed off	Wheyed off	48			
								Good	Good	Slight foam	Good	0	65	54	Skim
								Good	Good	Slight foam	Good	24			
								Good	Good	Slight foam	Good	48			

THE EFFECT OF SALT ON THE WHEYING OFF PROPERTIES OF BUTTERMILK

A small amount of salt is generally added to commercial buttermilk when manufactured on a large scale, since it is believed to eliminate the sharp twang and, acting as a condiment, yields a more agreeable product from the standpoint of palatability. Salt has also frequently been said to prevent wheying off. Accordingly, it was deemed advisable to determine what effect, if any, the addition of salt in varying amounts would have on the qualities of the resulting buttermilk, providing the salt was added after the buttermilk had been prepared.

Mother cultures were prepared in the usual manner, four different cultures being used. The bulk for the commercial product was heated in four gallon lots to a temperature of 190° F., cooled immediately to 70° F., and inoculated with about 2% of the mother culture. When curdled, the curd was broken up by placing the cans in which the product was prepared in ice water and stirring with a hand agitator until it was of uniform consistency and had reached the temperature of 50° F.

The four lots were then divided into portions of five quarts each and to four of the quarts was added salt in varying amounts while quart Number 5, being the control, contained no salt. The quart bottles were then set in a storage temperature of 45° F. and held at that temperature for four days and examined daily to determine the effect of salt on the wheying off properties. The viscosity of each of the four bulk portions of buttermilk was taken as soon as the product had been cooled to 50° F. and before it was separated into the five lots already mentioned. The effect of salt on flavor was also noted after the salt had thoroughly dissolved.

Conclusions

1. The results indicate that as far as wheying off is concerned, the addition of salt has little effect on commercial buttermilk when added in quantities as used in the experiment.

2. When salt was added in quantities of .1% (equivalent to approximately one gram per quart) a distinct change in flavor was noted which was not considered as being advantageous to palatability.

3. Salt may be added to commercial buttermilk in quantities not exceeding .05% (approximately ½ gram per quart) without noticeably affecting the flavor. From the standpoint of palatability and from the results of the experiments the addition of salt was not deemed necessary or advisable.

4. No experiments were run to determine the effect of adding salt before culturing the bulk product.

The Effect of Salt on the Wheying Off of Commercial Buttermilk—Series I

Culture	Temperature of Heating, ° F.	Time Held (minutes)	Temperature of Incubation	Time of Breaking Curd	Character of Curd Before Breaking Up	Acidity of Buttermilk %	Viscosity: Time to Empty from a 50 cc Pipette (sec.)	Viscosity: Time to Flow Over a 12" Glass Surface (seconds)	Lots of Each Culture	Temperature at Which Each Lot Was Held, ° F.	Size of Each Lot	Amount of Salt Added per Quart (grams)	Effect of Salt on Flavor	Characteristics of Buttermilk After Standing; i. e., Amount of Whey Formed — Hours: 1	12	48	96	Acidity After 96 Hours
A	190	0	70	Curd was agitated only sufficiently to break it thoroughly and avoid foam.	Fairly firm but soft when agitated	.85	55	110	1	50	1 qquart	.5	One gram of salt per quart imparted an undesirable salt flavor, while one-half gram per quart did not appear to materially affect it.	Good; viscous; highly satisfactory.	Good; viscous; highly satisfactory.	Same as control	Same as control	.88
	190	0	70						2	50		1.				Same as control	Same as control	.86
	190	0	70						3	50		1.5				More open than control	More open than control	.86
	190	0	70						4	50		2.				Same as 1.5	Same as 1.5	.87
	190	0	70						Control	50		Control				Very few bubbles Good	Very few bubbles Good	.84
B	190	0	70		Ideal	.84	37	92	1	50	1 qquart	.5				Very slightly more open than control	Same as 48	.95
	190	0	70						2	50		1.				Very slightly more open than control	Same as 48	.95
	190	0	70						3	50		1.5				Same as control	Same as 48	.94
	190	0	70						4	50		2.				Same as control	Same as 48	.96
	190	0	70						Control	50		Control				Very few bubbles on top Good	Same as 48	.90

Series 3 Continued

C	190	0	70	Curd was agitated only sufficiently to break it thoroughly and avoid foam.	Good	.9	30	60	1	50	1 quart	.5	One gram of salt per quart imparted an undesirable salt flavor, while one-half gram per quart did not appear to affect it.	Good; viscous; highly satisfactory.	Good; viscous; highly satisfactory.	Slightly More open than control	Same as 48	.95
	190	0	70						2	50		1.				Same as control	Same as 48	.89
	190	0	70						3	50		1.5				More open than control	Same as 48	.93
	190	0	70						4	50		2.				Same as control	Same as 48	.91
	190	0	70						Control	50		Control				Very few bubbles	Same as 48	.90
D	190	0	70		Good Slightly soft	.86	36	90	1	50	1 quart	.5				More open than control	Same as 48	.93
	190	0	70						2	50		1.				Good	Same as 48	.94
	190	0	70						3	50		1.5				More open than control	Same as 48	.95
	190	0	70						4	50		2.				Same as control	Same as 48	.95
	190	0	70						Control	50		Control				Good	Same as 48	.96

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