新規発酵食品製造のための大豆タンパクゲル調製条件の検討

Preparation of Soybean Protein Gel For A Novel Fermented Protein Food†

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Key Words : Soybean protein, Soybean protein gel, Fermented soybean protein food, Tofuyo, Texture, Genus *Monascus*
キーワード：大豆タンパク質、大豆タンパク質ゲル、大豆タンパク質の発酵食品、とうふよう、テクスチャー、紅麹菌

Summary

Preparation methods of soybean protein gel for a novel fermented food which has a mild creamy cheese type flavor, were investigated. Optimum conditions for quality of the gel were affected by chemical properties and quantities of coagulant, amount of moisture, and heating temperature and duration when the gel was prepared by deflating the mixture of the soybean protein isolate (SPI), soybean oil, water, and coagulant and by heating in the casing. Found were 68 to 70 % of moisture, 2.77 g of calcium sulfate for 100 g of SPI, and 60 min heating at 80℃ as the best conditions for the gel preparation.

However, the gel-based fermented food prepared under the conditions mentioned above did not have smooth and was not good for taste. The quality of the product was affected by amount of calcium sulfate added. The best quality of the fermented food was obtained with the gel which prepared by increasing calcium sulfate up to 3.68 g for 100 g of SPI.

Introduction

Soybean has been recognized as a nutritious food since an ancient time. It has been used for traditional foods such as tofu, tofu-related foods, miso, shoyu and natto in Japan. In nowadays, due to the fact that attention on functional properties of soybean

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protein such as gelation, viscosity, emulsification, foaming *etc.* has been paid greatly[1,3], soybean protein has been used as an important material for a lot of fabricated foods and soy based foods such as sausage, bacon, and many meat like products[3].

While there are many reports[5,7] on the textural and rheological properties of soybean protein gel, little attention has been paid on the gel-based fermented food.

Here we report the preparation methods of the gel for a novel fermented food which has a mild creamy cheese type flavor.

Materials and Methods

Preparation of soybean protein gel

Preparation of soybean gel was as follows; 54.3 g of soybean protein isolate, 37.2 g of soybean oil, 208.5 g of water and/or coagulant were mixed with a Speed Cutter (Type: National, MK-3) for 3 min, and deflated. After the mixture, was cased into the vinilidene-chloride-tube (Type: Kureha film, A-08, 4 cm of the width), it was heated at 80℃ for 60 min. The gel obtained was cooled with streaming water, and kept at 4℃ for 12 hr. After being cooled, it was kept at room temperature for an hour, and it was cut into 2.5 cm of the diameter and 3 cm of the height.

Preparation of a fermented food

The fermented food was prepared by the method of tofuyo-making[8-12], except 30 % of ethyl alcohol concentration of awamori (distilled liquor). The gels were soaked into the moromi at 30℃ for 2 months.

Textural measurements

Hardness and jelly strength of the gel were measured by the method of Iio[4] with a New Curd-Meter (Type: M-302, Iio Electric Co. Ltd.). The measuring conditions were the same as the previous paper[10].

Organoleptic evaluation

Organoleptic evaluation of the fermented food were carried out as described previously[10,12].

Results and Discussion

1. Preparation of soybean protein gel

(1) Effect of moisture on hardness and jelly strength of the gel

Content of moisture was an important factor in the physical properties of the gel. And then, in order to know suitable physical properties of the gel for making the fermented food, it was examined by preparing the gels with some varieties of moisture content (65 to 75 %). As sown in Fig. 1, the lesser moisture content was the larger the values of hardness and jelly strength of the gel. In this gel with 65 % of moisture content, oil content was relatively higher against SPI; oil oozed on surface of the gel. The gel with 75 % of moisture content was not only soft, but also peeled off the surface because separation of the gel from the case was difficult. The gels with 68-70 % of moisture content were shown as good for textrual properties. And thus, in this experiment,

an optimum moisture content was decided as 69.5% and giving conditions to work easily (hardness: 15.8×10^4 dyne/cm^2, jelly strength:17.3×10^5 dyne/cm^2). Moreover, coagulant should be added for increasing values of hardness of the gel.

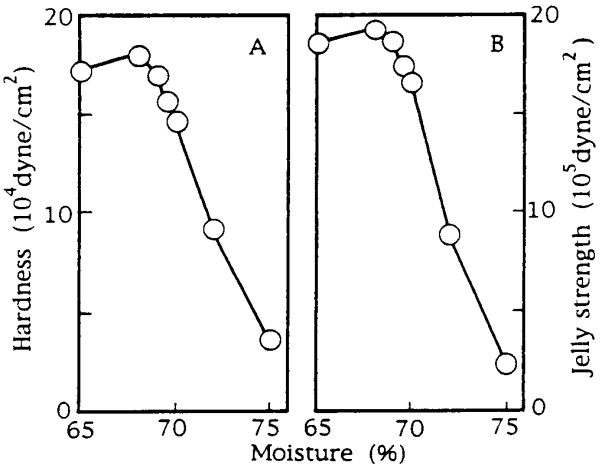

Fig. 1

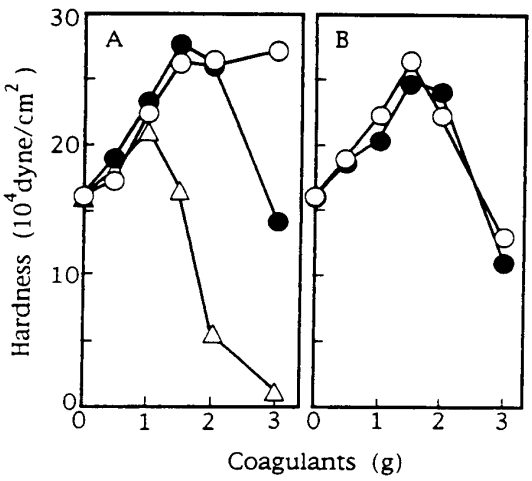

Fig. 2

Fig. 1 Effect of moisture on hardness and jelly strength of soybean protein gel. A;hardness, B;jelly strength

Fig. 2 Effects of varieties and quantities of coagulant on hardness of soybean protein gel. A ○ ; $CaSO_4 \cdot 2H_2O$, ● ; Glucono-δ-lactone, △ ; $CaCl_2 \cdot 2H_2O$ B ○ ; Brine, ● ; $MgCl_2 \cdot 6H_2O$

(2) *Effects of varieties and quantities of coagulants on hardness and jelly strength of the gel*

In order to obtain the suitable texture of the gel, the effect of varieties and quantities of coagulant on hardness and jelly strength of the gel were investigated. As shown in Fig. 2, hardness of the gel prepared with calcium sulfate increased linearly with calcium sulfate added up to 1.5 g, and increased gradually by a further addition. Hardness of the gel prepared with glucono-δ-lactone (GDL) increased with an addition of GDL up to 1.5 g, and rapidly decreased with a further addition of GDL. Hardness of the gels prepared with calcium chloride, brine, and magnesium chloride changed almost similar to that of GDL.

Jelly strength of the gel tends to decrease by an increase in the coagulants added (Fig. 3). That is, it decreased markedly at more than 0.5 g of calcium chloride, 1.0 g of GDL, 0.5 g of brine, and 1.0 g of magnesium chloride. However, values of jelly strength of the gel prepared from calcium chloride (more than 1.0 g) did not decrease more markedly than other coagulants. When considered with stability and balance in both hardness and jelly strength of the gel, calcium sulfate was selected as the best coagulant. The best properties of the gel were obtained by 1.5 g of calcium sulfate (corresponding to 2.77 g for 100 g of SPI).

(3) *Effects of heating-temperature and heating-time on hardness and jelly strength of the gel*

The effect of heating-temperature on hardness and jelly strength of the gel was investigated. Hardness of the gel increased with an increase in heating-temperature, and its most highest value was obtained at 80℃. Jelly strength of the gel changed almost similarly to the case of hardness. It was known that the textural properties of soybean protein gel were changed markedly at 70 to 90 ℃[7], and the results obtained in this experiment were also in good agreement to that case[7]. At a temperature of 80℃, the best gel which was well-balanced in both hardness and jelly strength was obtained. (Data are not shown.)

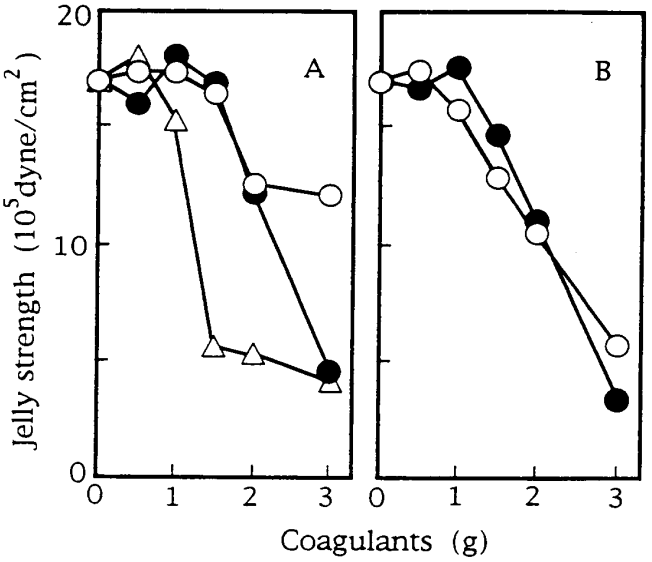

Fig. 3 Effects of varieties and quantities of coagulant on jelly strength of soybean protein gel.

A ○ ; $CaSO_4 \cdot 2H_2O$, ● ; Glucono-δ-lactone,
△ ; $CaCl_2 \cdot 2H_2O$
B ○ ; Brine, ● ; $MgCl_2 \cdot 6H_2O$

The effect of heating-time on hardness and jelly strength of the gel was examined. When it was heated at 80℃ for 45 min, hardness of the gel reached at the maximum value and almost maintained the value up to 90 min. Jelly strength of the gel showed a constant value at 80 ℃ for 60 to 90 min. Therefore, the heating-time for preparation of the gel was practically judged as 60 min. (Data are not shown.)

2. Production of a soybean protein gel-based fermented food

Production of a novel soybean protein gel-based fermented food, which was similar to tofuyo[8-12] was investigated. The gel was used instead of tofu cubes.

(*1*) *Effect of calcium sulfate on the quality of the fermented food*

Effect of quality of calcium sulfate on hardness and jelly strength of the fermented food is shown in Table 1. The values of hardness of the gel increased with an increase in the amount of calcium sulfate, but the values of jelly strength did not. When up to 1.0 g of calcium sulfate was added, hardness of the product showed about constant values (10 to 11×10^4 dyne/cm^2) regardless of the original gel. When calcium sulfate weighting more than 1.5 g was added, the values of hardness of the product showed less than 9.0×10^4 dyne/cm^2. When calcium sulfate (up to 1.5 g) was added, jelly strength of the product was at an almost constant value. According to Yasuda *et al.*[8] the most suitable value of hardness of the tofu cubes for making tofuyo was around 28×10^4 dyne/cm^2. The near the values to this optimum hardness value were obtained by an addition of 1.5 to 2.0 g of calcium sulfate.

Table 1 Effect of quantities of calcium sulfate on hardness and jelly strength of sp-gel-based fermented food.

$CaSO_4 \cdot 2H_2O$ (g)	Hardness (10^4 dyne/cm^2)		Jelly strength (10^5 dyne/cm^2)	
	Sp-gel[1)]	The product[2)]	Sp-gel[1)]	The product[2)]
0	15.8	10.5	17.5	5.4
0.25	16.5	11.6	17.5	5.2
0.50	17.8	10.8	17.7	5.5
0.75	20.3	10.4	17.5	5.9
1.00	23.0	9.9	16.5	5.6
1.50	26.0	8.9	14.1	5.7
2.00	26.0	8.4	12.9	4.0

1) Sp-gel: Soybean protein gel
2) The product: Sp-gel-based fermented food

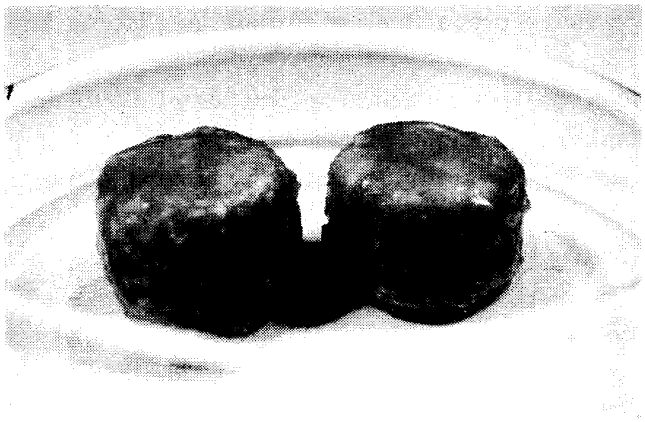

Fig. 4. The fermented soybean protein food.

The results of sensory evaluation showed that they were similar to the traditional tofuyo in the flavor. The products prepared with the gels contained up to 1.0 g of calcium sulfate not only had cracks on the surface but also did not progress to maturation sufficiently. However, when calcium sulfate weighting more than 1.5 g was added, the product had a smooth texture. Especially, when 2.0 g of calcium sulfate was added, the product had no crack on the surface (Fig. 4). Additionally, it had a very smooth texture and good taste such as a creamy cheese type flavor (data are not shown.). And thus, we concluded that the gel should be prepared by increasing calcium sulfate up to 2.0 g (corresponding to 3.68 g for 100 g of SPI) in order to obtain the best quality of the fermented food.

Therefore Ca^{2+}ion is considered to be essential factor for formation of a smooth texture in the product. Although, the form and significance of Ca^{2+} ion in the protein food are not clear, calcium-bridge in the protein molecule may be formed. And then, when protein of the gel was degraded by the proteases which originated in the koji in the soak during the fermentation, the Ca^{2+} ion would contribute to affect protease activities and physical properties of the gel. As the results, it was considered that a good texture in the product was formed. The roles of Ca^{2+} ion during the fermentation or ripening mechanisms of the product still remained to be solved.

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新規発酵食品製造のための大豆タンパクゲル調製条件の検討

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要　約

大豆タンパク、大豆油、水及び凝固剤をよく混練し、加熱ゲルを調製した。このゲルを用いた発酵食品の製造法について検討した。物性から見たゲルの調製条件は水分含量（60〜70%）、凝固剤添加量（大豆タンパク100gあたり硫酸カルシウム2.77g）とし、80℃で60分間加熱することが適切だと思われた。とうふよう製造法で、乾燥豆腐の代わりにこのようにして得られた大豆タンパクゲルを用いた発酵食品の製造法についてさらに検討した。その結果、硫酸カルシウム添加量が少ない場合には、製品の表面にひび割れが生じ、熟成がうまく進行しなかった。一方、大豆タンパク100 gあたり3.68 gの硫酸カルシウムを添加した時には、組織がなめらかなとうふよう類似の新しい発酵食品が得られた。

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