

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

BUTTER MAKING

CLEAN MILK AND COMMERCIAL
STARTERS

(Information Bulletin).

BY

WALTER G. SACKETT

The Agricultural Experiment Station

FORT COLLINS, COLORADO

THE STATE BOARD OF AGRICULTURE

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CLEAN MILK AND COMMERCIAL STARTERS AS FACTORS IN BUTTER MAKING

By WALTER G. SACKETT.

It is a fact familiar to all of us, whether we are buying butter or whether we have butter to sell, that farm, ranch and country butter seldom, if ever, commands as high a price on the retail market as creamery butter. There are no doubt cases where precedent, alone, dictates the price of the farmer's product, it having become an established custom in certain towns and at certain stores to pay the countryman from five to ten cents per pound less for his product than for the creamery goods. Injustice is often done the farmer in this way, for some country butter is equal in quality, if not superior, to creamery butter. Why, then, this universal custom of rating the creamery product above that of the ranch? The cold truth of the matter is that the average run of ranch butter is inferior in flavor and keeping qualities to the ordinary creamery output, and the consumer is not willing to pay the factory price for the inferior home article. The question at once arises, why this should be the case, for, most certainly the conditions which enter into good butter making ought to be more easily controlled by the individual farmer, who can give his personal attention to each step in the process, from the milking up to delivery to the consumer, than by the creamery overseer who must take the whole milk or gathered cream from many different sources, some clean, some filthy, and mix it all together. Yet by proper handling from this point, he is able to turn out a first class product. Of course, it goes without saying that no one can make as good butter from dirty, filthy cream as from that which has been produced on a clean farm where some attention is given to the sanitary conditions. Cleanliness is without question the first and foremost consideration in making either good butter or cheese. The word *cleanliness* when used in connection with the dairy and dairy products has a very broad meaning and demands the attention of everyone who has anything at all, no matter how insignificant, to do with the care and handling of the milk and cream. The farmer who does the milking is apt to forget that dirt and filth are intimately associated with his part of the work, and no matter how careless he has been with the milking, he expects the good housewife to turn out a butter of excellent quality, which will score as high or higher than the creamery product. This is absolutely impossible and out of the question.

Those who are engaged in butter making as a profession consider that the two most important factors in good butter making are clean milk and proper ripening of the cream. Both of these can be con-

trolled by the butter maker no matter whether the output is a thousand pounds a day or six pounds a week. Clean milk can be obtained only by the most scrupulous care on the part of those who are entrusted with the handling, and the proper ripening of the cream is best accomplished by the use of what are known as *commercial starters*, which will be discussed fully later on.

To the majority of people who use milk or cream in one form or another, *clean milk* signifies milk free from visible dirt, such as cow hair, hay, straw, etc. As a matter of fact, such forms of dirt are seldom met with in the milk as delivered to the consumer, and of themselves are practically harmless except to the esthetic taste. The milkman has learned to strain his milk and rid it of such debris. It is the filth that we can not see with the unaided eye that does the harm and makes the consumption of dirty milk dangerous. Every particle of dust, every hair, every bit of straw is covered with myriads of bacteria, and when these foreign substances find their way into the milk, the germs are washed off and immediately begin to grow and multiply in the milk. When we know that a single cow hair may harbor from 4,000 to 10,000 germs which can multiply once every half hour, are we not justified in labeling milk which contains such hairs as unfit for use?

When every precaution is taken against contamination, it is possible to obtain milk directly from the cow which contains as few as 200 to 300 germs per cubic centimeter (one-fourth of a teaspoonful); with somewhat less care the numbers will increase to 5,000; when carelessly drawn and handled, it frequently contains in the beginning from 25,000 to 100,000.

Many of our large cities have placed a limit to the number of bacteria which the city milk supply may contain and yet be offered for sale. The city of Boston (1) has set this number at 500,000, Rochester, N. Y., 100,000, and Milwaukee 250,000. In New York City, Park (2) found that during the coldest weather, the milk sold in the shops averaged over 300,000 bacteria per cubic centimeter; during cool weather, about 1,000,000 and during the hot weather, about 5,000,000. In Chicago, Jordan and Heineman (3) found in market milk collected during April, May and June, numbers ranging from 10,000 to 74,000,000. Sedgwick and Batchelder (4) have examined samples of milk from groceries in Boston which contained over 4,500,000. Stevens

(1). Article 51, Sect. 1. Regulations for the Sale and Care of Milk, Boston Board of Health.

(2) Park: Jour. Hyg., 1, 1901, 1, p. 391.

(3) Jordan and Heinemann: Rept. of Civil Federation of Chicago, 1904.

(4) Sedgwick and Batchelder: Bost. Med. Jour., 1892, 126, p. 25.

(1) has shown the milk supply of Raleigh, N. C., to vary in bacterial content from 1,200 during November to 54,000,000 in May.

A number of the bacteria which fall into milk are harmless in themselves, but during their growth they bring about certain changes which produce disagreeable odors and flavors, and frequently deleterious substances. The natural souring of milk is accomplished by the lactic acid germ. However, Marshall (2) has shown that the lactic bacteria are favorably influenced by the presence of other bacteria, notably by germs of filth, which for the sake of the present illustration, let us call "B." The lactic germ we shall designate "A." By growing the lactic acid germ by itself and also by associating it with the germ B, Dr. Marshall has been able to show the increased number of lactic forms when associated with B in milk. At the time of lopping or curdling of culture A+B, the ratio of the lactic acid bacteria in the two cultures was:

$$A:A+B::27:1614.$$

Again, he has demonstrated that germ B produces stable products which withstand sterilization and exert the same influence over germ A in milk cultures as the living germ. The comparative number of lactic germs in culture A and in culture (A + products of germ B) was expressed by the ratio:

$$A:(A+\text{products of germ B})::27:1007.$$

From this it follows that clean milk will keep sweet much longer than other milk. We see this same thing every day in a practical way when we notice that milk from certain dairies sours so much more quickly than that from other sources, and if we trace down this matter still further, we invariably find that the better milk comes from the cleaner stable.

There are also those forms of microscopic life which produce *bitter milk*, *ropy milk*, and milk of different colors commonly designated bloody milk, blue milk and yellow milk. If these bacteria are present in the milk, they will be present also in the cream and will impart their disagreeable properties to the butter made from it.

A few suggestions along the line of clean milk may not be out of place at this time. The writer feels that while this topic has been treated upon thoroughly and exhaustively in many publications and by institute speakers, yet, not all of us who are in the dairy business, have understood fully and put into practice the principles and methods advanced by the advocates of sanitary milk.

No dairyman who pretends to produce clean milk should allow his cows to have access to muddy bayous, wading places and irrigating ditches. It is not through any preference, but as a last resort, that cattle in the summer time stand knee deep in mud and water to get

(1) Market Milk, bacteriological data. Cant. of Bakt, II Abt. Bd. XX. No. 4-5. 1907, p. 114.

(2) Special bulletin No. 33, 1905. Mich. Exp. Station.

away from flies. If some other provisions were made for their comfort, they would not have to seek this refuge. Provide an abundance of shade in the pasture lot and fence off the mud.

See that there is an ample supply of good, clean, drinking water and wholesome food. It is much better to do all of the feeding and bedding after the milking is done, since in handling dry hay or fodder, the air is filled with dust and dirt which will settle into the milk at milking time. If the cows are allowed to eat while being milked, there is always more or less commotion caused by tossing the heads and nosing the feed, and this means a constant supply of dust in the stable. There may be some uneasiness shown at first if they are compelled to wait for their feed, but it is only a question of educating them to it. Those dairymen who are practicing this are getting good results and can testify to the improved quality of the milk.

Some of the cow stables which one sees in traveling through the country are a disgrace to any civilized community. Just because a cow *can* endure such accommodations is no excuse for their existence. Warm, well ventilated, well lighted stables will pay for themselves many times over in increased yield and quality of the milk. Fly screens are a very necessary adjunct to a good stable, and a frequent coat of whitewash will help considerably toward its appearance and sanitary condition. If the stable is properly constructed, the cows can be kept clean and comfortable, and their flanks free from great masses of manure, which, when dried, is apt to fall into the pail during milking. It is to this source that we can trace many of the objectionable "cowy" flavors found in the milk.

Manure must not be allowed to accumulate in the barn lot until the milker is compelled to wear hip boots to get through it on his way to the stable. The udder and flank of the animals should be wiped off with a cloth moistened with some germicide, such as 3 per cent. carbolic acid, or lysol, or 1-1000 mercuric chlorid, just previous to milking; the cows should be brushed frequently to remove any loose hairs or foreign matter.

Very few dairymen stop to consider the importance of cleanliness of their own person when working around milk. It is the usual practice to put on the filthiest pair of overalls available, since milking in the average cow barn is considered a dirty job, which in itself is, indeed, an admission of guilt. The same suit of overalls is used while milking, cleaning out the cow stable, bedding the horses and hauling manure, and it is not until they become so stiff and caked with filth as to make it difficult to get into them, that it is considered at all necessary to have them washed. The dairies of today, which are producing certified milk, furnish their milkers with a clean, white uniform every day. If we could do away with the long standing blue jeans and adopt a white suit we should realize very soon that the cow stables need cleaning up, and that the length of time required for a pair of overalls to become soiled is much shorter than was supposed formerly.

Milkers are not as particular about washing their hands before

milking as they should be. It frequently happens that the hired man will be called in from hauling manure or feeding the pigs, or some similar operation, to help with the milking. The chances are that he will never think of washing his hands, but, if, contrary to the usual custom, he should do so, nine times out of ten he will wipe them either on his dirty overalls or on a red bandanna that has escaped the wash tub some three weeks past.

It seems almost unnecessary to have to call attention to the danger of employing persons as milkers who are suffering with any contagious or infectious disease. Tuberculosis, typhoid fever, and diphtheria may gain access to the milk through such channels, and epidemics follow as a result. No one who is afflicted with any of these troubles should be allowed any part, no matter how small, in the care and handling of the milk.

While speaking of the spread of disease through milk as the medium, the common house fly must be charged with being the most dangerous agent known to humanity in polluting milk, and the greatest menace to public health by way of spreading disease. The bare statement of this fact should be sufficient to convince any one of average intelligence of the great importance of exterminating this pest,

As a rule, the housewife, to whom is entrusted the cleaning of the pails, pans and cans, does her work more thoroughly than the others associated with her in the dairy work. However, it may not be out of place to mention one or two points in connection with her duties. The mere scalding of a utensil by pouring boiling water over it is not always adequate to sterilize it and render it sweet and clean. It is frequently necessary to allow water to boil in the pails and cans for a half hour or longer in order that the dirt and grease which find their way into the cracks and seams can be soaked up and gotten rid of. Some good washing powder should be used in this operation. The strainer cloths should be boiled thoroughly. After thorough rinsing with boiling water, the different utensils should be placed in the brightest sunshine available, and not on a bench on the shady side of the milk-house. Bright sunshine is one of the worst enemies of germ life, and since it is so effective and so cheap, let us use lots of it, not only in our milk cans, but in our damp, musty cellars, "spare" bed rooms, company parlors, and then turning toward the dark, gloomy barns, give the horses and cattle their share.

The writer has a farmer in mind whose usual custom is to cool off his milk bucket, which has been sterilizing in the bright sunshine for half a day previous to milking, by pumping water into it from a well located in the barn yard at the edge of a hog-wallow. This is certainly a very questionable procedure, since practically all of the good from scalding and sunning is counteracted and more than this there is often danger of introducing undesirable germs into the milk by this means.

It is a matter of common knowledge, that milk absorbs foreign odors very readily and retains them as tenaciously. It follows, natu-

rally, from this that milk must be kept in a clean, cool, well ventilated room, free from all taints and flavors. Anyone who has ever exposed a pan of milk in an ice box along with onions, boiled cabbage, cantaloupes or cucumbers, or who has placed it in a freshly painted or varnished room, or who has allowed the cans of milk to remain in a vile smelling stable for some time, knows the inevitable consequence. The cream from such milk must necessarily give its respective flavor to the butter made from it, and when the consumer complains of an off flavor, the ranchman proclaims his innocence.

Much of the dirt and dust, together with many disagreeable odors, can be obviated by arranging a small milk-room, adjacent to the cow stable and separated from the cows by a tight partition. Here the straining can be done and the cans kept while they are being filled from the milkers' pails.

The cream should be cooled as soon after separation as possible in order to check the growth of bacteria. This can be accomplished easily by placing the cans, containing the milk or cream, in cold well water by which a temperature of at least 50 degrees F. should be obtained.

Inasmuch as the offensive germs thrive chiefly in the curdy part of the cream, it follows that a thick cream, low in curd, will keep better than a thin cream. For the same reason, poorly worked butter, containing considerable buttermilk, will not keep as well as butter which is worked thoroughly. Consequently, it is best to separate as heavy a cream as the separator will handle and as is consistent with the time of year, say 35 per cent. in winter and 40 per cent. in summer. Besides obtaining a better grade of cream for butter making, the bulk is reduced, which simplifies the handling, and more skimmed milk is available for feeding purposes.

In closing this chapter upon the production of clean milk, its application to butter making must not be lost sight of. Stated briefly, it is simply this: high class butter can come only from clean cream and clean cream is possible only from clean milk.

THE USE OF COMMERCIAL STARTERS.

The natural flavor of well made butter from fresh, clean cream is very pleasing to the taste of the average person and it is chiefly this desirable flavor for which the consumer pays. It is obvious, then, that the goal toward which the butter maker must strive is a desirable flavor, accompanied by a pleasing aroma. To be sure, the texture can not be lost sight of, but when the layman buys a pound of butter, he judges it for flavor first of all, and inasmuch as his judgment will determine ultimately the demand for a certain brand of butter, it is important that his verdict be given the weight it deserves.

As noted above, the bacteria which are present in the cream, and which in the end find their way into the butter, are responsible in a large measure for the flavor. On the one hand, if filth germs dominate in the cream, then the butter will have a strong, rancid flavor and odor from the beginning. On the other hand, if the

cream has been gathered under sanitary conditions, with cleanliness in mind, all things being equal, a good quality of butter is to be expected. However, this last condition exists so rarely that it can be passed by with mere mention.

Now if it were possible to introduce into the fresh cream immense numbers of desirable bacteria which would give it a good flavor, and which would impart to the butter that "grassy" or "nutty" taste so much sought for, we might be able to control the flavor, in a measure, in spite of the unsanitary condition of the cream. The Starter fills this demand.

The Nature of a Starter.

Hastings (1) has defined a starter as "A quantity of milk in which acid forming bacteria have grown until the milk contains large numbers of them. The addition of the starter seeds the cream with great numbers of bacteria which are in a healthy condition and which, by their growth, cause the acid fermentation to progress rapidly and in a more definite manner than without the addition of the starter." In other words, the starter is the active agent involved in ripening the cream.

Starters are of two kinds, commercial and natural, depending upon the method by which the bacteria are obtained.

The Commercial Starter.

Starters prepared by various commercial firms, where facilities are provided for careful bacteriological work, are known as commercial or pure culture starters. They usually contain but one species of germ and this one selected from many others for its peculiar butter making properties. To be a good starter, the culture must develop at ordinary temperatures, 68 degrees to 70 degrees F.; it must produce acid rapidly and in quantity sufficient to allow of exhaustive churning; and it must be capable of producing substances which will impart to the butter the desired flavor and aroma. The bacteriologist, who prepares these cultures, has all of these points in mind when selecting a specific germ, and for this reason more uniform and satisfactory results are to be obtained with the commercial starter than with the home made or natural starter which is apt to contain germs, good, bad and indifferent.

The cost of these commercial products is so small in comparison with the benefits to be derived that their more general use is to be recommended. The initial cost of a starter is about fifty cents and by careful handling it can be propagated for an indefinite time. They are for sale under trade names such as Butter Culture, Flavorone, Lactic Ferment, etc., and can be procured directly from the manufacturer or through any drug store.

(1) Hastings: 181, Wisconsin Exp. Station.

Propagation of the Starter.

Commercial starters are put up by the different manufacturers in two forms, one a powder and the other a liquid. Inasmuch as extreme care has been exercised in their preparation to keep them free from contamination, it is important that they shall not be opened until ready to be used. This suggestion is offered since a person with the average curiosity would be tempted to open the bottle and taste or smell the contents, and in so doing expose it to dust and air contamination.

The first step in the propagation of the starter is the preparation of what is known as the "mother starter." One quart milk bottles are very convenient vessels for this part of the work. Some suitable cover or stopper must be provided for the bottles; Bushnell and Wright (1) recommended a cotton batting plug, while Hastings (2) uses an ordinary glass tumbler inverted over the mouth of the bottle. It is also necessary to have some instrument for transferring portions of the mother starter to other bottles in order to perpetuate the culture. For this purpose, Bushnell and Wright recommend a cotton swab attached to a piece of heavy copper wire; Hastings prefers a silver plated teaspoon with a piece of well tinned wire soldered to the handle to give length.

Having procured a number of one quart milk bottles, they should be boiled thoroughly in water for thirty minutes and then allowed to drain in a clean place. Next, several of the bottles are two-thirds to three-fourths filled with fresh, clean, whole or skimmed milk, preferably the former, the spoon or cotton swab inserted, and the bottle finally stoppered with a firm cotton plug covered with a glass tumbler. The bottles and contents are now sterilized in flowing steam for thirty to forty minutes on three consecutive days in order to kill the bacteria present in the milk. This sterilizing may be accomplished in a specially constructed steamer or in an ordinary wash boiler provided with a false bottom or shelf on which to set the bottles. Such a device is described fully by Bushnell and Wright (1). A common kitchen steamer will serve fairly well, provided it is high enough to admit the bottles and still permit the lid to fit down tight. Some authorities believe that better results are obtained when the milk is sterilized on one day only instead of three, their reason being that the prolonged heating injures the milk for starter purposes since the lactic acid germ thrives best in milk which is heated less. The only advantage in heating the milk three days is that it is rendered absolutely sterile, while one day's heating would not destroy the resistant spore forms of the bacteria which might be present, and which, if allowed to develop in the mother starter, would spoil it for that purpose. This would be true especially if several bottles of milk, were steril-

(1) Bushnell and Wright: Bul. No. 246, Mich. Exp. Sta.

(2) loc. cit.

(1) loc. cit.

ized ahead. If the three day sterilization is employed, the bottles should be kept in a warm room between each sterilization to hasten the development of the spores into the vegetative forms, which are more easily killed by heat. If the one day sterilization is adopted, all the more care must be taken in selecting clean milk since the fewer the bacteria present, the more efficient will be the sterilization.

Add the entire contents of the bottle of culture obtained from the manufacturer to one of the bottles of sterile milk and shake it gently for about five minutes so as to distribute the culture uniformly through the milk. Allow it to develop at a temperature of 75 degrees to 85 degrees F. The milk will become soured and curdled into a solid mass in from 18 to 24 hours and in this condition is known as the "Mother Starter." It is now ready for use in building up the starter proper, to be employed in ripening the cream. But before taking this step, a small portion of it should be transferred to a second bottle of sterile milk either with the teaspoon provided or by simply carrying over the cotton swab to the new bottle and allowing it to remain there for use the next day. In this way a second mother starter is prepared for the following day. In making the transfers from one bottle to another, the bottles should be left open to the air only long enough to make the transfer and then closed at once. If this precaution is not taken, there is great danger of contamination by air bacteria which would result, probably, in the starter going "off flavor." New mother starters should be prepared in this way every day whether they are to be used or not, since the activity of the lactic acid bacteria decreases rather rapidly if this is not done.

A good mother starter should appear smooth, glistening, firm and free from gas holes or free whey. It is always desirable to examine the ripened starter for flavor, odor, and acidity. This should be done by pouring a small quantity from the bottle into a clean cup, rather than by dipping any utensil into it which might be the means of introducing undesirable germs. The starter should have a clean taste, that is, it should be free from any disagreeable flavors; it should have a pleasant odor and should be only slightly acid.

Preparation of the Starter Proper.

The milk for this purpose should be selected for its purity and must be pasteurized by heating it for thirty to forty-five minutes at a temperature of 150 degrees to 160 degrees F. Cool this milk to 75 degrees to 85 degrees F. before adding the mother starter.

To forty or fifty parts of pasteurized whole or skimmed milk, add one part of mother starter. Let this stand for 18 to 24 hours at room temperature, 68 degrees to 70 degrees F., when it will be curdled; stir it thoroughly and it is ready to be added to the cream as a starter. The starter should be used at the time it contains the greatest number of active organisms. If too much acid is developed, the bacteria are killed, and to this fact is due the bad effects of over

ripening. The amount of acid which should be developed in a starter is from 0.6 to 0.7 per cent. for at this time it contains the largest number of active bacteria. Another way of judging is by the thickening of the milk which usually takes place at about 0.7 per cent. acid when the temperature is 65 degrees to 70 degrees F.

Ripening the Cream.

For every ten gallons of cream, use from one to two gallons of starter, or, in other words, from ten to twenty per cent. The exact amount can not be stated definitely, as much depends upon the age, acidity, temperature and thickness of the cream, of which the dairyman must be the judge. The cream should be sweet and as fresh as possible when the starter is added, and as much starter should be used as can be handled conveniently. In warm weather either ice or pasteurization must be resorted to to keep the cream sweet from one churning to the next, or else the churnings must be more frequent. Too much must not be expected of a starter, for while it may improve the quality of butter made from old, stale cream that has soured, it gives the best results when used with fresh sweet cream. A temperature of 70 degrees F. should be maintained during the ripening which is completed when the cream has acquired an acidity of 0.5 to 0.6 per cent. Under favorable conditions, this will require from six to eight hours. During this time, the cream should be stirred frequently to insure uniform ripening.

In regard to ripening, Rasmussen (1) says, "It should be considered that too sour cream, as a rule, gives a butter with a strong flavor and with poor keeping qualities and, therefore, the danger of getting the cream too sour before churning is greater than not getting it sour enough." In the absence of any chemical means for determining the per cent. of acid present, the only alternative is experience in judging the ripeness by the taste, aroma and appearance. As a general thing, "cream is ready to churn when it has a mild but distinctly sour taste, not too sharp or bitter, and has a glossy brittle appearance."

Pasteurized Cream.

During recent years, the pasteurization of cream for butter making seems to be gaining favor in our best creameries. In fact this practice has become almost a necessity in those localities where cream of all kinds is gathered from various sources. The butter maker has come to realize that if he is to have control over his finished product, so that he shall have some assurance of the constant and uniform quality of the output, he must resort to means by which he can eliminate the variable factors in his cream, namely, those undesirable bacteria and disagreeable flavors which will develop later on and make their presence manifest in the finished article. By heating the cream

(1) Bul. 141, New Hampshire Exp. Sta., 1909.

from 170 degrees to 180 degrees F. and *cooling it at once* nearly all of the bacteria are destroyed and many of the objectionable odors are driven off. If a starter is added to pasteurized cream, the lactic acid germs are given a comparatively free field in which to work and exert their beneficial influence. "This (1) method of ripening has a number of advantages over the use of unheated cream. It gives the maker full control over the ripening for by the process of pasteurization most of the bacteria are destroyed, then by the use of the pure culture, the same type of ripening, is assured and a uniform product results, a product that is uniform from month to month."

Kinds of Commercial Starters.

As stated before, commercial starters are put on the market in two forms, liquid and dry. The liquid cultures are usually prepared by inoculating a bottle of sterilized milk with the lactic acid germ, and when received by the purchaser, it has the appearance of sour milk which is exactly what it is, differing, however, from ordinary sour milk or natural starter, in that the curdling in this case has been produced by a pure culture. The liquid cultures are not as long lived as the dry forms and deteriorate more rapidly because of the harmful action of the lactic acid present upon the lactic germs.

The dry starters which are sold in the form of a powder are made by mixing a large quantity of starch, milk sugar or powdered milk with sterilized milk, soured by the lactic culture and the mixture subsequently dried at a low temperature. In this condition, the germs can not grow, but lie dormant, the organism being able to withstand dessication for a considerable period of time. In this state, no lactic acid can be produced, and its injurious effect is eliminated. For this reason the dry starters will keep much longer than the liquid ones.

Most dairy supply houses carry these starters in stock, but starters, like eggs, are better the fresher they are, and for this reason it is usually safer to send directly to the manufacturer, than to depend upon the old stock in the supply house.

A list of some of the manufacturers of commercial starters is given below:

Elov Ericsson,
60-62 E. Fifth St.,
St. Paul, Minn.

Parke, Davis & Co.,
Detroit,
Michigan.

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

O. Douglas Butter Culture, Co.,
68 Northampton St.,
Boston, Mass.

(1) Flavorou: Parke, Davis & Co., Detroit, Mich.