Physical Properties and Microstructure of Cream Cheese

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Some cream cheeses commercially manufactured from fresh cream, whole milk and skim milk powder were examined for quality characteristics such as general composition, physical properties and microstructure. The results obtained were summarized as follows: (1) Average yield of final products was 400 kg per 1000 kg of cheese milk. (2) The mean compositions of all 21 samples were 0.92, 55.68, 33.32, 8.55 and 1.08% in acidity, moisture, fat, protein and ash, respectively. (3) Elastic modulus and adhesiveness of the cream cheese were estimated using 11 and 10 samples, respectively. The former averaged $15.46 \times 10^4$ dyne/cm², the latter $1.21 \times 10^3$ dyne/cm², indicating that these physical properties were liable to variation compared with chemical compositions. (4) Scanning electron microscopy for examining the microstructure of these cream cheeses revealed that remarkable structural changes occurred during cheese making: A part of fat globules was contacted with casein micelle aggregates forming amorphous clumps, while residues of fat globule fragments were fused one another and produced large clusters in every place.

In Japan, natural cheese has been manufactured in a small scale. Recently, soft type natural cheese making has been promoted as a part of the utilization of left-over milk and for the nutritive improvement of people. Under such a social condition in dairy field, cream cheese, one of the soft type cheese, has already been manufactured on a large scale at a district in Japan. The cheese is one of the most popular cheeses in the United States because of its pleasing flavor, body and texture characteristics, and the manufacturing procedure has already been established in detail[1]–[3]. However, no information has been available concerning the properties of cream cheese made in Japan. The purpose of this study was, therefore, an industrial attempt of cream cheese making and the examination of the microstructure as well as the physical properties of the cheese.

Methods

Cheese making

Standardization of cheese milk was accomplished using fresh cream, whole milk and skim milk powder before homogenization and pasteurization. Cream cheese samples were manufactured on 21 separate days from one 1000 kg cheese vat of cheese milk according to appropriate modifications of the normal procedure.

Table 1 Steps in manufacturing cream cheese

<table>
<thead>
<tr>
<th>Manufacturing step</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standardization</td>
<td>Fresh cream, whole milk and skim milk powder</td>
</tr>
<tr>
<td>Homogenization</td>
<td>100 kg/cm²</td>
</tr>
<tr>
<td>Pasteurization</td>
<td>75°C, 15 s</td>
</tr>
<tr>
<td>Starters added</td>
<td>2~3% (Streptococcus lactis and Streptococcus cremoris)</td>
</tr>
<tr>
<td>Setting</td>
<td>23°C, 10 h</td>
</tr>
<tr>
<td>Cutting</td>
<td>(Acidity: 0.9~1.0%)</td>
</tr>
<tr>
<td>Cooking</td>
<td>Added warm water (30°C) and raised the temperature to 57°C</td>
</tr>
<tr>
<td>Pressing</td>
<td>2 h</td>
</tr>
<tr>
<td>Emulsification</td>
<td>80°C, 30 min</td>
</tr>
<tr>
<td>Homogenization</td>
<td>100 kg/cm²</td>
</tr>
<tr>
<td>Filling and packaging</td>
<td>Hot-pack method</td>
</tr>
</tbody>
</table>
cedures as shown in Table 1, and then kept at about 5°C until used for the experiments. Gross compositions (acidity, moisture, fat, protein and ash) for manufactured cheeses were determined according to the normal method.

**Estimation of physical properties**

A block of each cheese sample (1.5 × 1.5 × 2.5 cm) was applied to a rheometer (Sanwa-riken, JK-T 264 type) with an attached plunger according to the procedure described previously for milk rennet curd. Elastic modulus (stress/strain, dyne/cm²) of cream cheese was calculated in the linear range of strain-stress relationship, on the basis of cheese hardness (980 × g dyne, the value given by means of a rheometer as noted above), cross section of plunger (0.1963 cm²), length of cheese sample (2.5 cm) and penetration depth of plunger (0.4807 cm).

For the estimation of adhesiveness, cheese samples were cored into cylinders, 3.0 cm in diameter and 1.0 cm in height, and were compressed with a force of 400 g in a Sanwa-riken JK-T 264 type rheometer. Adhesiveness of cream cheese (dyne/cm²) was calculated from cheese hardness (980 × g dyne, the value given by means of a rheometer), cross section of plunger (3.14 cm²), length of cheese sample (2.5 cm) and penetration depth of plunger (0.4759 cm) as the area of the negative peak beneath the base line of the recorded strain-stress curve.

**Examination of microstructure**

Scanning electron microscopic analysis of cream cheese was carried out by some modifications of the techniques of GLASER et al. and EMMONS et al.: Cheese samples approximately three mm cubes were fixed in 2.5% glutaraldehyde solution for 24 h and postfixed in one % osmium tetroxide solution for 5 h. The samples were then soaked in a series of ethanol-distilled water solutions (50, 60, 70, 80, 90, 95, 100% (v/v) ethanol) as intermediate fluid. Samples were allowed to stay for 10 min in each concentration, dried in a critical point drier, coated with gold in a sputter coater, and examined with a Nippon Denshi JSM-35 C type scanning electron microscope (Nippon Denshi Corporation, Tokyo, Japan) at an accelerating voltage of 15 kv.

**Results and discussion**

**Composition of cheese**

On cream cheese making, cheese milk is generally standardized to yield cheese containing at least 33% fat and not more than 55% moisture. In the present study, the standardization of cheese milk was accomplished in order to make commercial cream cheese containing 33% moisture, 33% fat, 10% protein and 1% ash as a criterion of product constituents. Mean yield of cream cheese manufactured by the usual procedure as shown in Table 1 represented approximately 400 kg with little variation from 1000 kg of cheese milk. General cheese compositions, expressed as percentages of acidity, moisture, fat, protein and ash, were given in Table 2. From results obtained, variation in acidity (coefficient of variation: 6.5%) was somewhat higher than in

<table>
<thead>
<tr>
<th>Item</th>
<th>No. of sample</th>
<th>Max.</th>
<th>Min.</th>
<th>Mean ± S. D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Composition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acidity (%)</td>
<td>21</td>
<td>1.03</td>
<td>0.83</td>
<td>0.92±0.06</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>21</td>
<td>57.89</td>
<td>58.13</td>
<td>55.68±1.33</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>21</td>
<td>35.33</td>
<td>30.34</td>
<td>33.32±1.24</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>21</td>
<td>9.22</td>
<td>8.21</td>
<td>8.59±0.36</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>21</td>
<td>1.13</td>
<td>1.02</td>
<td>1.08±0.04</td>
</tr>
<tr>
<td>Physical property</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elastic modulus ×10⁴ dyne/cm²</td>
<td>11</td>
<td>19.92</td>
<td>8.54</td>
<td>15.46±4.26</td>
</tr>
<tr>
<td>Adhesiveness ×10⁴ dyne/cm²</td>
<td>10</td>
<td>3.00</td>
<td>0.53</td>
<td>1.21±0.83</td>
</tr>
</tbody>
</table>
other cheese compositions, which were from
2.4% in moisture to 4.2% in protein as the
coefficient of variation. In conclusion, the
constituent compositions resulted from 21 cheese
samples were approximately 56% in moisture,
33% in fat, 9% in protein and 1% in ash,
respectively. These values were almost similar
to desired ones.

**Physical properties of cheese**

There are many reasons concerning with food
texture, and one of the principal reasons is to
meet consumer acceptability by proper quality
control of food products10). From this stand-
point, two different parameters, elastic modulus
and adhesiveness, of physical properties were
determined using 11 and 10 cheese samples,
respectively, and the results were also shown
in Table 2. By calculating from these values,
the coefficients of variation were 27.6 and
68.6% for elastic modulus and adhesiveness,
respectively, indicating much more variable
for the latter than the former. Substantial
variations in the physical properties were
eclucitated from these results despite a little
variation in general composition of cream
cheese.

**Microstructure of cheese**

Further detailed investigation concerning the
characteristics of cream cheese was carried out
by means of scanning electron microscopy using
six different samples (Fig. 1). As seen in
Fig. 1A and 1B, fine network in the micro-
structure of cream cheese was observed: Fat
appeared to be distributed by two step of

![Fig. 1 Scanning electron micrographs of cream cheeses](image)

A, B, C, D, E, F: Six different samples: Magnification markers represent 1 μm.
homogenization and one step of emulsification during cheese manufacture, whereas casein micelles may be aggregated into amorphous masses and formed an appreciably heterogenous matrix, which appeared to entrap homogenized fat during various steps of cheese making process. On the other hand, it was shown in Fig. 1C and 1D that a part of the fat globules in the cheese was aggregated into large clusters in places and residues of those were possibly fused with some aggregated casein micelles, forming a somewhat looser or coarser structure than those in Fig. 1A and 1B. Fat and casein areas in the appearance of cream cheese made in this experiment, however, could not be distinguished with certainty at any place by the scanning electron microscopy. Starter bacteria were distinctly seen near the incomplete fusion of casein aggregates as denoted by arrows in Fig. 1A and 1D. Further evidences were provided in Fig. 1E and 1F, in which many big clusters were formed by the collection and fusion of fat globules into large area as compared with those in Fig. 1C and 1D.

The structural changes during cheese making have already found that casein micelles aggregate to form chains and then a network in which fat globules are entrapped. For instance, casein micelles in Cheddar cheese are seen to aggregate into a network, coalesce and finally form a granular mass, whereas fat globules are gradually forced into clumps as a result of shrinkage of the casein network. Curd textures of Cheddar cheese are also shown to be entangled long flexible rods like noodles, and the entanglement of flexible and rod-like casein aggregate is considered to occur after breaking of native casein micelle with renneting followed by curing. GLASER et al. showed for Cottage cheese, one of the soft, unripened cheeses, that casein micelles aggregated into chains, then strands and clusters, and eventually into amorphous masses. However, it was found from the present experiment that the structure in cream cheese was appreciably different as compared with those in above-mentioned cheeses: The markedly heterogeneous structure might be formed at various steps of cheese making because of the fairly large amount of milk fat in cheese milk. Certainly, by means of homogenization, milk fat would be distributed uniformly in the form of small fat globules, and then fat melting and recrystallizing might take place during various processes of cheese making. It was suggested from above-mentioned results that a part of fat globule fragments was contacted with casein micelle network to form the incomplete, amorphous clumps, whereas residues of fat globules were aggregated and fused one another, producing large clusters in place. Variability in microstructure between samples of commercial cream cheese has been observed also by Kalab et al. Large globules of fat were observed occasionally and were attributed to the difference in manufacturing process of cheese. The high ratio of casein to fat in cream cheese could contribute to the increased tendency for coalescence. In order to obtain the more detailed information concerning the formation of structure of cream cheese, it will be necessary to observe cheese curds at different stages during cheese manufacture.

This study was presented at the 29th Annual Meeting of the Japanese Society of Food Science and Technology, Tokyo, April 7, 1982.

References

8) Emmons, D. B., Kalab, M., Larmond, E. and

(Received Oct. 19, 1982)

クレームチーズの物性と微細構造

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フレッシュクリーム、全乳および脱脂粉乳を用いて標準化を行い、工業的規模で製造したクリームチーズについて一般組成、物性および微細構造をしらべた。得られた結果の要点は次のとおりである。

(1) チーズ製造用原料乳1,000 kg 当たりの平均生産量は400 kg であった。(2) 製造した21試料すべての平均組成は、酸度0.92％、水分55.68％、脂肪33.32％、蛋白質8.55％、灰分1.08％であった。(3) 11および10試料のクリームチーズについて弾性率および粘着性を測定した結果、それぞれの平均値は15.46×10^3 サイクロン/cm^2 および1.21×10^2 サイクロン/cm^2 であった。一般組成と比較してかなり大きい変動を示した。(4) 走査型電子顕微鏡によるクリームチーズの微細構造の観察結果から、チーズ製造工程中に著しい構造変化を起こすことが示唆された。脂肪球の一部はケサインミセルの集合体に取り込まれ、不溶性凝集体を形成し、他の脂肪球は互いに融合し、製品の各所に大きい脂肪塊が存在することを認めた。