

and surrounding. Thus milk kept at a temperature of 57° F for fifteen hours contained only 100,000 bacteria per cubic centimeter, the same milk kept at 95° F for the same time held, per cubic centimeter, 72,000,000, showing very forcibly the effect of temperature upon their development. The most favorable temperature is that at which it is drawn from the cow. So that if the milk be immediately cooled down, all development is practically checked, and in order to induce fermentation it is necessary to warm it up again.

Let us now turn our attention to some of the more common forms of fermentation occurring in milk. The most universal one, of course, and the one with which we are all so familiar, is that of souring. In this a certain class of organisms have the powers of attacking the milk sugar and breaking it up. The exact nature of the change is not quite understood, but the first visible product is lactic acid. This acid in common with all others has the power of precipitating the casein which exists in a state of semi-solution in the milk, and as soon as sufficient acid is developed it is coagulated and appears in the form of curd. The power of producing this acid from milk sugar seems to be quite common amongst these organisms, many species possessing it, though none of them act in just the same way. With a large number the amount produced is not sufficient to cause any trouble, but other species develop more rapidly and form large amounts of acid. To the presence of this is due the peculiar flavor of sour milk. As just mentioned, however, if the milk be at once cooled down the increase will be checked, and by practicing scrupulous cleanliness their number may be greatly minimized. It should be remembered that milk is the most easily contaminated of all substances and that when just warm from the animal it is especially susceptible to any such influences. In no other way except by the action of these organisms can milk become sour. The phenomena of souring during a thunderstorm so often attributed to the electrical condition of the atmosphere, is due to no other cause than that the warm sunny conditions that usually accompany such a storm are just the conditions most favorable to the rapid development of these lactic ferments. Milk deprived of its bacteria shows no tendency to sour or change in any way during these storms, or even under the influence of electric currents.

Just here it may be of interest to notice the difference between this form of fermentation and that occasioned by the action of rennet during the process of cheese making. In both cases the principal result is the precipitation of the casein. In the former, as we have seen, it is thrown down by the acidity of the milk without any change taking place in its nature, but in the latter the case is very different. There is no tendency toward acid development at all. The action of the rennet appears to be such that it breaks the casein up into two compounds, one of which is soluble and is lost in the whey, while the other, in the presence of certain of the salts, particularly those of calcium, is insoluble, and as these are always present the milk is at once coagulated, forming the curd of the cheese maker.

Besides that of souring there are a great many other kinds of fermentation which commonly occur in milk, though most of them are not of quite so much importance. Some, however, are worthy of notice. There is one class which produces alkalinity in the milk and occasionally causes some trouble, but as a rule the acid-forming species are more numerous and, getting the start of them, develop much more rapidly, producing sufficient acid to counteract their effect. There is another class which appears to attack the albumin

ous contents and give rise to bitter milk. Sometimes accompanying these and sometimes alone is found a class giving rise to butyric acid. The well known phenomenon of blue milk is due to a species which appears to act in conjunction with the lactic organisms, giving the milk a very characteristic blue color. Slimy fermentation is common in some parts, and often cause a good deal of trouble as such milk can furnish no cream. Its formation is due to a number of species which have the power of changing certain parts of the milk, making it exceedingly stringy. Besides these mentioned there are innumerable other classes all of which if allowed free action would produce their peculiar results.

Let us now turn aside from these theoretical considerations and view the matter from a more practical standpoint. We have seen that nearly all changes occurring in milk, and this applies also to cheese and butter, are due entirely to the presence of certain organisms which are introduced, owing to filthy conditions, after the milk is drawn from the cow. Some of them such as "ripening" or the "curing" of cheese are, when occurring at the proper time, quite necessary, but others are always to be avoided, for they invariably lead to mischievous results. The presence of a certain number of these organisms must be looked upon as inevitable, for under practical conditions it is impossible to help them all out. It is possible, however to reduce their number to a minimum, and to prevent those which are in from developing fast enough to cause any trouble. The source of all contamination as just mentioned is in unclean surroundings. An impure atmosphere, filth of any sort about the animal, especially the teats or udder, any form of uncleanness in the pails, are common sources of many of the germs, and as is universally known no substance is so susceptible to contamination as milk. The minute pores of a wooden vessel out of which it is impossible to wash the small particles of decayed milk is often the unknown source of a great deal of trouble, for they serve as resting places for myriad of germs. The temperature at which they are absorbed most readily and develop most rapidly is about 95° F, while their activity is diminished as the temperature lowers until at about 40° F, it ceases altogether; so that by cooling the milk down as soon as possible not only is their development checked but also their absorption, and by practicing most scrupulous cleanliness in every department the media from which they are derived are removed.

Let us glance hastily at the very important part which bacteria play in butter and cheese making. In the former the butter maker always "ripens" his cream. This is done by warming it for a time, thus allowing the lactic ferments a chance to do their work. It is exactly similar to the process of souring. Besides facilitating the operation of churning this imparts a much finer flavor to the butter. This is done by certain species working in conjunction with the lactic ferments. These have been isolated and cultures obtained, and in parts of Germany are put in the milk artificially to insure the development of the proper flavor in the butter, and are said to work with fair success.

In cheese making these organisms play a much more important part for without them the cheese would be absolutely worthless. New cheese is just like curd and it is not until the process of curing has gone on for a time that it is at all palatable, the right flavor only appears after it has been somewhat changed by the proper ferments within it. These are always in the milk and if the conditions be such