Continuous Manufacture of Cottage and Other Uncured Cheese Varieties

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ABSTRACT

Manufacture of quarg (quark) by continuous fermentation in a two-stage fermenter is discussed. The process, which required sterile media and utilized single strain lactic streptococci, operated successfully for several days without problems. A mechanical washer-cooler for cottage cheese curd is described. It provides for curd washing in an enclosed system and utilizes about half the water needed for vat washing.

The growth of lactic streptococci in cottage cheese milk appears to contribute something other than acid production which affects the body and texture of cottage cheese curd. When skim milk was precultured to pH 5.7 or 5.5 prior to making cottage cheese by direct acidification, the moisture holding capacity and firmness of the curd were increased and body and texture scores were improved. A combination of preculturing skim milk coupled with continuous direct acidification is proposed for cottage cheese making.

INTRODUCTION

Efforts to improve the efficiency of cheese making have frequently been directed toward mechanization of traditional processes. This has resulted in the elimination of a good deal of drudgery, but for the most part has left basic cheese making procedures intact. A number of new mechanical devices that fit this pattern have successfully found their way into commercial cheese making operations in recent years.

A fundamental approach has been to identify the essential chemical, physical, and microbiological changes that occur during cheese making, and determine, if possible, whether alternate methods might be used to accomplish the same result, viz. yield cheese with the same qualities possessed by the traditional product.

While these two approaches to the problem have differed, they have not been independent of one another. Sometimes mechanical equipment has altered the process, and in turn, stimulated questions about fundamental cheese making procedures. The success of the Bell-Siro Cheese Make II and Cheddarmaster cheddaring tower has raised questions about the necessity for extensive curd flow during the cheddaring of Cheddar cheese (16, 20).

Research on the manufacture of cottage and other uncured varieties of cheese has followed the same double approach typical of cheese research in general. Thus, new mechanical devices have appeared on the market to simplify and make more efficient the traditional methods of cottage cheese making at the same time that direct acidification and continuous fermentation were being investigated in the laboratory and pilot plant.

CONTINUOUS FERMENTATION

Quarg (quark) is an uncured cheese-like product popular in some areas of Europe that resembles bakers cheese manufactured in the United States. Connor (4) investigated the production of quarg by continuous fermentation. He used two fermenters; the first was a stirred fermenter that operated at a constant pH of about 5.5 to 5.6. Sterile milk substrate was introduced continuously into this fermenter as product was removed and pumped into the top of a second quiescent fermenter. In the second fermenter acid development continued to about pH 4.6 where final coagulation occurred. The coagulated mass emerged from the bottom of the fermenter. Whey was then separated by centrifugation. He successfully operated his continuous fermentation process for several days with good results after he had established conditions that were optimal for operating the fermenters. Prolonged operation of a continuous fermentation system would require a sterile phage-free media which may limit its application for most varieties of cheese. Also, dependable acid production at a constant rate would probably require the use...
of single-strain lactic cultures as were used by Connor (4).

Continuous fermentation for cottage cheese making presents difficulties, particularly if heat sterilized milk is used. It is difficult, however, to overlook the excellent work of Emmons et al. (9), who produced good quality cottage cheese curd from milk that had been heat-treated to 77.7°C for 30 min. Subsequently, Noznick and Bundus (19) and Vakaleris (23) were awarded patents for producing cottage cheese from high-heat milk. Much is yet to be learned about the effect of heat on milk and its relation to curd formation; however, when procedures are developed for making consistently good quality cottage cheese curd from heat sterilized milk, continuous fermentation might become a useful process for the cottage cheese industry.

Discontinuous prefermentation of cottage cheese milk is a practice already in operation in some cottage cheese plants. Inoculated cottage cheese milk is precultured in large storage tanks to a pH value that is not low enough to induce coagulation — usually about pH 5.5 to 5.7. It is then pumped into the cheese vats for final setting and cooking. This procedure has the advantage of freeing the vats during part of the setting time and increasing the efficiency of their utilization.

MECHANICAL CURD WASHING

An interesting development in the mechanization of cottage cheese making has been a washer-cooler designed to wash cottage cheese curd in an enclosed system and at the same time reduce the consumption of wash water (see Fig. 1). At the conclusion of cooking, part of the whey is drained away after which the remaining curd and whey are pumped into the bottom of the washer-cooler. The rate of pumping is such that the curd settles to the bottom of the washer as the whey moves slowly through it. As the last whey enters the washer, it is followed by tempering wash water which moves in beneath the whey and forces it out the drain at the top. A screen is provided at the outlet in case air is pumped into the system which will cause frothing and loss of fines through the outlet. When sufficient tempering water has been introduced, it is followed by chilled water for final cooling.

After the curd has been washed adequately and cooled to 4.4°C the mixture of curd and chilled water is pumped out the bottom of the washer-cooler to a suitable draining device.

Fig. 1. A washer-cooler for cottage cheese curd. Courtesy Rietz Manufacturing Company.

Fig. 2 shows one arrangement of equipment for the washing and draining cycle. A three-way valve between the vat and a reversible pump permits filling the washer-cooler from the vat and removing the chilled curd and water from the washer-cooler with the same pump. In this system the drainer is used also for mixing the dry curd and creaming mixture before it is pumped to the packaging machine.

The main advantages of this system appear to be (a) an enclosed operation that is not susceptible to outside contamination and, (b) a saving of wash water. The mechanical washer-cooler requires about half the water used in conventional vat washing (15).

DIRECT ACIDIFICATION

Direct chemical acidification as a substitute for acid production by microorganisms has stirred the imagination of cheese researchers for many years. It is understandable that most direct acid cheese research has been related to cheese varieties that require little or no curing. Deane and Hammond (7) made cottage cheese by adding acid anhydrides such as D-glucono-delta-lactone and meso-lactide to skim milk in a cheese vat. These compounds hydrolyzed to form their corresponding acids while the milk remained quiescent. Good quality cottage cheese reportedly was produced from curd formed in this way, but the cost of the anhydrides and the time required for hydrolysis were distinct disadvantages.
A patent was issued to Corbin (5) covering a batch process which included partial acidification of skim milk with approved food grade acids to a pH slightly higher than needed to cause coagulation, then addition of D-glucono-delta-lactone for final acidification. This process has found commercial acceptance in a few cottage cheese plants (1, 14) and has been approved as one of the alternate methods of manufacture in the Standards of Identity for Cottage Cheese Dry Curd (13).

Direct acid cottage cheese also can be made by addition of concentrated acid to skim milk at a temperature low enough to prevent coagulation, then heating to induce coagulation. At 4 C the pH of the milk may be adjusted to 4.6 without producing coagulation. In this process, it is important that heating take place without internal movement of the milk (11). A patent issued to Little (18) utilized a modification of cold acidification for the batch manufacture of cottage cheese. Sufficient rennet was added to the cold acidified milk to induce coagulation without the necessity of heating. The curd was then cut at 4.4 C, and the cooking operation started from that point.

Patents have been issued to Wakeman (24) and Wakeman et al. (25) covering a mechanical process which utilizes direct acidification and quiescent heating for the continuous manufacture of cottage cheese curd.

Skim milk is pasteurized and deaerated under vacuum while hot to remove dissolved gases. This prevents the formation of gas pockets in the curd when it is cooked. The pasteurized milk is cooled in an airtight system to 4 C and hydrochloric acid injected into the cold milk to adjust the pH to approximately 4.6. The cold acidified milk is then introduced into the bottom of a curd former which consists of a cluster of .79 cm tubes surrounded by an appropriate heating medium that brings the acidified skim milk to a suitable coagulation temperature as it progresses upward in the tubes. The principle of operation of the curd former is illustrated by a single curd former tube in Fig. 3. Coagulation begins around the

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Fig. 2. Equipment for washing, cooling, draining, and creaming cottage cheese in a closed system. Courtesy Rietz Manufacturing Company.

Fig. 3. Diagram of the operating principle of a continuous curd former. Ernstrom (11).
FIG. 4. Equipment for the continuous manufacture of cottage cheese curd by direct acidification. Courtesy Crepaco Inc.
outside of the column of milk and progresses toward the center of the column as heat penetrates the cylinder of milk. When it emerges from the top, it is completely coagulated and may be cut into appropriate sizes by a rotating knife. When coagulation takes place, some whey is expelled to form a lubricating film between the coagulum and the wall of the tube. This allows the product to slip up the tube without internal agitation. When the curd emerges from the top of the curd former, it is firm enough to feed directly into a continuous cooker that cooks the curd in approximately 20 min. An illustration of the equipment arrangement is in Fig. 4. The hot curd is rapidly separated from the whey as it emerges from the cooker and is then washed, drained, and creamed. The total process from raw skim milk to the end of washing requires about 35 min. When the curd emerges from the cooker at about 76 C, the whey is immediately drained away leaving the curd in a condition where moisture expulsion is rapid. The curd is washed in a continuous washer designed to increase the pH of the curd, preserve a meaty texture, and cool the curd ready for creaming.

The process is capable of producing about 635 kg of curd per hour from skim milk containing 9% solids and is now included as an approved procedure in the Federal Standards of Identity for cottage cheese (12).

Direct acidification for the manufacture of cottage cheese is based on the assumption that the only essential function of starter organisms in the traditional process is the production of lactic acid for coagulation. While excellent flavored cottage cheese has been produced by direct acidification in the continuous process, a consumer survey by Born and Muck (3) indicated that consumer acceptance ratings of the continuous direct acid product were slightly, but not significantly, lower than for conventional cottage cheese manufactured in their plant. To those working with the product, however, continuously made direct acid curd was always lower in moisture and did not possess the same firm meaty body typical of good quality cottage cheese. After creaming, the curd was usually too soft to meet the demands of most markets. These problems raised questions that challenged the basic assumption that the only important function of starter bacteria in cottage cheese is to produce acid.

**PRECURATING SKIM MILK FOR DIRECT ACID COTTAGE CHEESE**

Although lactic streptococci are not notably proteolytic, they will produce detectable proteases (6, 17, 21, 22). Whether these proteases or some other nonacid producing function of the starter microorganism contributes to the body and texture of cottage cheese was investigated.

Pasteurized skim milk was divided into two lots. The first was inoculated (5%) with a culture of *Streptococcus lactis* C2 and the second with the same amount of *Streptococcus cremoris* AM2. During incubation at 32.2 C samples of milk periodically were removed and deproteinized in a 2% solution of trichloroacetic acid (TCA). The increase in nonprotein nitrogen (NPN) in the TCA filtrate was followed by treating it with Folin-Ciocalteau reagent (Fisher Scientific Co., Fair Lawn, NJ.) as described by Cowman and Speck (6) and measuring the increase in absorption at 650 nm. Fig. 5 shows that there was a measurable increase in NPN during the time normally used for setting cottage cheese. Proteolysis of the milk proteins, however, was not extensive because no change in NPN was measurable when 12% TCA was used as a deproteinizing agent.

Cottage cheese making experiments next were conducted in which pasteurized skim milk was inoculated with 5% starter culture (S. lactis C2), divided into two lots and incubated at 32.2 C. The two lots were allowed to develop acid to pH 6.0 and 5.5 respectively. They were then cooled to 4 C, acidified to pH 4.6 with hydrochloric acid, heated quiescently by electrical resistance heating to 32.3 C (11), and made into cottage cheese.
Another lot of cottage cheese curd was made entirely by direct acidification without the aid of starter organisms, and a fourth lot was made by a conventional short-set culture process (10). All lots were cooked to 62°C in 120 min. The experiment was replicated 10 times and the curd analyzed for moisture (2) and firmness (8). After creaming, the body and texture of the cottage cheese were graded by a panel of four experienced judges on a scale of 1 to 5 in which 1 was superior, 2 excellent, 3 satisfactory, 4 objectionable, and 5 unsalable.

Fig. 6 shows the average moisture content of 10 lots of cottage cheese curd made by the four procedures. Vertical lines atop each bar represent standard deviations from the mean.

Scores in Table 1 indicate that, in the opinion of the judges, the body and texture of direct acid cottage cheese was improved by preculturing the skim milk prior to cheese making. Statistical analysis of the scores revealed a highly significant quality improvement of procedure 2 over procedure 1, and a highly significant improvement of procedure 3 over procedure 2. There was no significant difference between the scores of cottage cheese made by procedures 3 and 4.

The lactic streptococci produced an effect in skim milk other than acid production that improved the moisture holding capacity of direct acid cottage cheese curd, and also helped establish a degree of curd firmness that was not lost following creaming of the curd.

Since preculturing skim milk for cottage cheese making is an established practice in some plants, continuous direct acidification plus prefermentation could provide a practical marriage of processes to maximize the advantages of both.

### Table 1. Average body and texture scores of direct acid cottage cheese made from precultured and nonprecultured skim milk.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Body and texture scores</th>
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<tbody>
<tr>
<td>1) Skim milk not precultured, curd made by direct acidification</td>
<td>3.70</td>
</tr>
<tr>
<td>2) Skim milk precultured to pH 6.0; curd made by direct acidification</td>
<td>3.11</td>
</tr>
<tr>
<td>3) Skim milk precultured to pH 5.5; curd made by direct acidification</td>
<td>2.80</td>
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<tr>
<td>4) Curd made by conventional starter process (control)</td>
<td>2.88</td>
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*1, Superior; 2, Excellent; 3, Satisfactory; 4, Objectionable; and 5, Unsalable.*
REFERENCES