Cooking Methods for a Soft Diet Using Chicken Based on Food Texture Analysis

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Summary Undernutrition caused by difficulties in masticating is of growing concern among the elderly. Soft diets are often served at nursing homes; however, the styles differ with nursing homes. Improperly modified food texture and consistency may lead to further loss of nutritive value. Therefore, we developed a method to produce a soft diet using chicken. The texture-modified chicken was prepared by boiling a mixture of minced chicken and additive foodstuff that softened the meat. The best food additive was determined through testing cooking process, size after modification and texture. The optimum proportions of each component in the mixture were determined measuring food texture using a creep meter. Teriyaki chicken was cooked using the texture-modified chicken, and provided to a nursing home. The amount of food intake by elderly residents was subsequently surveyed. This study involved 22 residents (1 man and 21 women; mean age 91.4 ± 5.3 y). Consequently, yakifū, which was made from wheat gluten, was the most suitable additive foodstuff. The hardness of the texture-modified chicken, with proportions of minced chicken, yakifū, and water being 50%, 10%, and 40% respectively, was under 40,000 N/m2. The intake amount of the texture-modified chicken of subjects whose intake amount of conventional chicken using chicken thigh was not 100% was significantly higher. These findings suggest that properly modified food textures could contribute to improve the quality of meals by preventing undernutrition among the elderly with mastication difficulties.

Key Words soft diet, food texture, elderly, intake amount

The average life expectancy of the Japanese population is increasing. According to the 2010 complete life table, men and women live, on average, until the age of 79.59 and 86.35 y, respectively (1). However, the healthy life expectancy of men being 70.42 y and women 73.62 y (2), we can consider that Japanese men and women live with physical limitations for about 9 and 13 y, respectively. The number of people certified for long-term care and support in 2013 was 5.64 million in the Long-Term Care Insurance business (3). With the number of certifications for long-term care constantly increasing with the growing elderly population, it becomes difficult to sustain both the medical and long-term care insurance systems. Therefore, it is important to enhance the healthy life expectancy.

Many elderly use dentures due to the loss of their teeth (4). Incompatible dentures, muscle weakness, and stomatitis cause a decrease in masticatory strength. Weak masticatory strength causes difficulties in eating ordinary diets, resulting in a decreased intake amount and undernutrition (5). Consequently, decline of muscle strength leads to a need for long-term care and support.

In many nursing homes, residents who have difficulties in eating ordinary diets are provided with a soft diet (6–8). However, it has been reported that many nursing homes provide diets following their own standards (9). Since the dysphagia diet committee of the Japanese Society of Dysphagia Rehabilitation introduced the Japanese Dysphagia Diet 2013 (10), standardization of a soft diet has been proceeding in Japan. But this criterion shows properties of the soft diet only with words. To evaluate the texture adequacy of a soft diet objectively, a physical measurement method is necessary. The Dysphagia Diets Pyramid (11) is a well-known physical assessment method for food texture. Therefore, we referred the Dysphagia Diets Pyramid in this study. It is classified into six steps: the diet composed of jelly with less than 2 g of protein per 100 g of food used to start rehabilitation of dysphagia patients who suffered a stroke (L0), the diets consisting of jelly, pudding or mousse containing protein (L1, L2), the diet made of puree or paste (L3), soft

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Soft Diet Based on Food Texture

differences in protein content of the texture-modified chicken with 70 g of chicken thigh before the experiment, soy powder, freeze-dried tofu and yakifu could not be mixed with minced chicken as planned. Thus, water was necessary to mix soy powder, freeze-dried tofu and yakifu with chicken. When the additive foodstuff soaked with water was added to minced chicken, we focused on softening the texture-modified chicken. Consequently, the added weight of each foodstuff is shown in Table 1.

Test method for additive foodstuff (Table 1): The cooking processes of the samples were evaluated subjectively from very easy “++”, to difficult “-”. We also assessed the size of the texture-modified chicken containing the same amount of protein as conventional teriyaki chicken obtained when using 70 g of chicken thigh. We compared the samples visually. A sample that was as small as the conventional teriyaki chicken was evaluated “+++”, and one that was too large for one portion was evaluated “-”. Texture was also judged by eating the samples. A sample much softer than the conventional teriyaki chicken was evaluated “++”, whereas one too hard was evaluated “-”. “++” was used as an intermediate appreciation between “+++” and “-”. These tests were carried out and discussed by four researchers.

Test method for proportions in the texture-modified chicken using yakifu: We decided that yakifu was the most suitable additive foodstuff. Then we studied proportions of minced chicken, yakifu, and water in the texture-modified chicken. To determine the proportions used in the samples undergoing texture measurements, the triangular diagram (Fig. 1) was used. An optional point on the triangular diagram shows the proportions

![Fig. 1. Triangular diagram of three ingredients. The solid line, dotted line, and broken line show the proportion of minced chicken, yakifu, and water respectively.](Image)

**METHODS**

**Study of additive foodstuff and proportions for texture-modified chicken.**

Preparation of samples: We used chicken breast for texture-modified meat, because chicken breast contained more protein than chicken thigh. Chicken breast with skin and fat removed was used in this study. About 80 g of 25 mm-cut chicken was ground for 45 s using the food processor MK-K81 (Panasonic) in rough mode. We tested five types of foodstuffs: canned soy beans, soy powder, tofu, freeze-dried tofu, and “yakifu,” all of them commercially available. Canned soy beans were ground using the food processor in high-speed mode and strained to remove the skin. Water was removed from some of the tofu. To do so, 100 g of tofu was wrapped in kitchen paper and compressed with a 260-g weight for 30 min. As a result, the weight of the tofu became 70 g. The freeze-dried tofu was grated. Yakifu was ground using the food processor in high-speed mode. Minced chicken and the additive foodstuff were mixed, divided in 10-g samples, and boiled for 5 min, ensuring they spent 1 min above 75˚C. Even though we decided the amount of each foodstuff that was added to 30 g of minced chicken to equalize the protein content of texture-modified chicken with 70 g of chicken thigh before the experiment, soy powder, freeze-dried tofu and yakifu could not be mixed with minced chicken as planned. Thus, water was necessary to mix soy powder, freeze-dried tofu and yakifu with chicken. When the additive foodstuff soaked with water was added to minced chicken, we focused on softening the texture-modified chicken. Consequently, the added weight of each foodstuff is shown in Table 1.

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**Fig. 1. Triangular diagram of three ingredients. The solid line, dotted line, and broken line show the proportion of minced chicken, yakifu, and water respectively.**

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of minced chicken, yakifu, and water used. Solid lines, dotted lines and broken lines show the weight percentages of minced chicken, yakifu, and water, respectively. In the case of yakifu/water $>1/2$, yakifu could not be soaked in water in the preliminary study; this area was thus omitted. With yakifu/water $<1/6$, water was too abundant to allow chicken cut-like forms; thus, this area was also omitted. Moreover, when minced chicken contents were lower than 30%, the meat taste could not be detected; this area was consequently omitted. We created seven samples for which we measured textures, where minced chicken, yakifu, and water contents were (a) 30%, 10%, 60%, (b) 40%, 10%, 50%, (c) 50%, 10%, 40%, (d) 60%, 10%, 30%, (e) 70%, 10%, 20%, (f) 30%, 20%, 50%, and (g) 40%, 20%, 40%, respectively.

Texture measurement: The texture measurement method was based on the Dysphagia Diets Pyramid. Samples were packed into a laboratory stainless dish with a diameter of 40 mm and depth of 15 mm. A 20-mm diameter cylindrical plunger was then plunged into the samples. The samples were kept at 20 $\pm$ 2 $^\circ$C, a 20 N load cell was used, the distortion factor was 66.67%, and the plunging rate was 1 mm/s. Hardness was calculated from the highest point on the texture curve. Each measurement was repeated five times, the highest and the lowest values were omitted, and the average was calculated using the remaining three values.

The hardness of sample (b) was under 40,000 N/m$^2$, and that of sample (c) was near 40,000 N/m$^2$ (Table 2). We measured the hardness of sample (b) and (c) after stewing in soup containing soy sauce, mirin-like seasoning, cooking sake, sugar and water to decide the proportion of texture-modified chicken to provide. Each measurement was repeated two times, and the average was calculated.

Providing meals and survey of intake amount.

Survey dates and subjects: Surveys were conducted by researchers at a nursing home in Kyoto twice in the month of November 2014. We provided teriyaki chicken for lunch using the texture-modified chicken on the first survey date (9 November), and the conventional chicken thigh on the second survey date (17 November) as a soft diet. All the other dishes were kept unchanged.

The subjects were composed of 22 residents (1 man and 21 women; mean age 91.4 $\pm$ 5.3 y). They did not need assistance for eating. We confirmed subjects did not have wheat allergy prior to the study. The type of diet assigned to each resident was determined based on their eating status, their own requests and observations made after admission by the medical doctor, the physical therapist, the occupational therapist, the nurse and the registered diettitian of the facility. This study was approved by the Ethics Committee of Doshisha Women's College of Liberal Arts (No. 56), and the study was conducted in accordance with the principles of the Declaration of Helsinki.

Cooking method of the conventional teriyaki chicken (one serving): Seventy grams of chicken thigh was cut into bite-size chunks and baked with 2 g of salad oil. It was then introduced into a pressure cooker along with 5 g of soy sauce, 3 g of mirin-like seasoning, 2 g of cooking sake, 1 g of sugar, and water in which all foodstuff was immersed and stewed. A mixture of 2 g of starch and 2 g of water was subsequently added into the cooker to thicken the soup. We prepared 45 servings.

Cooking method of teriyaki chicken using the texture-modified chicken (one serving): Thirty-seven grams of water, 0.5 g of ginger juice and 1 g of soy sauce were added to 9 g of ground yakifu. Then 46 g of minced chicken breast was added to them and mixed. The mixture was divided into three parts, which were shaped like chicken cuts and boiled for 5 min. These texture-modified chicken portions were put into a pot with 4 g of soy sauce, 3 g of mirin-like seasoning, 2 g of cooking sake, 1 g of sugar and water in which all foodstuff was immersed and stewed. A mixture of 2 g of starch and 2 g of water was subsequently added into the cooker to thicken the soup. We prepared 45 servings.

Texture measurement: A sample of the meal provided in the nursing home was brought back to the laboratory with refrigerant packs and the texture was measured within 4 h. The measurement method was the same as mentioned above. Each measurement was repeated five times, the highest and the lowest values were omitted, and the average was calculated using the remaining three values.

Measurement method of intake amount: During the preparation of tray service, the texture-modified chicken and the chicken thigh of the main dishes were weighed; three servings of texture-modified chicken or chicken thigh were picked from the dish and weighed, their average weight was then treated as one serving. When the subject left some texture-modified or chicken thigh, the leftovers were weighed and deducted from the total weight of served chicken. The resulting value was treated as the intake amount. The intake rate was calculated by dividing the intake amount by the amount served.

Nutritional value calculation: Nutritional values were calculated using the sixth edition of the Japanese Standard Tables of Food Composition.

Data analysis: We used the data of 10 subjects whose intake rate of the conventional chicken thigh was not 100%. The Wilcoxon rank sum test was carried out using IBM SPSS Statistics v22.0.

RESULTS

Study on additive foodstuff (Table 1)

We carried out preliminary studies to decide which additive foodstuff to use for softening chicken. We prepared five type of the foodstuff: canned soy beans, soy powder, tofu, freeze-dried tofu and yakifu. When using canned soy beans, removing the thin skin was a difficult task. The taste of soy was too strong to sense a chicken taste from the texture-modified chicken using soy powder. Tofu contains too much water. Even after water was removed from the tofu, the size of the texture-modified chicken was much bigger than that of the conventional chicken. The texture-modified chicken using freeze-dried tofu was too hard to provide a suitable soft diet.
The texture-modified chicken with added yakifu and water received a good evaluation in terms of cooking process, size after modification and texture.

**Study of proportions in the texture-modified chicken using yakifu**

Table 2 shows the hardness of the samples determined by texture measurements. Even though sample (b) was the only sample with hardness lower than 40,000 N/m² after boiling for 2 min, the hardness of sample (c) dropped to 25,100 N/m² after stewing in a seasoning soup. We detected a stronger meat taste in sample (c), which contained more minced chicken than sample (b). Consequently, the proportions of the sample that was provided in the nursing home were 50% minced chicken, 10% yakifu, and 40% water. The hardness of the provided texture-modified chicken was 28,000 N/m². The hardness of the teriyaki chicken thigh was 63,000 N/m², hence higher than the upper limit of the measurement in these conditions.

**Nutritional value**

Table 3 shows the energy, protein, fat, and carbohydrate per 100 g of texture-modified chicken or chicken thigh. The energy levels, as well as the protein and fat contents of the texture-modified chicken containing yakifu and water were lower than those of the chicken thigh. The amino acid score of texture-modified chicken was 100%, as with chicken breast. The weight of the texture-modified chicken that was provided in the nursing home was 2.80×10⁴ N/m².
home was adapted in order to match the protein content in 70 g of chicken thigh. Therefore, 9 g of yakifu was added to the texture-modified chicken, which is equivalent to one serving size of the ordinary stew dish.

Survey of intake amount

The number of subjects whose intake rate of the conventional chicken thigh was 100% was 12. We decided to focus on 10 subjects whose intake rate was not 100%, to prevent undernutrition. The intake rate of each of the 10 subjects of the texture-modified chicken was higher than that of the conventional chicken thigh (Fig. 2). Table 4 shows the means of intake rate, intake amount, protein intake and energy intake of the 10 subjects. As shown in Table 3, the protein content of texture-modified chicken was less than that of chicken thigh. To make the amount of protein the same for both kinds of chicken, we had to prepare the texture-modified chicken in bigger portions. Also, its size became larger after stewing because yakifu absorbed seasoning soup. Consequently, the weight of the texture-modified chicken was about twice that of the conventional chicken thigh, but the intake rate and intake amount were significantly higher ($p<0.01$) (Table 4).

**DISCUSSION**

Cooking method of chicken for soft diet

We evaluated various chicken cooking methods based on physical properties in order to provide food as a soft diet in a nursing home. As a result, we managed to cook teriyaki chicken at a final hardness equivalent to the L4

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**Table 3.** Nutritional value of texture-modified chicken and chicken thigh (per 100 g before cooking).

<table>
<thead>
<tr>
<th></th>
<th>Energy (kcal)</th>
<th>Protein (g)</th>
<th>Fat (g)</th>
<th>Carbohydrate (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texture-modified chicken</td>
<td>91</td>
<td>13.8</td>
<td>1.0</td>
<td>5.6</td>
</tr>
<tr>
<td>Chicken thigh</td>
<td>116</td>
<td>18.9</td>
<td>3.9</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**Table 4.** Intake rate of teriyaki chicken using texture-modified chicken and chicken thigh.

<table>
<thead>
<tr>
<th></th>
<th>Texture-modified chicken ($n=10$) means±SD</th>
<th>Chicken thigh ($n=10$) means±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake rate (%)</td>
<td>79.5±22.3**</td>
<td>29.5±25.7</td>
</tr>
<tr>
<td>Intake amount (g)</td>
<td>93.2±26.2**</td>
<td>15.6±13.5</td>
</tr>
<tr>
<td>Protein intake (g)</td>
<td>10.2±2.9**</td>
<td>3.9±3.4</td>
</tr>
<tr>
<td>Energy intake (kcal)</td>
<td>68±19**</td>
<td>24±21</td>
</tr>
<tr>
<td>Weight before cooking (g)</td>
<td>93.5</td>
<td>70.0</td>
</tr>
<tr>
<td>Weight after cooking (g)</td>
<td>117.3</td>
<td>52.7</td>
</tr>
<tr>
<td>Total protein (g)</td>
<td>12.9</td>
<td>13.2</td>
</tr>
<tr>
<td>Total energy (kcal)</td>
<td>85</td>
<td>81</td>
</tr>
</tbody>
</table>

* $p<0.01$ compared with chicken thigh by Wilcoxon rank sum test.

Weight of texture-modified chicken increased and that of chicken thigh decreased after cooking.
level of the Dysphagia Diets Pyramid, obtaining a final texture-modified chicken product composed of 50% minced chicken, 10% yakifu and 40% water, stewed in a seasoning soup.

The cooking of softened texture-modified meat has been reported previously. Kuroda et al. (17) and Taka-hashi et al. (18) developed texture-modified meat using minced chicken thigh with onion, and minced pork with some types of tuber, respectively. We estimated the protein contents of the texture-modified meats obtained using onion or potato, which contained a lot of carbohydrate and little protein. To maintain the protein intake of the eaters, it is good to use additive foodstuff containing high levels of protein. We thus focused on soy bean and yakifu processed food.

Even though soy bean-processed foods were suitable for protein sources, they were not selected as an additive foodstuff. Because commercially available soy powder was not heated, much harshness arose from the texture-modified chicken using soy powder during the boil, and the taste of soy was strong. The texture-modified chicken obtained using grated freeze-dried tofu was the hardest among the soy bean-processed samples (Table 1). It is well established that stewed freeze-dried tofu is not suitable for a soft diet because of its tendency to lose water and its difficult mastication pattern.

Even though the protein content of yakifu is lower than in soy bean-processed food, it remains higher than that of onion or potato. Thus, the texture-modified chicken developed in this study provided a better protein source for the elderly than the texture-modified meat created in former studies. However, it cannot be provided for people with wheat allergy.

Suitable hardness for soft diet

When providing teriyaki chicken in the nursing home, the intake rate of the texture-modified chicken, for which the hardness was under 40,000 N/m², of the subjects whose intake amount of conventional chicken thigh was not 100%, was significantly higher than that of the conventional chicken thigh, for which the hardness was above 63,000 N/m². We could not obtain the hardness value of the conventional chicken thigh because of the limitation of the load cell at a texture measurement. The breaking stresses, measured by using a 5-mm diameter plunger and at 80% of distortion factor, of the texture-modified chicken, the chicken thigh for a soft diet or an ordinary diet were 60,000 N/m², 150,000 N/m² and 450,000 N/m², respectively. Even though the chicken thigh cooked for a soft diet was softer than when prepared for an ordinary diet, the texture-modified chicken was still much softer.

We inferred that the masticatory force of subjects whose intake amount of conventional chicken thigh was not 100% might be weak. It would be helpful to provide two kinds of soft diet: conventional chicken thigh and texture-modified chicken, but it takes time and effort. To avoid undernutrition, there was a high probability that the meal containing the texture-modified chicken with a 28,000 N/m² hardness would be more suitable for a soft diet.

Nursing homes rarely have a texture measurement instrument in their kitchen; therefore, cooks evaluated the softness of a soft diet by individual judgement. In this study, by surveying the intake amount of meals cooked with quantitative assessment of hardness, we could determine the most suitable meal. We suggest that the intake rate of the elderly eating appropriate soft diets would increase and their nutritional status be maintained, through sharing of suitable cooking methods among nursing homes.

Water contents and sizes of texture-modified chicken

Mousse-formed and blended foods are softer than soft diet (9) but cooked with much more water (19). It is necessary to add water in order to soften food. The provided weight of texture-modified chicken including water-soaked yakifu was about twice that of the conventional chicken thigh (Table 4). According to the interviews we carried out with some subjects, the provided amount of texture-modified chicken was too much.

Limitations of this study

Texture measurements should be done at the temperature at which the food is provided. Indeed, physical properties of cooked meat are affected by its temperature (19). However, we measured the textures of the samples at 20°C, at which they would have been softer than at the provided temperature.

The provided amount values in this study correspond to an average weight of three servings. We judged that this method would limit disturbance to the ordinary running of lunch service in the nursing home. A similar method was reported in a previous work (20). Nevertheless, we could not correctly measure individual intake amounts due to discrepancies in the amounts dished up. This method is suitable to evaluate the general trends among all subjects, but not accurate enough to assess the intake amounts for each subject and subsequently suggest methods to increase them. Therefore, it is necessary to improve the methods for measuring the provided and intake amounts while keeping disturbances to the ordinary service to a minimum.

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