Whey as Seen Under a Microscope.

Unpasteurized whey — filled with bacteria and yeasts causing lactic-acid, alcoholic, and other fermentations.

Pasteurized whey — contains a practically pure culture of a lactic-acid bacillus, *B. bulgaricus*.

**WHY AND HOW PASTEURIZE DAIRY BY-PRODUCTS.**

SUMMARIZED BY
F. H. HALL

FROM BULLETIN BY
W. D. DOTTERER AND R. S. BREED.

PUBLISHED BY THE DEPARTMENT OF AGRICULTURE.
WHY AND HOW PASTEURIZE DAIRY BY-PRODUCTS.

F. H. HALL.

Pasteurization of dairy products and by-products serves two purposes, chiefly, of which protection of health is by far the more important. When we demand that the process be applied to milk or cream it is usually in order to prevent danger to ourselves, and particularly to our babies and children, from milk-born diseases or intestinal troubles due to the germs that cause or accompany milk fermentations. That pasteurization prolongs the period of palatability of milk and cream and thus influences their food value, and that the process enables the buttermaker to secure a better or more uniform product, are incidental benefits that have a direct financial appeal; but it is the argument for "safety first" in milk handling that has compelled the passage of so many laws and ordinances making pasteurization a requirement before milk of uncertain sanitary quality is distributed to consumers.

The same argument for health preservation applies, though less directly, in favor of pasteurizing dairy by-products — skim milk and whey — which serve only rarely as food for man, but most commonly as food for farm animals. The unpasteurized by-products sent back to the farms from skimming stations and butter and cheese factories may carry the germs of disease from any herd in the community to any or all others. Many instances are known in which this has actually occurred. Thus, new animals become infected, and through these animals the danger of spreading disease to human beings is increased and the possibility of eradicating plagues like tuberculosis reduced.

But in favor of pasteurizing dairy by-products, a strong financial appeal can be made: In the first place, the advent of any communicable ailment like tuberculosis or foot-and-mouth disease among a farmer’s cattle or swine always means both direct and indirect financial loss; and pasteurization effectively guards one of the avenues by which such diseases come, thus protecting the herd owner against this loss. Second, pasteurization preserves unaltered for considerable periods the palatability and the food value

*This is a brief review of Bulletin No. 412 of this Station on The Pasteurization of Dairy By-Products, by W. D. Dotterrer and R. S. Breed, in cooperation with the New York State Commission for the Investigation of Bovine Tuberculosis (Theobald Smith, Chairman, and Linsly R. Williams, Secretary). Those interested in the detailed account of the investigations will be furnished, on application, with copies of the complete bulletin so long as these are available.

[2]
of the by-products and so prevents a financial loss that would otherwise be certain. In unpasteurized whey lactic-acid, alcholic, and other fermentations take place due to the unchecked activities of bacteria and yeasts; and these fermentations lead to changes in the food compounds that lower their energy-producing power in the body. Third, pasteurization prevents some direct losses of food constituents that result from the usual handling of whey, and makes it possible to secure more uniform and more fair distribution of the valuable compounds to the patrons of the factory. In unpasteurized whey the fat soon rises to the top of the whey tank in a layer, so that the first few patrons who dip out whey secure nearly all of the fat; while if the whey is drawn from the bottom of the tank the last man to be served may get the fat. When the whey is pumped from the bottom, the fat remains in the tank, gradually forming an unsightly, ill-smelling mass which is the home of countless millions of germs. In such cases the patrons lose practically all of the food value of the fat. Pasteurization retards the rising of the fat and keeps it evenly distributed throughout the liquid so that it is all drawn out with the whey and fairly divided among the factory patrons. Fourth, pasteurization of whey frees it from many undesirable organisms which cause trouble in making cheese when farmers' cans become seeded with them.

The advantage of pasteurization of dairy by-products and the comparative ease and inexpensiveness of its application have led several states to enact laws making it compulsory at all factories and stations that return by-products to their patrons. The New York State Commission for the Investigation of Bovine Tuberculosis, with other organizations and individuals, urged the passage of such a law for this State in 1914, but failed to secure it. This Commission believes that the opposition to such a law was based largely on ignorance of the good effects of pasteurization and an erroneous idea of the difficulty and expense of pasteurizing products of this character.

The Commission requested the Station to make investigations to ascertain the practicability and value of pasteurization and of the conditions necessary to make the process efficient. Cooperation with the Commission was agreed to and series of studies made during the summer and fall of 1915 at seven cheddar cheese factories and two skimming stations where pasteurization of by-products is already in operation though not demanded by law.

It speaks well for the merits of pasteurization to learn that the process has been voluntarily adopted at fifty-five cheese factories in the State; and that, so far as can be learned, it has not been abandoned at any place after its introduction. Patrons of the factories seem sufficiently well pleased with the improvement in the quality of the by-products returned to bear all or nearly all of the slight expense of pasteurizing; and the owners of several large factories see enough
benefit from the cheesemaker’s side to do the work for less than its actual cost. This cost should not greatly exceed one cent for each hundred pounds of whey and may be as low as one-half cent.

In making the investigations a man was sent to the different factories and stations to observe the general arrangements for pasteurization and the actual conditions resulting from its use, to note the temperatures secured during the heating of the whey or skim milk and the rate of cooling as the material passed to and stood in the distributing tank; and to take samples of the by-product before, during and at various intervals after pasteurizing. In a few cases bacteriological examination of these samples was made at or near the factory, but in most instances the bottles were iced and sent as quickly as possible to the Station laboratory where careful study of the samples could be made.

Pasteurization merely means heating liquids or other materials to such a point that disease germs shall be destroyed and other undesirable organisms so reduced in number that their action shall not become noticeable for a considerable time. Various temperatures and periods of time may be used to secure these results; so it is not surprising to find that the legal requirements for pasteurization differ considerably in different states. A wider range is possible in treating by-products than in heating milk and cream, since too high temperature or too long continued heating affects the flavor of these products and makes them distasteful to many consumers. This slight change in flavor can be disregarded in case of food for animals; so the states compelling pasteurization of by-products usually require temperatures high enough not only to destroy most of the germs present but also to so change the by-product itself that a simple chemical test will show whether or not it has been pasteurized and thus furnish evidence for the prosecution of violators of the law. The Iowa law requires the heating of dairy by-products to 185° F., the Minnesota law to 180° F., and the Pennsylvania law to 178° F., any of which temperatures would insure satisfactory germ control and furnish evidence that the milk had been heated. The Michigan law requires 185° F. for “flash” treatment (heating without holding), but also allows holding at 145° for thirty minutes as an alternative method. This temperature and time will destroy most bacteria and all known disease-causing organisms.

In only one of the seven cheese factories visited in connection with the investigations were the temperatures secured in pasteurizing the whey high enough to meet the requirements of any of the laws except those allowed in Michigan for an alternative method. The temperature at the one exceptional factory rarely reached 178° F. Two of the factories did not meet the Michigan
“holding” requirements (145° for 30 minutes) and these two lost some of the value of the partial pasteurization by adding separator slop or water to the whey after the temperature was too low to pasteurize the added material. A third factory, though using temperatures high enough to secure efficient pasteurization, made the whole process unsatisfactory by adding unheated liquid to the partially cooled whey.

In four of the seven factories the pasteurization was effective, both as judged by the general condition of the whey in the distributing tank and by the bacterial analysis of the samples taken. In all four of these factories the pasteurization was by means of a steam line running into the whey tank. This is apparently a more effective method than by the addition of steam to the whey or skim milk by the “jetting,” or injector-pump, method of transferring the material about the factory and to the distributing tank. One disadvantage of the direct-pipe method is that a factory-man may occasionally shut off the steam supply a little too soon. The addition of steam in the jetting or double “jetting” method is more positive, but is usually insufficient to heat the whey to the temperature necessary to produce satisfactory pasteurization; and if the system breaks down at any time and the material runs to the tank by gravity only, with no supplementary method of heating provided, of course no pasteurization of that day’s whey is possible. This was found to occur occasionally.

By either method of treatment, approximately eight pounds of water is added, as steam, to each one hundred pounds of whey pasteurized. This dilution is not a serious defect; since the patrons lay more stress on quantity than on quality of product — a condition leading sometimes to the direct addition of considerable water to the whey in order that the last patrons may get their full share, even if the first ones take somewhat more than they should.

At Factory A the whey was heated by direct steam in a half-buried tank outside the factory, after it had been siphoned out of the making vats onto the floor and had run through a trench in the floor and a buried pipe to the tank. It was the intention of the cheesemaker to heat the whey to at least 160° F.; but the readings of a recording thermometer in the tank, taken every day for nearly six weeks, showed that the temperature was usually higher than this and occasionally reached 178° F.

Though the tank itself was seldom cleaned and its sides were thickly scaled over, the whey was so well pasteurized by the heating that it appeared in good condition on each of the three days when samples were taken and had a clean, sweet smell very different from that of unpasteurized whey. The fat remained perfectly suspended in the tank, and the albumin, though curdled and tending to sink, was easily dipped out with the whey. Bacteriological analyses
showed exceedingly satisfactory reduction in numbers, 150,000,000 per unit in the raw whey on one day being reduced to 51 in the pasteurized whey four and one-half hours later, 63,000,000 on the next day reduced to 700 three hours later, and 70,000,000 the third day falling to 6000 when the steam had been off forty-five minutes. The pasteurized whey, after standing all night in the tank, showed comparatively small numbers of the undesirable bacteria, which are active at ordinary open air temperatures; but contained very large numbers of an acid-producing form that finds its best condition for growth at or above body temperature and survives higher temperatures than most other bacteria. The presence of this organism was not revealed by the usual laboratory handling, but only after incubating the culture plates for two additional days at a higher temperature. The occurrence of this bacillus, *B. bulgaricus*, has undoubtedly often been overlooked, and its presence in such abundance is one of the surprises of this investigation. It produces a clean, rapid souring of milk which is not specially undesirable and which is necessary in making certain types of cheese. Its activity in the slowly cooling pasteurized whey checks the development of other less desirable germs.

At Factory B the whey was "jetted" twice, first from the making vat to a tank on the second floor, from which it ran by gravity to a fat separator, then to a barrel from which it was jetted to a wooden tub-tank outside. The whey cooled off rapidly in running through the pipes to this tank, particularly in cold weather, and separator slop, washings and added water were run into the whey tank, usually after the whey had cooled below the pasteurizing point. The tank was kept clean, the whey smelled sweet, and the albumin was not coagulated; so that, on the whole, the patrons were getting a much better product than before pasteurizing had been introduced. However, the temperatures used and held in the tank would not always insure destruction of the tubercle bacillus, nor was the reduction in the number of the other germs wholly satisfactory. The greatest reduction was only to 11,600 germs per unit after the whey had stood 30 minutes, and later the numbers rapidly increased again, especially when separator slop was added.

At Factory C conditions were much the same as at B, the whey being "jetted" twice and separator slop being added. The whey was also cooled quite rapidly by having to run a long distance through a pipe after the second "jetting". The whey was undoubtedly improved for the patrons' use, but not as much as it would have been by thorough pasteurization; and danger of the spread of tuberculosis was not eliminated.

A Victor pasteurizer is used at Factory D. This is a small, horizontal, metal cylinder into which live steam is admitted and mixes with the whey as it passes through. The whey is "jetted" from the making vat to a fat separator and then passes through the pas-
teurizer, in which the temperature can be readily controlled. Very satisfactory germ control could easily be secured; but the whey flows by gravity to a tank, in which it cools quite rapidly, after which the separator slop is added, making the destruction of disease germs very uncertain.

At Factory E and at Factory F, direct steam to the tank secures very satisfactory pasteurization of the whey. The process is aided in E by one “jetting” of the whey, but is handicapped by having the tank so far from the source of steam that much heat is lost by radiation. Reduction of the bacteria counts from over 50,000,000 to 2,000 or less were secured, the fat remained well suspended and the whey was in fine condition for feeding. At Factory F the raw whey was not so thoroughly seeded with bacteria as at E, and the final counts were reduced to the same satisfactory figures.

At Factory G, where conditions were about as at F, similar reduction in the number of the bacteria was secured on one day of the three when samples were taken, and the pasteurization was undoubtedly efficient on all three days, so far as disease germs are concerned. But on two days the whey from the making vat was very heavily seeded with Bacillus bulgaricus, which resists quite high temperatures and did not perish at the temperatures used — not exceeding 156° F. In consequence, the numbers of bacteria developing from pasteurized whey on plates carried for the added two days at high temperature were still in the millions. These bacteria, though souring the whey rapidly, did not give it any undesirable characteristics.

At an eighth factory a sample of old, unpasteurized whey was taken from a tank which looked and smelled like an old swill barrel — one that had never been cleaned. On this tank the fat had collected in a layer that could not be drawn off through the pump until it had become very unsightly and foul smelling. Samples of this whey gave counts of only 4,000,000 germs per unit on plates incubated as described for this investigation; but microscopic counts showed 1,500,000,000 Bacillus bulgaricus and 30,000,000 yeasts in addition to these.

Best method of pasteurizing whey. The observations made and figures secured at the separate factories indicate clearly that the heating of whey in the distributing tank by direct steam is the most convenient, most reliable and most effective method of pasteurizing, as it is, also, the least expensive.

Pasteurizing skim milk. At one of the skimming stations where pasteurization of skim milk was attempted, the results were far from satisfactory on the first day of testing, when the matter of temperature was left to the operator. A Reid flash pasteurizer was used and the temperature supposed to be secured was 160° F., but in reality it did not rise above about 152° F. and in two of the runs was less than 145°. By heating to
152° F. the bacteria count was reduced from 1,000,000 to 63,000; but the milk was pumped from the pasteurizer to the distributing tank and the pump and pipe were evidently so seeded with germs that a sample of the supposedly pasteurized milk, taken from this tank, showed a higher count than before pasteurizing. By runs at lower temperatures (143° and 144°) the counts were not reduced below 500,000; but the washing and heating of pump and pipe by the hot milk gradually disposed of some of their unfavorable influence, so that at the last test the count in the tank was lowest.

On the second day the temperature was raised, by request of the bacteriologist making the tests, and runs at 162° and 170° reduced the counts to 8,000 and 500, respectively, in the milk as it left the pasteurizer; while the counts were not high, even in the tank — especially not on the last run when the full effect of the flow of the hot milk through pump and pipes was shown.

In the second skimming station, the milk is heated in a tank by using a Wizard agitator, and the count was reduced from 616,000 to 43,000 by holding the milk at 155° F. for 30 minutes; and as the milk was promptly cooled to about 50° F. the count had not increased greatly when the milk was returned to the patrons 20 hours later.

By admitting live steam into the pipe through which the milk is pumped from the separator to the agitator tank the temperature was raised to between 175° and 180°, whereby the death of 98 per cent. of the bacteria was secured. The milk, drawn into an unwashed can at a temperature of 146° F., stood for 30 hours at a temperature of about 70° without souring.

So far as these studies show there are two general methods of pasteurizing skim milk satisfactorily: the holding process with subsequent cooling and returning of milk to patrons the following day, and the flash system.

The first is expensive because of the cost of equipment and cooling, and may give unsatisfactory results unless carefully controlled.

By the flash method of heating, a regular milk pasteurizer may be used, though somewhat expensive, or some simple arrangement may be adopted by which condensed steam is added directly to the milk. In either case the best results are secured when the milk is turned back immediately to the patrons and put in the cans at a temperature that will hold it above 145° for 30 minutes. This will destroy most of the bacteria in the can and the milk will remain in good condition for a considerable time. By prompt cooling on return to the farm the length of keeping can be extended.