Textural Study of Double Layered Cheese consisting in a Gouda and Cheddar cheese

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Cutting tests were performed in order to investigate the differences in physical properties between two types of standard cheese produced independently, and composite cheese (consisting of a Gouda side and a Cheddar side) produced using the production processes used for the two types of hard cheese (Gouda cheese and Cheddar cheese). All the cheese types in this study demonstrated a tendency toward softening, with decrease in hardness, cutting strength and cutting energy, as the ripening process advanced. A t-test was performed to compare the measured values of both sides of the composite cheese with their counterpart standard cheeses. The results revealed an increase in the number of measured parameters that exhibited significant differences (P<0.05) between the 60 and 120 days of ripening. Thus the differences in physical properties between the composite cheese and the two types of standard cheese produced independently were confirmed.

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Since each type of hard cheese was produced using a specific method, it was not possible to have two different flavors in one type of hard cheese. We previously reported on the manufacturing method and characteristics of composite cheese which was produced, then, using the following scheme. Initially, the standard method for producing Gouda cheese was used and then, when the process reached the stage of drawing the whey, the curd was divided into two parts; one part was subjected to the Gouda cheese production process, and the other part, to the Cheddar cheese production process. Next, the two different kinds of cheese produced by the Gouda and Cheddar cheese production processes were layered, without mixing, before ripening. Finally, the two-layered cheese was ripened as a composite cheese (consisting of a Gouda side and a Cheddar side). In this composite cheese \( \alpha_s \) casein generally decomposed faster than \( \beta \) casein, and was converted to \( \alpha_s \) I-casein as in a type of hard cheese, and the taste and aroma of both Gouda and Cheddar cheeses remained, thus demonstrating the possibility of producing a unique hard type of cheese. We also reported that electrostatic interactions, hydrophobic interactions, hydrogen bond and disulfide bond interactions within protein molecules or between protein molecules were weak, and confirmed the differences in peptide and enzyme activities during ripening by a migration graph obtained by using two-dimensional electrophoresis.

In general, cheese is allowed to ripen for several months in a special room in which low temperature and high humidity are maintained. The structural flexibility of cheese decreases as ripening advances. There are many reports on the physical properties of cheese during theripening process.

In this report, we studied the differences in
physical properties in the composite cheese consisting of two hard cheeses and in individual cheeses, Gouda or Cheddar cheese, by cutting tests during ripening.

Materials and Methods

1. Sample

In this experiment, Gouda cheese and Cheddar cheese, used as standard cheeses, were produced by the method described in our previous report\(^1\). Composite cheese was produced by the method shown in Fig.1.

2. Chemical analysis

Quantitative analysis of moisture, protein, fat, ash and lactose was performed using conventional methods\(^9\), and chemical analysis of watersoluble total nitrogen, total nitrogen, non-protein nitrogen and pH was performed according to the previously described methods\(^1\).

3. Measurement of the physical properties

We measured the physical properties of the cheese samples using the Fudoh Rheometer (RT-3005D, Rheotech). The central sections of the Gouda standard cheese, Cheddar standard cheese, and the Gouda and Cheddar sides of composite cheese were cut into samples measuring 2 cm × 3 cm × 1 cm. Cutting tests on the cheese samples were performed using an adapter No. 30 with a 500 g range, 30 cm/min measurement speed and 30 cm/min sweep speed as shown in Fig. 2. The measured parameters were hardness, cutting strength and cutting energy as shown in Fig. 3. All measurements were performed at room temperature.

Fig. 1 Manufacturing procedure of the composite cheese. Chemical composition of raw milk: fat 3.8%, solid not fat 8.72%, specific gravity 1.0325, acidity 0.135. Composite cheese size: 20 cm × 30 cm × 8 cm.

Fig. 2 Exclusive adapter of the Rheometer

Fig. 3 The measured parameters of the cutting test
temperature. A Rheoploter (TR-801, Rheotech) was used for the analysis.

4. Statistical treatment

A JUSE-QCAS (version 2.0, JUSE CO., Ltd., Tokyo) of personal computer program was used for the analysis (t-test).

Results and discussion

First, we conducted a general analysis of the composite cheese and the two types of standard cheese after 120 days of ripening. As shown in Table 1, the Gouda side of the composite cheese consisted of 40.0% moisture, 26.0% protein, 30.8% fat, 1.8% ash and 1.2% lactose. The Cheddar side of the composite cheese consisted of 39.8% water, 21.8% protein, 34.5% fat, 1.8% ash and 1.1% lactose. When the compositions of the Gouda and Cheddar sides in a composite cheese were compared with those of the two types of standard cheese, no significant differences were observed. However, a slightly higher fat content was noted in all samples from the composite cheese than that reported previously by others, which may be attributed to using nonadjusted raw milk in the composite cheese.

Table 1 Chemical composition of the Experimental Cheeses, ripening for 120 days (Average, n=2 to 5)

<table>
<thead>
<tr>
<th>Term</th>
<th>Standard cheese</th>
<th>Composite cheese</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gouda</td>
<td>Cheddar</td>
</tr>
<tr>
<td>Moisture (g/100g)</td>
<td>39.5</td>
<td>39.1</td>
</tr>
<tr>
<td>Protein (g/100g)</td>
<td>26.8</td>
<td>23.0</td>
</tr>
<tr>
<td>Fat (g/100g)</td>
<td>30.6</td>
<td>34.8</td>
</tr>
<tr>
<td>Ash (g/100g)</td>
<td>1.8</td>
<td>1.9</td>
</tr>
<tr>
<td>Lactose (g/100g)</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Ripening degree (%)</td>
<td>27.0</td>
<td>28.0</td>
</tr>
<tr>
<td>NPN/Total N (%)</td>
<td>20.7</td>
<td>22.5</td>
</tr>
<tr>
<td>pH</td>
<td>5.31</td>
<td>5.15</td>
</tr>
</tbody>
</table>


Table 2 Changes of cutting test in the textures during ripening of the Composite cheese of the Gouda side and standard Gouda cheese (Average, n=5)

<table>
<thead>
<tr>
<th>Physical property</th>
<th>Gouda</th>
<th>Gouda side</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>Hardness (g)</td>
<td>257</td>
<td>241</td>
</tr>
<tr>
<td>Cutting strength (g/cm²)</td>
<td>32</td>
<td>29</td>
</tr>
<tr>
<td>Cutting energy (erg/cm²)</td>
<td>30503</td>
<td>28315</td>
</tr>
</tbody>
</table>

* is recognized with the t-test of significant at 5% level.

Table 3 Changes of cutting test in the textures during ripening of the Composite cheese of the Cheddar side and standard Cheddar cheese (Average, n=5)

<table>
<thead>
<tr>
<th>Physical property</th>
<th>Cheddar</th>
<th>Cheddar side</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>Hardness (g)</td>
<td>360</td>
<td>274</td>
</tr>
<tr>
<td>Cutting strength (g/cm²)</td>
<td>45</td>
<td>34</td>
</tr>
<tr>
<td>Cutting energy (erg/cm²)</td>
<td>33067</td>
<td>25706</td>
</tr>
</tbody>
</table>

* is recognized with the t-test of significant at 5% level.
cheese production process. Secondly, cutting tests using the Rheometer were performed after confirmation by chemical analysis that standard ripening had occurred. As shown in Table 2 and Table 3, the hardness, cutting strength and cutting energy show a tendency to decrease as the ripening process advanced. The hardness, cutting strength and cutting energy of the Gouda side in a composite cheese were 256 g ~ 135 g, 32 g / cm$^2$ ~ 16 g / cm$^2$, 30213 erg / cm$^2$ ~ 12828 erg / cm$^2$, respectively. The hardness, cutting strength and cutting energy of the Cheddar side in a composite cheese were 357 g ~ 141 g, 45 g / cm$^2$ ~ 17 g / cm$^2$, 32918 erg / cm$^2$ ~ 13008 erg / cm$^2$, respectively. CREAMER et al. have reported that a cheese curd lost flexibility and plasticity during the Cheddar cheese decomposition process$^{11)}$. Consistent with this report, in this study, we demonstrated that the composite cheese physically softened, as indicated by the decrease in hardness, cutting strength and cutting energy. GRAPPIN et al. have reported that the proteins are cleaved at various sites during ripening and the protein network loses part of its original structure, which alters the rheological properties of cheese$^{12)}$. A t- test was performed to compare the physical characteristics of the composite cheese with those of the two types of standard cheese. The results revealed significant differences (P < 0.05) in hardness between the Gouda side of the composite cheese and the Gouda standard cheese at 30, 60 and 120 days of ripening, and in cutting energy at 30, 60, 90 and 120 days of ripening. Significant differences (P < 0.05) in hardness and cutting strength were also observed between the Cheddar side of the composite cheese and in the Cheddar standard cheese at 60, 90 and 120 days of ripening, and in cutting energy at 60 and 120 days of ripening. It was considered that the differences (P <0.05) in texture were related to the differences in both water soluble-nitrogen content and non-protein-nitrogen content of the casein solution in the cheese$^{11)}$, and peptide formation$^{21)}$ because no difference was noted by the chemical composition analysis.

These results, which were obtained by cutting tests using the Rheometer, indicated that the hardness, cutting strength and cutting energy decreased as the ripening process advanced in both the Gouda and Cheddar sides of the composite cheese. Moreover the differences in the values of these physical parameters in the composite cheese compared with that in their counterpart standard cheeses were found to increase significantly (P < 0.05) during the latter half of the ripening period, because of its different ripening process.

We are currently studying the joint of the Gouda side and Cheddar side of the composite cheese in detail.

References
12) GRAPPIN, R., RANK, T. C. and Olson, N. F.:
   J. Dairy Sci., 68, 531 (1985)

ゴーダチーズ並びにチェダーチーズを2層に積層して
熟成させた複合型チーズのテクスチャーについて

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一般的にチーズは、それぞれのチーズが特有な製法で
製造されており、その結果、その品種に特有な組織およ
び芳香を持ったチーズが出来上がる。著者らは、ゴーダチーズ製造行程の中で、ホエー排除以降を2つの
工程に分けた。すなわち、1つをゴーダチーズ工程へ、
他をチェダーチーズ工程へと移行させ、熟成前に2種
類のカードを混合することなく重ね合わせて複合型
（ゴーダ側とチェダーチーズ）チーズに形成し、単独で製
造したチーズとの相違を追求している。本稿では、こ
の2種類の硬質系チーズの製法を重ね合わせて製造し
た複合型チーズの物性の相違を調べる目的で、レオメ
ーターを使用して切断試験の強度、切断強度および切
断エネルギーの測定を行った。切断試験の各項目は、
熟成の進行と共に減少した。また、複合型チーズの両
側チーズは、各コントロールチーズと比較して熟成60
日目から120日目において有意（P<0.05）を示す試
験項目が増加し、複合型チーズとして熟成させた為に
特有な発酵過程をたどることによって単独で製造した
チーズと相違する物性を示すことが分かった。
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