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Effect of Coagulants on Textural Characteristics of Soybean Curd

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〈**Abstract**〉

Various coagulants, such as calcium sulfate, gluconodelta lactone and calcium chloride, are incorporated to the soy milk to characterize the texture, quality and microstructure of soybean curd. Chemical components of the soybean curd varied depending upon the type of coagulants used. The product prepared from gluconodelta lactone has lower chemical contents, such as moisture, protein and calcium levels, than any others. The calcium level was higher suggesting that more protein precipitates with higher levels of calcium as a coagulant. Thus, the type of coagulant was predicted to influence the precipitation of the protein. In application of Tukey's range test for various soybean curds, gluconodelta lactone soybean curd for hardness and acceptability was significantly different from the calcium compound soybean curds, while the soybean curds for cohesiveness were not significantly different. Photomicrographs by SEM showed that the walls of the calcium compound soybean curd are more compact and denser than the gluconodelta lactone product, which illustrates an even matrix that protein are aggregates in a uniform manner. From the results of this study help predict that the coagulant effects the microstructural and textural behavior of the protein lamella.

두부의 조직특성에 관한 응고제 영향

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〈요　　약〉

응고제 종류가 두부의 조직, 성상, 미세구조 특성에 미치는 영향을 검토하였다. 두부의 주요 성분은 사용한 응고제에 따라 다르며 gluconodelta lactone에 의해 제조된 두부의 수분, 단백질, 칼슘의 함량은 칼슘응고제를 사용한 제품보다 낮았다. 특히 칼슘 함량은 단백질 함량과 함수관계를 가진 것으로 생각된다. 따라서 응고제의 종류는 단백질 응고에 영향을 미쳤으며 통계처리에 의해서 비칼슘 응고제를 사용한 경우는 칼슘 응고제를 사용한 제품과 견고도, 기호도 측정에서 다른 결과를 나타내었다. 전자 현미경에 의한 구조 관찰에서 칼슘 응고제는 치밀한 조직의 기벽, 패턴을 나타내었으나 비칼슘 응고제인 gluconodelta lactone은 균일한 조직구조특성을 나타내었다. 이 연구결과에서 응고제는 민감하게 두부단백의 lamella 구조와 조직감에 큰 영향을 미치고 있었다.

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Ⅰ. Introduction

Soybean curd is one of the important nonfermented soybean products which have been widely used in a variety of dishes by oriental people for many centuries. Tofu, like soy sauce and soy milk, are unique soy protein foods consumed to provide good nutritional and digestibility qualities[1,3]. The traditional manufacting processes of soybean curd involve first a soy milk manufacturing process, a coagulation process, and then a pressing process. Soybean cake involves the curd of ground soybeans which is precipitated by adding coagulant to the soy milk and draining the whey. Various coagulants are incorporated to the soy milk but the calcium salts are considered to yield a more preferred texture. Calcium sulfate[4] is the most widely used and produces the higher quality product. The use of calcium sulfate, however, causes some problems. The salt is practically insoluble but the salt could be added as a dry powder to achieve the desirable result. Gluconodelta lactone has no salting out potential but does precipitate the protein. The coagulant causes proteins to associate by forming salt bridges and by lowering the pH causing the proteins to become more neutral. Disagreement exists as to the relative importance of the two effects. One study point out that the soy protein started to coagulate as the pH fell below 6.0. However, the proteins did not precipitate at all concentrations of calcium carbonate which has a higher pH range.

The conclusion was that pH and not calcium ion concentration is the overwhelming cause of coagulation of the soy protein. The soybean curd is considered to be a soy isolate having an isoelectric point of 6.0[5]. Nonetheless, the calcium does bind to the protein chain facilitating precipitation and yield high levels of calcium in the final product.

This study was undertaken to elucidate the textural and microstructural profile of the soybean curd coagulated by calcium salts and non calcium salt.

Ⅱ. Materials and Methods

1. Preparation of soybean curd

Soybeans (Tracy variety) were soaked in water overnight, then ground with water in a waring blender for 6 min. at high speed. Additional water was added to obtain soy slurry. The soy slurry was boiled for 5 min. and strained through a filter cloth for soy milk. The soy milk was cooked for 10 min. at 100°C and then cooled to 72°C. The coagulant was added slowly while stirring until the soy protein started to coagulate. The curd was transferred to a plastic box lined with cheese cloth to drain off the water. The curd was pressed by a 200g weight placed on top of the curd for 1 hr.. The resultant is called soybean curd((tofu).

2. Coagulating agents

Reagent grade calcium sulfate and calcium chloride from Fisher Scientific Co. and gluconodelta lactone from Merck Co. were used.

3. Chemical analysis

Moisture determinations were made in duplicate on two gram samples by freeze drying. Ash content was determined by the AOAC[6]. The concentration of calcium was determined using Atomic Absorption Spectro photometry. Protein content was determined by the Boric Acid Modification of the Kjeldahl nitrogen method[6].

4. Textural property and sensory evaluation

Textural properties[7] such as hardness and cohesiveness were evaluated using the Instron Universal Testing Instrument (model 100). Sensory evaluatiton for acceptability was evaluated by the sensory panel. The scale for acceptability was arranged from 1 (very low) to 10 (very high). Sensory evaluation was modified from the method described by Lu et. al[6].

5. Scanning electron microscope (SEM)

Small sample cubes were fixed in glutaraldehyde overnight, quickly frozen in liquid nitrogen, and dehydrated by freeze drying. Samples were placed on stubs and coated with gold/palladium to be viewed under the scanning electron microscope.

Ⅲ. Results and Discussion

The quality of soybean curd is mainly indicated by chemical compounds, textural behavior and general acceptability.[8] Table 1 shows the values for the analyses of the products. The calcium compounds(calcium sulfate and calcium chloride) and gluconodelta lactone all precipitated soy protein. Result shows that the protein content of gluconodelta lactone soybean curd was lower than that of all calcium compound products. The moisture content of soybean curds prepared from various coagulants ranged from 84—85% with an average value of 84.7. The soybean curd is actually classified as soft or hard according to moisture content[3]. The product prepared from gluconodelta lactone has lower moisture than any others. The calcium level was also higher suggesting that more protein precipitates with higher levels of calcium as a coagulant. However it is not possible to make a definite conclusion since the glucono delta lactone is generally used as a coagulant to make the commercial product. The calcium level of the gluconodelta lactone soybean curd has a much lower but the amount of protein precipitated was similar. Thus, the type of coagulant and the processing conditions will influence the precipitation of the protein. It is desirable for soybean curd to have bland taste, smooth and softer texture. The qualities of soybean curd, especially texture and acceptability are better determined by the physical properties rather than by chemical compositions. Acceptability and characteristics of the soybean

Table 1. Chemical comparison of soybean curd*

soybean curd made with	coagulant added(%)	protein(%)	moisture(%)	ash(%)	calcium(mg/g)
calcium sulfate	1.5	8.02	84.6	1.12	0.31
gluconodelta lactone	1.5	7.82	84.2	1.05	0.09
calcium chloride	1.5	7.89	85.2	1.08	0.29

*mean of three batches

Table 2. Textural and Sensory profiles of soybean curds**

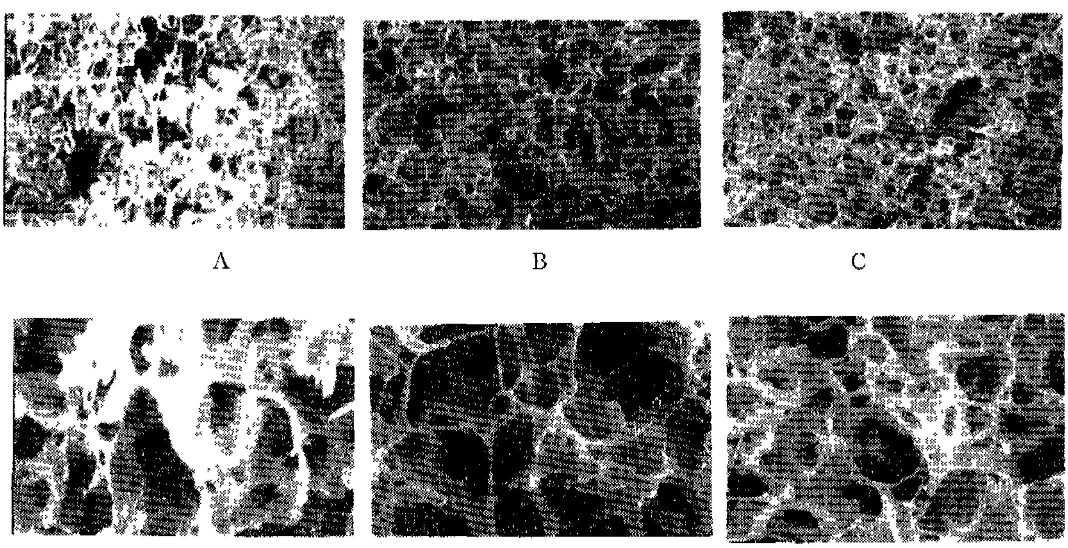
soybean made with	Textural parameters		Sensory parameter acceptability
	cohesiveness	Hardness(kg)	
calcium sulfate	0.20[a]	0.26[a]	5[a*]
gluconodelta lactone	0.24[a]	0.13[b*]	8[b]
calcium chloride	0.21[a]	0.19[c*]	6[a]

* means with the same letter are not significantly different in a confidence of 0.95
**mean of three batches

curd prepared from calcium sulfate, gluconodelta lactone and calcium chloride were compared, and results are shown in Table 2. It was observed that the gluconodelta lactone soybean curd had a smooth and soft, and the hardness was increased in order of calcium chloride and calcium sulfate. The soybean curd prepared from calcium sulfate had a hard and firm texture but it was not exhibited coarse. Table 2 also illustrates the effect of coagulant source on the textural measurements. In application of Tukey's range test for various soybean curds, it is very clear that gluconodelta lactone soybean curd for hardness was significantly different from the calcium compound soybean curds, while the soybean curds for cohesiveness were not significantly different. Taste panel score showed that the calcium compound soybean curds were classified into same grouping for acceptability with no significant differences at the 1% or the 5% levels. However, the score for gluconodelta lactone soybean curd was shown much higher than calcium compound products. The resulting score values are not necessarily correlated with the quality of product. However, the score of general acceptability is somewhat related to the product quality.

Further studies were done using different coagulants to determine if there are differences in the appearance of the protein lamella under the scanning electron microscope. Photomicrographs (Fig. 1) of the soybean curd under the SEM reveal that how the protein matrix entraps the water, fat globules and calcium ions.

The protein matrix appears analogous to a sponge structure. It is immediately obvious from the micrographs that the walls of the calcium compound soybean curd are more compact and denser than the gluconodelta lactone product, which illustrates an even matrix that protein are aggregates in a uniform manner. The gluconodelta lactone product showed a uniform, cell-like matrix and an open, fibrous, and porous matrix presumably corresponding to the unique surface characteristic



A B C

D E F

Fig. 1. Microstructure of soybean curds coagulated with different coagulants.

A. calcium sulfate (×900) D. calcium sulfate (×3,600)
B. gluconodelta lactone (×900) E. gluconodelta lactone (×3,600)
C. calcium chloride (×900) F. calcium chloride (×3,600)

of agglomerated protein gels. The calcium compound soybean curd showed that matrix strands appeared to be overlapped and interwoven in the gel network. From the results of this study help predict that the calcium bridging of the protein chains affects the structure of the lamella. The addition of a salt such as calcium forms a bridge between two negative side chain. This cation dissipates the repulsive forces which were preventing the chains from associating and forms a link between the two. The pH effect trends to decrease the repulsive forces as the protein chains become neutral overall. This allows hydrogen bonds to form. The uncharged nature of the side chains leads to hydrophobic effect drawing the protein chains closer together and squeezing out unbound water molecules. Thus coagulant such as gluconodelta lactone can precipitate the protein without the presence of a cation. Together, however, the salt acts synergistically with the pH effect to give more efficient precipitation of the soy protein.

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