Heat Treatment of Cultured Dairy Products

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ABSTRACT

By heat-treating cultured dairy products, lactic acid bacteria as well as contaminants are eliminated so that a considerable prolongation of shelf-life can be achieved. In general, a temperature of 70°C and a holding time of 30-60 sec are sufficient to eliminate lactic acid bacteria as well as contaminants, primarily yeasts and molds. The heat resistance of the thermophilic lactic acid bacteria proved to be 10-15°C higher than that of the mesophilic lactic acid bacteria. The different steps of the technology are reviewed. The manufacture of dessert products based on whey proteins is also proposed. In the conclusion, it is pointed out that this technology is recommended only if recontamination of the product during the filling process is avoided.

The problem of heat-treating cultured milk products to prolong their shelf life is not new. A U.S. patent published in 1914 describes the manufacturing process of canned cream-cheese which had been heated at 100°C for an extended period. For several decades a “hot-pack-cream-cheese”, a kind of double-cream cheese heat-treated at 69-70°C and subsequently hot-filled in bags has been known in the U.S.; the shelf-life of this product supposedly being more than 60 days (5).

Pasteurization of yogurt was first patented by Klebs in 1928 “as a process for manufacturing from milk a creamy, vitamin containing yogurt beverage with a long shelf life characterized in that the milk is fermented in a closed package at approx. 45°C, sealed, quickly heated to 60°C and held at this temperature, then followed by fast cooling” (14).

STORAGE LIFE

The increasing popularity of cultured milk products, which is partly due to their combination with fruit, also required development of new technologies to obtain a prolonged shelf-life which is imperative for optimal distribution and sale. By heat-treatment of the finished product and subsequent aseptic filling this aim can be reached.

The shelf-life of cultured milk products depends on the microflora therein. Though lactic acid bacteria are eliminated during heat-treatment of cultured milk, the problem of contamination during the filling process still exists and can only be solved by aseptic filling (Fig. 1). To prolong the shelf-life, the following requirements regarding the technological process must be met: (a) avoidance of post-acidification (after-acidification) bitter taste, (b) elimination of contaminants such as coliforms, yeasts and molds and (c) avoidance of unnecessary loss of valuable nutrients so that the economic consequences will result in easier distribution, access to more distant markets and easier shopping and storing for the consumer.

MICROBIOLOGICAL ASPECTS OF HEAT-TREATMENT

By heat-treating cultured milk products it is intended to more or less eliminate the lactic acid bacteria as well as contaminants such as yeasts and molds so that during the long period of storage there will be no metabolism of microorganisms such as post-acidification and proteolysis. Beside the microbiological aspects of this technology, consistency and structure of the product should remain unchanged.

First, the microbiological aspects of heat-treatment of cultured milk, including quark, will be discussed. Fliteler and Puhan (6) investigated the influence of temperature and H-ion concentration on elimination of lactic acid bacteria and other contaminants during heat-treatment of yogurt and quark. With decreasing pH in the product, heat-treatment results in a progressive reduction of the thermophilic and mesophilic lactic acid bacteria. The thermophilic lactic acid bacteria, however, resisted higher temperatures than did the mesophilic lactic. In yogurt with pH 4.55, 97.6% of the lactic acid bacteria survived heat-treatment at 65°C, 22 sec, whereas at pH 3.82, 99.99% of the lactic acid bacteria were eliminated at the mentioned temperature/time relation. In quark, however, only 0.01% of the mesophilic lactic acid bacteria survived heat treatment at 60°C, 60 sec and pH 4.5.

At the holding time of 22 sec for yogurt and 60 sec for quark, and the same pH in both products, it became evident that for eliminating 99.98 - 99.99% of the lactic
HEATING CULTURED DAIRY PRODUCTS

TABLE 1. Elimination of thermophilic lactic acid bacteria\(^a\) during heat-treatment of yogurt (6).

<table>
<thead>
<tr>
<th>Holding time, sec</th>
<th>Survival rate (%) at pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>4.55</td>
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<tr>
<td></td>
<td>4.05</td>
</tr>
<tr>
<td>55 C</td>
<td>100</td>
</tr>
<tr>
<td>60 C</td>
<td>100</td>
</tr>
<tr>
<td>65 C</td>
<td>97.6</td>
</tr>
<tr>
<td>70 C</td>
<td>0.015</td>
</tr>
<tr>
<td>75 C</td>
<td>0.001</td>
</tr>
</tbody>
</table>

\(^a\)Before heat-treatment: 6 \times 10^9 microorganisms/ml.

TABLE 2. Elimination of mesophilic lactic acid bacteria\(^a\) (homo- and heterofermentative) during heat-treatment of quark (6).

<table>
<thead>
<tr>
<th>Holding time, sec</th>
<th>Survival rate (%) at pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>35</td>
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<td></td>
<td>30</td>
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<tr>
<td>50 C</td>
<td>3.56</td>
</tr>
<tr>
<td>55 C</td>
<td>0.174</td>
</tr>
<tr>
<td>60 C</td>
<td>0.005</td>
</tr>
<tr>
<td>65 C</td>
<td>0.003</td>
</tr>
<tr>
<td>70 C</td>
<td>0.001</td>
</tr>
</tbody>
</table>

\(^a\)Before heat-treatment: 3 \times 10^9 microorganisms/ml.

Acid bacteria, the temperature for the thermophiles had to be approximately 15 C higher than that for the mesophiles. The remaining 0.01 to 0.02% of lactic acid bacteria practically showed no activity so that after storage for 2 months at 20 C, post-acidification could be measured neither in yogurt nor quark.

Flüeler (5) also investigated elimination of Escherichia coli, Enterobacter aerogenes, Pseudomonas fluorescens, Kluyveromyces fragilis, Geotrichum candidum, Bacillus cereus and Clostridium sporogenes during heat-treatment of cultured milk. In yogurt with pH 4.07, heat treatment at 55 C was sufficient to inactivate E. coli completely. However, 40% of E. coli survived heat treatment at this temperature at a slightly higher pH of 4.55. In quark, E. coli was inactivated completely at 55 C.

In yogurt, 60 C can be considered as the minimum temperature to inactivate K. fragilis and G. candidum completely, whereas in quark this minimum is slightly higher, i.e. between 60 and 65 C. The reason for this greater heat resistance of these two microorganisms in quark is probably due to the higher solids content and consequently lower lactic acid concentration.

TEMPERATURE OF HEAT-TREATMENT

A survey on development of heat-treatment technology for cultured dairy products from the basic investigation by Schulz (14), followed by Klupsch (8), Siegenthaler (16), Flüeler and Puhan (6), Robinson and Tamime (13). Egli and Egli (4), Kohli (10), Puhan (11) and Id (7) leads to the conclusion that the temperature range lies between 60 and more than 75 C, whereby no distinction is made between mesophilic and thermophilic lactic acid bacteria. However, the observations made by Flüeler and Puhan (6) revealed that, apart from differences in heat resistance of lactic acid bacteria, the minimum temperature for inactivating contaminants and lactic acid bacteria, depending on the pH of the product, is also different. These results have been summarized in Fig. 2.

Contrary to Siegenthaler’s opinion (16), according to which the pasteurization temperature of the finished product “should be chosen as high as possible” and “that the upper limit is reached where a negative influence on the cultured milk product by cook-flavor or changes in consistency and structure occur”, we are of the opinion that the temperature should be kept as low as possible.

Without discussing the problem of whether the original name can still be used for heat-treated cultured milk products, two technologies of more recent date should be mentioned where the product is indeed undergoing heat treatment with the lactic acid bacteria remaining alive.

For manufacture of yogurt Battistotti et al. (3) and Bottazzi (2) use special thermoresistant Lactobacillus bulgaricus and Streptococcus thermophilus strains which
survive heat-treatment at 65°C. According to a HF/UHF multiple frequency method for heat-treating cultured milk products described by Bach (1), it is possible to inactivate yeasts and molds at a temperature below 60°C without damaging the added starter culture. Heat-treated cultured milk products in which the lactic acid bacteria remained active following heat-treatment must be stored at low temperatures, whereas the storage temperature for products with inactivated lactic acid bacteria can be higher.

**TECHNOLOGICAL ASPECTS OF HEAT-TREATMENT**

The purpose of heat-treating cultured milk products should be to prolong their shelf-life without, however, having any negative influence on their quality. But these two factors, heat and acidity, favor syneresis of the casein followed by a separation of precipitated casein and whey. It is thus the technologist's task to take measures to avoid such adverse effects on the quality of the product. Figure 3 shows the technological process for heat-treatment of cultured milk.

Contraction of the acid-precipitated casein is influenced by the following factors (14, 16): pH of the product; fat-, protein-, and sugar-content; heating temperature and -time of the milk before fermentation; proteolysis; type of hydrocolloid (stabilizer) and heating temperature of finished product.

Practical experience showed that with increasing heat-treatment of the milk for production of cultured milk products, contraction of the gel and thus its tendency towards syneresis diminishes considerably. In general, it is true that extensive denaturation of whey proteins has the effect of a stabilizer, increasing at the same time the viscosity of the product. The investigations of Schulz (15) show that the more intensively milk is heat-treated before fermentation, the higher the pH can be at which the cultured milk product is pasteurized (Fig. 4).

Higher fat and sugar contents are also beneficial for stability of the product, whereas the opposite applies to the casein content. As regards acidity, the product can be heated more easily when the pH is lower. If there should not be enough lactic acid, it is recommended to adjust the pH, depending on the product, with an accuracy of ± 0.05 by adding a mixture of citric and tartaric acid. In general, heat-treatment is carried out within the range of pH 4.40-4.10. At a pH below 4.0, a cultured milk product can generally be pasteurized without stabilizer (14).
Hydrocolloids are practically indispensible in heat-treating of cultured milk products as they stabilize the proteins, form gels and increase the viscosity (9,14). Hydrocolloids such as starch, gelatin or pectin may be added during the preparation of milk before fermentation or after fermentation but before heat-treatment if guar gum, locust bean gum, etc. are used. When selecting type and quantity of hydrocolloids, it must be kept in mind that these are merely additives necessary for heat-treatment and therefore should not change the properties of the finished product.

Heat-treatment of the product is followed by the filling process whereby it is of utmost importance that any contamination with yeasts and molds as well as lactic acid bacteria must be avoided. This is possible by either aseptic filling or hot filling. When filling the product aseptically it is cooled before filling. If the second method is applied, the product should be filled at the temperature it was heat-treated. To eliminate probable molds and yeasts, the temperature should not fall below 65°C (Fig. 2). Cooling of the packed product should be fast to avoid possible changes. Impeccable packing material, high hygienic standard, elimination of unsealed cups and thorough cleaning and disinfection of the machines following use as well as disinfection before filling are imperative for successful hot-filling of heat-treated cultured milk products (8).

In connection with heating and cooling, thought should also be given to the mechanical damage of the coagulum, especially that of low-fat products. Unsuitable pumps as well as too long and narrow pipes may have a negative influence on the consistency. By using stabilizers, the consistency of the product can be improved. However, the greater the mechanical damage was, the less effective the stabilizers will be. For this reason, the viscosity of aseptically-filled products is always less than that of hot-filled products.

Heat-treatment is mainly applied to cultured milk products with fruit and flavor added. Some flavor components are heat-labile. Furthermore, certain stabilizers such as locust bean gum and guar gum decrease the intensity of the flavor. For these reasons the heat-treated cultured milk product needs an overdose of flavoring material (12).

### WHEY-PROTEIN DESSERTS

Finally, I would like to mention the heat-treatment of milk-type desserts. The technology of these products, which are based on sweet or cultured milk, is relatively simple and the problems of shelf-life are similar to the afore-mentioned products.

Due to the low pH value of the fruit component, production of desserts with added fruit is possible only by using cultured milk. New possibilities appear by using whey proteins obtained by ultrafiltration. These can easily be mixed with fruit and gel is formed quickly at temperatures between 75 and 90°C. By a suitable combination of whey-protein concentrate and stabilizers it is possible to produce acid milk-based products without lactic acid fermentation (17).

### CONCLUSION

Even with the technical possibilities and the technological know-how of today for considerably prolonging the shelf-life of cultured milk products, I am of the opinion that these possibilities should not lead to a conversion of fresh products into canned food with a shelf-life of several months without refrigeration. Heat treatment of cultured milk products should not be considered as a possibility to correct lack of hygiene during production but rather as technological progress which is sensible only if recontamination of the product during the filling process will be avoided.

<table>
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<tr>
<th>Protein (%)</th>
<th>65</th>
<th>70</th>
<th>75</th>
<th>80</th>
<th>85</th>
<th>90</th>
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<tbody>
<tr>
<td>14</td>
<td>90'</td>
<td>25'</td>
<td>2'15'</td>
<td>50'</td>
<td>30'</td>
<td>25'</td>
</tr>
<tr>
<td>12</td>
<td>Non gelling</td>
<td>Non gelling</td>
<td>2'30'</td>
<td>60'</td>
<td>35'</td>
<td>30'</td>
</tr>
<tr>
<td>10</td>
<td>Non gelling</td>
<td>Non gelling</td>
<td>5'15'</td>
<td>1'10'</td>
<td>40'</td>
<td>30'</td>
</tr>
<tr>
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<td>40'</td>
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</tr>
<tr>
<td>6</td>
<td>-</td>
<td>-</td>
<td>Non gelling</td>
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</tr>
<tr>
<td>4</td>
<td>-</td>
<td>-</td>
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<td>2</td>
<td>-</td>
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<td>-</td>
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</tr>
</tbody>
</table>

\(^{a} 90\text{ min.}\)
\(^{b} 2\text{ min, 15 sec.}\)
ACKNOWLEDGMENT


REFERENCES


Interim Report of the Applied Laboratory Methods Committee 1979

The activities of the three subcommittees of the Applied Laboratory Methods Committee have been limited during the past year due to resignations of two sub-committee Chairpersons and increased job responsibilities of the third Chairperson. New Chairpersons are Berry Gay, Jr.- Subcommittee on Laboratory Methods for the Examination of Water and Other Environmental Samples and Clair Gothard - Subcommittee on Laboratory Methods for the Examination of Milk and Milk Products. Members of the Milk Methods Committee have served in various capacities in the preparation of new editions of APHA "Standard Methods for the Examination of Dairy Products." The 14th Edition has been published and Chapter Chairpersons will soon be selected for the 15th edition. Two members of this committee have been appointed to serve in control capacities and we anticipate additional requests for committee participation of members.

The new Chairpersons will be revitalizing their subcommittees, making changes or additions where applicable. All Chairpersons will be prioritizing subcommittee projects for development during calendar years 1979-1980.

Applied Laboratory Methods Committee
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Subcommittee to the Examination of Milk and Milk Products
Clair Gothard, Chairperson


Subcommittee to Laboratory Methods for the Examination of Food
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