Effects of Konjac Mannan Addition on the Properties of Pound Cakes

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Konjac mannan absorbs large amounts of water and forms gels that can be used in various processed foods. Moreover, it is a very interesting saccharide in that it is not decomposed by enzymes in the human body. However, few foods contain Konjac mannan. In this study, compared with control pound cakes, which contain soft wheat flour, egg, butter and sugar in a ratio of 1:1:0.75:0.75, the use of Konjac mannan gel in place of butter was examined. With 50% Konjac mannan substituted for butter (batter A), adequate physical properties and taste were obtained by increasing the amount of B.P. added to 3-4% of the weight of the wheat flour. Compared with the 28.9% water content of the control batter, the water content of batter A was 39.0%. Therefore, every batter in this study was controlled to have a water content of 39.0%. Batter B consisted of 25% Konjac mannan and water, batter C contained equal amounts of Konjac mannan and egg white, and batter D only contained egg white; all yielded preferable pound cakes by increasing the amount of B.P. added to 3-4% of the weight of the wheat flour. The degrees of caloric intake suppression were about 21, 17, 14 and 14% for A, B, C and D, respectively.

Keywords: Konjac mannan, pound cake, taste evaluation, calorie intake suppression, butter substitution

Confectionaries containing plenty of butter and sugar, such as pound cakes, are popular because of their delicious taste. However, as they are high in fat and oil, they are high in calories. Therefore, to decrease their calorie content, the use of various new saccharide sweeteners, instead of sugar, has been examined. We studied the effects of sweeteners on the properties of sponge cakes (Ichikawa & Mitsumura, 1996). Maltose or lactose could replace half of the sugar in the cakes, and the cake maintained both its physical properties and good taste. On the other hand, as butter is higher in calories per gram than any other material in the cake, the use of some low-calorie materials instead of butter would help decrease caloric intake.

Konjac mannan (Masuda, 1988; Shimizu, 1993) cannot be decomposed by human digestive enzymes, unlike starch, so it passes through the digestive system and has little effect on the caloric intake. Also of interest is its ability to suppress increases in cholesterol and neutral fat levels. This polysaccharide has recently entered the market as a food processing aid in jelly (Niwa et al., 1992; Nozaki & Sakurai, 1993), pork sausages (Osburn & Keeton, 1994) and beef patties, and it is used instead of fat. One group examined the effects of Konjac mannan or dietary fiber on bread (Pomeranz et al., 1977; Nagai et al., 1980; Nozaki & Sakurai, 1990) and muffin (Hippleheuser et al., 1995), but there have been few reports on its effects on pound cakes.

In this study, we examined the use of Konjac mannan gel instead of butter in pound cakes, and the appropriate conditions for keeping both good physical properties and a good taste.

Materials and Methods

Materials  “Violet” wheat flour from Nisshin Flour Milling Co., Ltd., Tokyo (a high-grade soft wheat flour; 14.5% moisture, 7.6% crude protein, and 0.32% ash) was used. Salt-free (14.5% moisture) (Yukijirushi Nyugyo Co., Ltd., Tokyo) butter was purchased. We used super purified sucrose (Spoon Brand from Taito Co., Ltd., Tokyo). Fresh eggs, with an egg yolk factor of 0.33-0.41, were purchased at the market. Konjac mannan gel was prepared by adding 30 times the weight of water to one weight of glucomannan powder (Kibun Food Co., Ltd., Tokyo).

Compounding of the materials  Among the 4 main components, egg, soft wheat flour, butter, and sugar used in the cakes, the weight ratio of these compound was 1:1:0.75:0.75, respectively. The amount of B.P. used was 1.5% of the soft wheat flour weight. Preparation of cake batter is shown in Fig. 1.

After the butter was softened and whipped, 75% of the total sugar was added and whipped. Konjac mannan in the gel state was added to this batter. To control the water content of the batter, water was added with soft wheat flour during the last stage.

The cake batter, 350 g, was poured into a stainless pan (7x16.5x6 cm) and baked at 170°C for 30 min.

The amounts of Konjac mannan and B.P. added: From the preliminary experiment on the amount of Konjac mannan substituted for butter in the cakes, the following results were obtained: with 75% Konjac mannan substituted, the cake looked like a rice cake and had no bubble when examined in cross section. Therefore, cakes with 25% and 50% Konjac mannan substituted were prepared. Similarly, the
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suitable amounts of B.P. added were within the range of 1.5 to 5.0% of the wheat flour weight.

The water content of the cake batter: Compared with the control cake batter (28.9%), the water content of batter A, in which 50% of the butter had been substituted with Konjac mannan, was 39.0%. Therefore, every sample batter in this study (from A to E), was controlled to have a 39.0% water content by the addition of water or egg whites.

These samples were named as follows: Batter A with 50% Konjac mannan substituted for butter, B with 25% substituted and water was added to control the water content, C with 25% substituted and egg whites were added to control the water content, D only with egg whites added to control the water content, and E only with water added. The weight component ratio of the control and samples A–E is shown in Table 1. All samples were prepared by the method outlined in Fig. 1, and the following properties were measured.

Specific gravity Specific gravity of the cake batter was calculated by dividing the cake batter’s weight by the weight of the same volume of water.

Water content Water content of each baked cake was measured using a Shimadzu Electric Water Content Meter (Shimadzu Co., Tokyo, EB-280-MOC).

Loaf volume The loaf volume of the cake was measured by the rapeseed displacement method 30 min after taking the cake out of the oven.

Texture measurement The samples were prepared by means of an Ultrasonic Sample-Cutter (Yamaden Co., Tokyo, USC-3305). The use of this cutter decreased the resistance on cutting soft materials, such as a sponge cake, to obtain samples with uniform size desired for rheological measurements (Yamano et al., 1991). At first samples (1.0 cm) were cut from the base of the cake, and then (1.5 cm) from the upper section by the USC cutter. The cake was then cut into 3.0×3.0 cm cubes. The texture meter (Yamaden Co., Reometer RE-3305-01) was used to determine the hardness and cohesiveness of the crumbs. The measurement parameters were a 16 mm*16 mm Lucite plunger, a 2-kg load, and 20% clearance.

Color measurement The color of the crumbs was measured by a Japan Densyoku (Tokyo) Color Difference Meter (Z-1001DP) to determine L, a, and b values, and the ΔE value was calculated from these values. The appearances of the cake were copied.

Taste evaluation of the cakes Fifteen students from a food science course at Otsuka Women’s University were chosen for the taste evaluation. Taste evaluation was given a score by the paired-comparisons method. The cakes were evaluated on a scale of (+3) to (−3) for hardness, hardness preference, texture, brittleness, brittleness preference, and as overall preference by the panelists.

Results Specific gravity The effects of Konjac mannan and egg white on the specific gravity are shown in Fig. 2. The specific gravity of the control was 0.86. As the substituted ratio of butter to Konjac mannan increased, the specific gravity value tended to increase to between 0.90 and 1.10. In spite of having a higher water content than the control and an increased amount of B.P., the specific gravity value of cake batter D, which was substituted with only egg whites was still slightly low.

Moisture content The addition of B.P. had little effect on the moisture content of baked pound cakes in all cases (Fig. 3). The control value was 27.4%, which was lower than the content in batter E, which only contained B.P. and water.

<table>
<thead>
<tr>
<th>Component</th>
<th>Control</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Egg yolk</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Egg white</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>130.8</td>
<td>158.2</td>
<td>80</td>
</tr>
<tr>
<td>Sugar</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Butter</td>
<td>90</td>
<td>45</td>
<td>67.5</td>
<td>67.5</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Konjac</td>
<td>—</td>
<td>45</td>
<td>22.5</td>
<td>22.5</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Water</td>
<td>—</td>
<td>35.9</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>68.9</td>
</tr>
<tr>
<td>B.P.</td>
<td>1.8</td>
<td>1.8-5.4</td>
<td>1.8-5.4</td>
<td>1.8-5.4</td>
<td>1.8-5.4</td>
<td>1.8-5.4</td>
</tr>
</tbody>
</table>

Fig. 1. Preparation of the cake batter.

Fig. 2. The specific gravity of various kinds of cake batter.
to control the water content and had a maximum value of about 38%. Batter D, in which the water content was substituted with egg whites, had a moisture content of about 37%. Batters A to C had moisture values of about 34.5-36.5%, which meant that about 2.5-4.5% of the water content evaporated during baking. The amount of water that evaporated during baking was increased by the addition of Konjac mannan.

**Specific volume** Different amounts of B.P. in every cake containing Konjac mannan affect the cake volume (A to E) (Fig. 4). Among them, the most remarkable variation in volume was observed when B.P. was added to batter A. In batter C, because of the synergistic effects of Konjac mannan and egg whites, the specific volume became constant when 3.5% B.P. was added, and no further increase in volume was observed by the addition of B.P. Batter E, which contains only B.P. and water to control the water content, did not yield sufficient loaf volume. Because of these results, the following items were compared from A to D.

**Hardness** The hardness of every sample (A-D), which was measured by a rheometer, showed higher values than the controls (Table 2). When the amount of B.P. added was increased, the hardness value decreased, but cakes had a tendency to be soft at the same time.

When Konjac mannan was used as a butter substitute, the amount of B.P. used had little effect on the hardness of the cake. When the water content was adjusted with egg white, such as in batter C, the hardness value was slightly higher. As the amount of B.P. was increased, these differences became smaller. The hardness value of the control was 3.94×10^4 (N/m²), and each sample, from A to D, baked with 3% B.P. had a value close to the control value.

**Cohesiveness** The cake crumbs tended to have higher cohesive values, except sample B, than the control; this value increased as the amount of B.P. was increased (Table 1). Increased cohesiveness is related to increased addition of B.P. We initially thought that this was caused by the addition of egg whites. The best fit value for batter B, which was 0.54 of the control one, occurred when the amount of B.P. was between 3.5 and 4.5%.

**Color evaluation (measurement)** Color measurements were made in the longitudinal section of the center of the baked cakes, and the L values are shown in Fig. 5. All the samples generally had lower values than the control, especially when only a small amount of B.P. was used. The ΔE values are shown in Fig. 6. A, which contains a lot of Konjac mannan, had a high ΔE value (=from 3.0 to 4.0), whereas, B, C and D had high values when 1.5% B.P. was added. ΔE values of about 2.0 (=slight, trace) and under were found when at least 3% B.P. was used. It seems that the crumb color

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**Table 2.** The hardness and cohesiveness values of various kinds of cakes.

<table>
<thead>
<tr>
<th>Amount of B.P. (%)</th>
<th>1.5</th>
<th>3.0</th>
<th>3.5</th>
<th>4.0</th>
<th>4.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3.94±0.34</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>4.98±0.22</td>
<td>3.57±0.10</td>
<td>2.92±0.16</td>
<td>2.54±0.12</td>
<td>2.38±0.33</td>
</tr>
<tr>
<td>B</td>
<td>4.12±0.30</td>
<td>3.54±0.17</td>
<td>2.75±0.07</td>
<td>2.27±0.19</td>
<td>2.35±0.21</td>
</tr>
<tr>
<td>C</td>
<td>5.00±0.06</td>
<td>3.66±0.34</td>
<td>2.68±0.18</td>
<td>2.78±0.29</td>
<td>2.50±0.23</td>
</tr>
<tr>
<td>D</td>
<td>5.42±0.32</td>
<td>3.42±0.31</td>
<td>3.33±0.51</td>
<td>2.95±0.17</td>
<td>2.30±0.23</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.38±0.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.17±0.09</td>
<td>5.61±0.27</td>
<td>5.76±0.15</td>
<td>6.17±0.17</td>
<td>5.96±0.24</td>
</tr>
<tr>
<td></td>
<td>3.50±0.59</td>
<td>5.59±0.22</td>
<td>5.18±0.38</td>
<td>5.29±0.20</td>
<td>5.29±0.35</td>
</tr>
<tr>
<td></td>
<td>5.59±0.24</td>
<td>6.59±0.13</td>
<td>6.28±0.34</td>
<td>6.45±0.17</td>
<td>6.75±0.07</td>
</tr>
<tr>
<td></td>
<td>6.25±0.17</td>
<td>6.81±0.02</td>
<td>6.71±0.12</td>
<td>6.78±0.07</td>
<td>6.89±0.06</td>
</tr>
</tbody>
</table>

- **A:** 50% of the butter substituted with Konjac mannan.
- **B:** 25% of the butter substituted with Konjac mannan and water was added.
- **C:** 25% of the butter substituted with Konjac mannan and egg whites was added.
- **D:** control with egg whites added.
of the baked cakes was affected by the grayish color of Konjac mannan and the amount of B.P. added.

Figure 7 shows the appearance of the crumb structure of A, B, C, and D compared to the control and different amounts of B.P.

Taste Results from samples of A and B with 50% and 25% Konjac mannan substituted for butter, respectively, are shown in Fig. 8 and Fig. 9, respectively, and they are compared with the control samples, which contain different amounts of B.P., by the paired-comparison method.

The degree of hardness decreased with the amount of B.P. added above 1.5% of the total weight of the cake in both A and B, and those with about 3.5% B.P. added were preferred. These results agreed with the hardness values measured by the texturometer. The textures of the cakes gave them a rougher feeling on the tongue when larger amounts of B.P. were added; also the degrees of brittleness were highest in these cakes. Batters A and B containing about 3.5% and 4.0% B.P. gave the best cakes. The difference between A and B is probably due to the large amounts of B.P. added to B in order to maintain sufficient loaf volume.

Further evaluations were performed on the most preferred samples of A and B previously mentioned, and on samples of C with 4.0% B.P., and D with 3.5% B.P. These were compared to the control sample containing no Konjac mannan. The
results are shown in Fig. 10. The hardness of samples A and D were approximately the same as in the control sample. Samples B and C containing egg white were harder. But little difference was found in the preference for either of them. Though D was less brittle, all the other properties were similar to those of the control.

**Discussion**

The use of water-absorptive Konjac mannan gel in place of water evaporated during baking. Because of the lower air content of the batter with Konjac mannan gel may be the source of such an effect.

On the moisture content of baked cakes, the addition of Konjac mannan had the effect of increasing the volume increase of the cake baked from the batter with Konjac mannan gel as already mentioned, water in the batter should be allowed to evaporate more easily than when added with water or egg whites only. The specific volume of the cake significantly decreased with the increase in the water content of the batter. By the addition of Konjac mannan or egg whites, the degree of volume decrease became a little smaller, but preferably the addition of B.P. yielded sufficient cake volume. These results suggest that the interaction of B.P. with Konjac mannan or egg whites had an effect on the volume increase of the cake baked from the batter with the higher water content.

As for the texture of the cake, the addition of B.P. also showed a remarkable effect on the hardness and cohesiveness. On the other hand, the addition of Konjac mannan showed a tendency to increase the hardness, which may be due to a relationship to the Konjac mannan gel structure.

The taste of cakes with Konjac mannan became preferable by similarly controlling the addition of B.P. which improved the hardness, brittleness, and so on.

Furthermore because of the moisture-keeping capacity of Konjac mannan, a cake could be obtained with a gentle feel to the mouth.

As previously mentioned, pound cakes with both adequate physical properties and a good taste could be obtained when B.P. 3–4% of the weight of wheat flour was added to a batter containing Konjac mannan and egg white.

In this study, the effect of Konjac mannan on the calorie content of pound cakes as well as its physical effects were investigated. We found that a preferable cake volume with a low caloric value was achieved when egg whites were substituted for butter, and 3.5 to 4.0% B.P. was added. The degree of energy intake suppression was about 21, 17, 14 and 14% for batters A, B, C and D, respectively.

**Acknowledgments**

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**References**


