THE CHEMISTRY OF COTTAGE CHEESE.

F. H. HALL, L. L. VAN SLYKE AND E. B. HART.

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F. H. HALL.

Cottage cheese chemically simple.

In thousands of homes in New York State, cottage, or Dutch, cheese is a familiar table dainty. Thousands of housewives and dairymaids, and hundreds of factory cheesemakers of the other sex, have repeatedly taken the steps necessary to transform the liquid food, milk, into the solid food, cottage cheese; yet it is doubtful if many of these producers could give more than a superficial account of what takes place in the process, and it is certain that, until within a very short time, no one could speak authoritatively as to the chemical changes which occur in making this form of cheese. Cottage cheese is, however, one of the simplest of our cheeses, as it is found to consist mainly of two substances, water and casein dilactate. The latter is one of the two chemical compounds, or salts, resulting from the union of casein in the milk with lactic acid formed by bacterial fermentation of milk sugar.

The white color, crumbly or semi-pasty consistency, and slightly acid flavor of cottage cheese are too well known to need description; and study of its composition and digestibility confirms the popular belief that it is well fitted for a place in our diets.

*This is a brief review of Bulletin No. 245 of this Station, on Chemical Changes in the Souring of Milk and their Relations to Cottage Cheese, by L. L. Van Slyke and E. B. Hart. Any one specially interested in the detailed account of the investigation will be furnished, on application, with a copy of the complete bulletin. The names of those who so request will be placed on our mailing list to receive future bulletins, popular or complete edition as desired. Bulletins are issued at irregular intervals as investigations are completed, not monthly.
In the manufacture and ripening of cheddar cheese the biological factor—that is, the effect of living organisms—is large, and, so far, we know of no other agency that will produce the same result in the later stages of ripening as do the bacteria in normal cheddar cheese. The true cheddar flavor appears to be lacking unless bacteria are allowed to develop; but in making cottage cheese, bacteria are useful mainly in producing the acid that curdles the milk, since no true "ripening" of cottage cheese takes place and the flavor is merely that of well-soured milk. The direct action of the bacteria may be dispensed with altogether by the use of small amounts of commercial acid to produce curdling and of a little sour milk or cream to give the flavor. By this substitution of commercial acid for the acid gradually produced by bacteria, the time of making cottage cheese may be greatly shortened and the amount of heating similarly diminished. Milk fresh from the separator may be made into good, palatable and digestible cheese within half an hour.

The clue to the chemistry of milk souring and cottage cheese making was found in the series of tests and observations on cheddar cheese that are recorded in bulletins of the Station issued during the past three seasons. In this work it was ascertained that, as the milk sours, the casein first forms with the lactic acid produced by bacterial activity a distinct chemical compound, or salt, which has been called casein monolactate, and which has fixed physical and chemical properties. As additional acid is produced by the multiplication of the bacteria, the monolactate reacts with more acid to form a second compound, characterized by other equally definite qualities. This second salt has been called casein dilactate.

Since cottage cheese is usually made directly from the milk, without the addition of rennet, study of the changes taking place in the process is comparatively simple, and very satisfactory knowledge of the steps in the transformation has been reached in recent experiments.
The ordinary souring of milk is caused by certain ones of those minute, single-celled plants known as bacteria. The organisms of this group of bacteria, which includes several species, live upon the sugar contained in the milk and leave, as a result of their activity, a certain amount of lactic and other acids, the amount produced depending mainly upon the number of bacteria of the proper sort present and upon the temperature at which the milk is kept.

In the tests preliminary to making cottage cheese, it was found, that, at the ordinary room temperature, 65° to 80° F., the milk sugar was changed quite rapidly for about 32 hours, then slowly for 72 to 96 hours, when this form of bacterial activity ceased. It is characteristic of many forms of bacteria that their action is self-limited; that is, that their products, after a certain concentration of them is reached in the material in which the bacteria are, appear to poison the organisms so that their functions cease, even though plenty of food material remains. It is as though human beings were confined where the carbon dioxide breathed out would accumulate until it produced stupefaction. In the souring of milk in the tests, when about nine-tenths of one per cent. of acid was formed in the milk, the production ceased although nearly three-fourths (72 per cent.) of the milk sugar was still untouched. About two-thirds of the milk sugar which disappeared could be accounted for by the lactic acid produced, while various other products like carbon dioxide, formic acid, acetic acid and alcohol were derived from the remaining 38 per cent. of the milk sugar changed.

The milk began to curdle, however, long before the maximum of acid was formed, coagulation taking place in from 24 to 29½ hours in different samples of milk, at which time the acid in the milk had reached six-tenths or seven-tenths of one per cent.

The coagulation, as already stated, is the result of the union of the milk casein with the acid formed, the combination being at first in the form of casein monolactate, a compound not soluble in water but easily soluble in rather weak brine, this compound gradually changing to casein dilactate which is soluble in neither water nor weak brine. It is not until considerable of the dilactate is formed that the milk appears curdled. In the
tests, from 13 to 14 per ct. of the casein in the milk was in the monolactate form when coagulation was first noticeable, and 86 to 87 per ct. in the dilactate form. With further formation of acid the casein all became casein dilactate, so that when the soured milk is ready for making cottage cheese, all the casein is in this relatively insoluble form.

Making the cheese. Following these preliminary tests, cottage cheese was made under various conditions, to ascertain what relations exist between the quantity of milk and the amount of cheese, to study the composition of the cheese and the changes it passes through, and to learn the details of making by which a uniform product could be assured. Skim milk, only, should be used since there is a considerable loss of fat in making cottage cheese from whole milk. The fat can be added later when the cheese is salted, in the form of thick cream, and the percentage easily varied to suit individual tastes.

It was found that the milk would produce from 17½ to 22½ per ct. of its weight of cheese, the amount depending largely upon the percentage of moisture the cheese contained. This water content varied from below 70 to over 80 per ct. and was regulated largely by the temperature used in curdling the milk and in heating the curd to expel moisture, and also upon the length of time the curd was heated. To secure cheese of the best texture it should be so handled that it will contain from 70 to 75 per ct. of moisture when finished, though some may prefer a drier and more crumbly cheese than this. The best success in making test cheeses by the ordinary method was reached when a good starter of sour milk was used (½ pound to 20 pounds of milk), and the temperature of souring and curdling was not allowed to rise much over 70° nor that of the heating to expel the whey above 90°. Under these conditions the time necessary for good curdling was about 24 hours, a very convenient period, the whey drained off perfectly and rapidly, and the desired amount of water could be easiest secured. If the temperature of souring, curdling and heating be too low, below 80°, the curd drains very slowly and the cheese is commonly too moist; while too high a temperature for souring is liable to give a soft, mushy curd.
Within the limits given as favorable, the cheese can be made quite moist by raising to 90° gradually, taking half an hour to reach that point, and holding at 90° for 15 minutes. Holding longer at 90° or raising the temperature above 90° tends to diminish the amount of water in the cheese.

Making with acid. Since curdling in case of cottage cheese made without rennet is due merely to the action of acid, it was thought that such cheese could be made from freshly separated milk without allowing the bacteria time to produce acid, if the acid were supplied in another form. The experiment was tried in two ways, using lactic acid, which is the one naturally found in milk, and hydrochloric acid, which is a common commercial article. Chemically pure hydrochloric acid should be used, however, as that sold in the drug stores contains impurities which might be undesirable.

The acid used is diluted with from eight to ten times its bulk of water and added to the milk when the latter has been brought to the proper temperature, stirring thoroughly through the milk. This stirring should be continued until the whey separates clear, and settles out in flakes. In this way the formation of lumps is prevented and the curd will be finely divided and will not require cutting.

With both acids good cheese was made, and the results, when the acid was properly proportioned to the milk and the temperature of the milk maintained at the suitable degree, were highly satisfactory as to texture and amount of product, and were secured in much less time than by the usual method. When sour cream was added to give the flavor, the cheese made with either acid was not to be easily distinguished by texture, taste or digestibility, from normally made cottage cheese.

At a temperature of 75° when the acid was added, 0.6 per ct. of lactic acid or 0.25 per ct. of hydrochloric acid gave curd of good texture which separated rapidly and completely from the whey. The temperature of the milk when the acid is added has much to do with the rapidity of the curd separation. At 60° it required 20 hours for the curd to drain, at 70° one hour and at 80° only 30 minutes. The percentage of moisture in the cheese was remarkably uniform, however, at any temperature.
Cheese made with the artificial acid differs slightly in chemical composition from normal cottage cheese, being considerably richer in sugar and slightly richer in casein. Bacteria do not have much time to work, in the milk, and little if any of the sugar is decomposed, hence more of it is carried by the curd.

The advantages from the use of acid in making cottage cheese lie in the saving of time and heat. Instead of waiting from 24 to 48 hours for curdling and some time for raising the temperature, the whey can be drawn off almost at once, and the curd drains quickly and is ready, without cutting, to be salted.

The whole process can be carried on at room temperature, also, instead of using additional heat as in normal making.

The disadvantages are the lack of sour milk flavor in cheese made from sweet milk, a disadvantage easily overcome by mixing in a little sour cream at salting, and the expense of the acid, a trifle of one-fourth of a cent for each pound of cheese, an outlay more than offset by the time and heat required for making in the old way.

Examination of cottage cheeses made from whole milk naturally soured, from skim milk pasteurized and unpasteurized, and with and without rennet, showed that there is no "ripening" of this cheese. It is usually eaten when freshly made, but even after three weeks, there had been only insignificant digestive or "breaking down" changes of the nitrogen compounds. In cheddar cheese, on the other hand, almost one-sixth of the nitrogen is contained in soluble forms at the end of three weeks.

From this lack of proteolytic, or breaking down, Digestibility changes, the chemist would naturally infer that of cottage cheese is less digestible than cheddar cheese; but common belief is to the contrary and is true. Cottage cheese proved, in artificial digestion tests at least, to be more readily digested than cheddar cheese. In this work, pepsin, which is the agent upon which digestion of nitrogenous materials in the stomach principally depends, was introduced into flasks containing cheddar or cottage cheese or some of the compounds formed during cheese
making; and the material allowed to remain for some time under conditions which favor digestive action.

It was proved in this way that cottage cheese is more digestible than cheddar cheese; and for two reasons: First, because cottage cheese does not "mat" together as does cheddar cheese, consequently the digestive juices find readier access and can attack the fine particles of the cottage cheese rapidly and effectively; and second, casein dilactate of which cottage cheese is mainly composed, is more digestible than para-casein monolactate which predominates in cheddar cheese. It was also found that cottage cheese made from whole milk was more readily digestible than that from skim milk, owing to the looser texture of the whole milk cheese. The fat does not impede digestion.

Good cottage cheese should have a soft, smooth Good cottage texture, being neither mushy nor dry and saw-cheese and dust like. Such a texture will accompany a how to moisture content of from 70 to 75 per ct. The make it. flavor should be that of mildly soured milk or well ripened cream, with an entire absence of bitter taste, flavor of stable, or other objectionable qualities. Such flavor may usually be secured by the use of a good starter; but if too much whey is retained the cheese may be sour. Flavor and texture are quite closely connected, at this point, for a slow draining curd is liable to result in poor textured and poor flavored cheese.

The various steps in making cottage cheese may be summarized as follows:

Use skim milk rather than whole milk, to avoid loss of fat. To secure proper flavor and speedy souring add a small amount of a good starter. This starter should be prepared from clean, fresh milk, separated from the cream and placed in a carefully cleaned receptacle, well covered and brought to a temperature of 90° and then allowed to stand from 20 to 24 hours at a temperature of 65° to 70°. The upper portion of this should be discarded and the amount needed strained through a fine strainer or hair sieve and thoroughly mixed with the milk from which cheese is to be made the next day. A portion may also be used
in preparing a starter for the next day, but as soon as any unfavorable effect is noticed a new starter should be prepared.

Several good and convenient commercial starters are on the market, for use of which directions accompany each package.

The milk is now kept at a temperature of 70° to 75° until well curdled, often in 24 hours, sometimes not until 48 hours. The curdled mass is broken up by hand or by a curd knife, raised gradually to 90° taking 30 to 40 minutes in the process. The whey should then separate clear in 15 to 20 minutes, after which it is run from the curd, and the latter placed in muslin bags or on racks to drain. When whey ceases to come from the curd, salt is added to taste or at the rate of about a pound for 100 pounds of cheese, the curd formed into balls and wrapped in oiled paper that may be obtained from any dairy supply house. For the finest quality of cheese, thick cream, preferably ripened cream, should be added at the rate of about an ounce for one pound of cheese, before the cheese is made into balls.

If it is thought best to hasten the curdling rennet extract may be added about eight hours after the starter has been introduced, using one ounce of rennet extract for 1,000 pounds of milk.