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Research Article

Comparison of Two Soy Globulins on the Dynamic-Mechanical Properties of the Dough and the Quality of Steamed Bread

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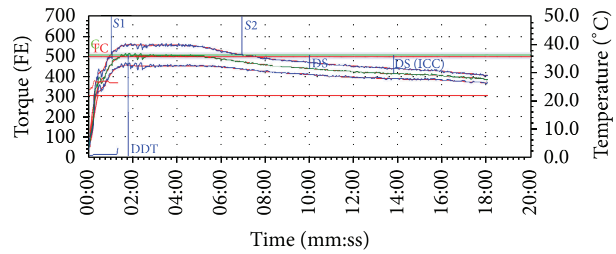
To investigate the effect of the soy protein concentrate (CSP) and 7S and 11S soy globulin on wheat dough and steamed bread (SB), mixing properties of the dough were assessed by farinograph and dynamic-mechanical analyzer (DMA). The quality attributes of SB were assessed by texture profile analyzer (TPA), sensory analysis, and scanning electron microscope (SEM). The results showed that CSP, 7S, or 11S (each from 2.0 to 4.0%) significantly decreased gluten content (from 29.4 to 26.0, 36.7 to 31.8, and 31.6 to 30.7%), when those were added to wheat flour. The CSP/wheat dough stability was increased (from 6.5 to 8.4, 6.5 to 8.5, and 6.5 to 8.3 min) and the degree of softening was decreased (from 71.0 to 68.0, 71.0 to 64.0, and 71.0 to 62.0 min), but 7S or 11S had the opposite result. Moreover, the ratio of 7S and 11S has a significant effect on the quality of the dough. The storage modulus and loss modulus of soy/wheat dough decreased in the order of CSP, control, 11S soy globulin, and 7S soy globulin. The hardness, chewiness, and cohesiveness of SB decreased in the order of control, CSP, 11S soy globulin, and 7S soy globulin. Microstructure demonstrated that gluten network was interfered by SPC, 7S, and 11S soy protein, which was in agreement with the texture analysis index. The quality of SB with 3% 11S was the best in texture, microstructure, and sensory. These findings indicate that 11S has the potential to be used as a special soy protein for SB making.

1. Introduction

The steamed bread (SB) is one of the most traditional staple foods in the Chinese diet, which also gains popularity and widely consumed by people of Southeast Asia. In Northern China, the making of SB accounts for 70% of wheat consumption. SB is a type of fermented wheat product with smooth white skin and compact crumb structure. The basic ingredients for making SB are wheat flour, water, and yeast [1, 2]. The quality of wheat flour has an important impact on the SB. However, wheat protein is usually short of essential amino acids such as lysine, tryptophan, and threonine. Therefore, wheat flour supplemented with high-protein-content products has great potential in overcoming protein-calorie malnutrition and improving the nutritional quality [3–5].

Several studies have been done regarding the effect of legume flour on pasta and bread quality, such as pea (*Pisum sativum* Linn.) [6], Mexican common bean (*Phaseolus vulgaris* L.) [7], and soybean (*Glycine max*) [8–11]. Incorporation of lupin and pigeon pea flour to semolina considerably improved the protein quality of pasta [12]. Soy is one of the most important legumes and frequently used because of its high protein content. Soy protein is rich in eight kinds of essential amino acids. Soy protein is one of the most nutritious plant proteins, of which the amino acid composition is close to the milk protein. The FAO/WHO (1985) human test results show that the essential amino acid composition of soy protein was more suitable for the human body, and the soy protein biological titer is 100 for the people over two years [13]. Soy protein consists of four major fractions (2S, 7S, 11S, and 15S globulin), of which the 7S and 11S fractions are the major components comprising about 70% of the storage proteins [14]. It is demonstrated that the addition of soy products in wheat flour can improve the protein quantity and the quality of mixed flour [15]. Dhingra and Jood [16] stated that adding full fat and defatted soy flour to wheat flour significantly ($P < 0.05$) increased protein, lysine, and total calcium contents. Others claimed that the 7S soy globulin is not related to the quality of loaf bread when less added [17, 18]. The 7S and 11S fractions are the major components of soy protein. However, it is not clear that 11S soy protein is related to the bread quality.

The results of studies mentioned above show that the protein quantity and the quality of pasta and bread were improved by soy flour. However, they failed to report the effect of 7S or 11S on wheat dough and baking quality. Also, the effect of these components on SB has rarely been elucidated. The aim of this study was to evaluate the effect of the soy protein and 7S and 11S soy protein on the quality of wheat dough and steamed bread.



TC: circulator temperature
C: consistency
S: stability
DS (ICC): degree of softening (ICC/12 min after max.)

Figure 1: Full-steamed bread formulation farinogram.

2. Materials and Methods

2.1. Materials. Defatted soy flour (54% of the protein content) was provided by a local milling company (Tongchuangyisheng Food Co., Ltd, Zhengzhou, Henan, China). Commercial wheat flour with 12.6% protein, 0.5% ash, and 12.3% (14% moisture basis/wet basis) was purchased from Tiandiren Wheat Flour Co., Ltd (Zhengzhou, China). This flour is suitable for making steamed bread (SB). Commercial active dry yeast was obtained from Angel yeast Co., Ltd, Chifeng, Inner Mongolia, China. All chemical reagents were of analytical grade and obtained from Xinfeng Chemical Co., Ltd, Zhengzhou, Henan, China.

2.2. Preparation of Soy Protein Concentrate (CSP), 7S, and 11S. The CSP-extracting method in this study was described by Delwiche et al. with minimal modification [19]. The defatted soy flour sample (100.0 g) was stirred with deionized water (1 : 15 w/v, 1500 mL). The pH was adjusted to 9.0 with 2.0 M NaOH solution. The solution was put into the 45°C water bath. After 1 h, the solution was centrifuged (10,000 ×g) for 20 min at room temperature (D-37520 low-temperature centrifuge, Kendro company, Germany) to extract soluble protein. 2.0 M HCl was added to the liquid phase to reach pH of 4.5. This solution was placed at 4°C for 24 h and then was centrifuged (9,000 ×g, 20 min, 4°C). The pellet was dissolved in deionized water (1 : 5 m/v), and the pH was adjusted to 7.5 with 2.0 M NaOH. The suspension liquid was freeze-dried to produce the soy protein concentrate (CSP). CSP yield was 41.2 g per 100 g defatted soy flour with protein content of 86.0%. 7S and 11S fractions were prepared according to Liu et al. [20] with some modifications. The prepared 7S and 11S fractions had the protein contents of 89.0% and 96.0%, respectively. Yields of 7S and 11S fractions were 20.9 g 7S per 100 g defatted soy flour and 17.3 g 11S per 100 g defatted soy flour, respectively. The freeze-dried CSP, 7S, or 11S was manually ground in a mortar.

2.3. Preparation of CSP, 7S, and 11S Fraction-Wheat Flour Blend. CSP, 7S, or 11S fraction were added to wheat flour at three levels. The amount of the fractions was calculated based on their protein content, to represent an incorporation of 2.0%, 3.0%, and 4.0% of protein from CSP, 7S, or 11S fraction (CSP: 2.3 g, 3.5 g, and 4.6 g; 7S: 2.2 g, 3.4 g, and 4.5 g; 11S: 2.1 g, 3.1 g, and 4.2 g per 100 g wheat flour). Wheat flour was used as the control sample. The wet gluten content of the flour samples was determined using the method 38-12A (AACC, 2000). Farinograms were performed in a 300 g Brabender Farinograph (Brabender Farinograph-AT, Duisburg, Germany), and responses of water absorption corr. for default consistency (WAC), degree of softening (10 min after beginning) (DS), and dough stability (*S*) were recorded (Figure 1).

2.4. Dynamic-Mechanical Analyses. The mechanical properties of the dough were determined using a stress-controlled dynamic-mechanical analyzer (DMA-Q 800, TA Instruments, USA) equipped with a tension clamp. The dough samples were pressed to a sheet of 2.0 mm thickness by a pasta machine (DMT-5, Fuxing, Shandong, China); then cylinder with the diameter of 12.5 mm was obtained by a special disc-shape mould. Test mode was compressed under controlled strain. Preloading was set at 0.005 N and strain amplitude was 5 μm. Frequency scans were performed varying from 1 to 10 Hz, at a constant temperature of 35°C.

2.5. Steamed Bread Making. SBs were prepared according to the method of Hao and Beta [21] with modification. Composite flour (100.0 g) was mixed with water to a final concentration of 85% (farinograph water absorption). Dry yeast (1.0 g) was added. The mixture was stirred with a glass stick and then kneaded for 7 min. The dough was fermented for 40 min at 38°C and 80% humidity. The dough was then placed in a steamer and steamed for 20 min. After steaming, SBs were placed in a container with a cover at room temperature for 1 h. The volume, weight, and TPA (texture profile analysis) of SB were measured. Volume of SBs was determined by rapeseed displacement. These parameters were measured at three different locations and expressed as the average and standard error. Texture analysis on SB was performed using a texture analyzer (TMB-Pro Texture Analyzer, Stable Micro System, FTC, USA). SB samples were divided as the following method: in order to obtain 5.0 cm thick middle slice, the tops and bottoms of SB were removed.

Table 1: Sensory evaluation for steamed bread.

Items	Scores evaluation standard	Marks
Specific volume (volume/weight)	Score is 20 when the specific volume is ≥2.3 and decreases by 1 point when the value of specific volume decreases by 0.1.	1–20
Exterior appearance	21.1–25: crust is smooth and white or milk-white; shape is symmetrical and stands upright; 15.1–21: middling; 1–15: crust is coarse and gray or dark; shape is asymmetrical and hard agglomerations occur.	1–25
Structure	30.1–35: good rebound after pressing with a finger; pores of longitudinal cut side are small and symmetrical; 21.1–30: middling; 1–21: poor rebound after pressing with a finger; pores of longitudinal cut side are large and asymmetrical.	1–35
Taste	13.1–15: sample feels dainty and does not stick to teeth when steamed bread is chewed; it is strong to the bite; 9.1–13: middling; 1–9: sample sticks to teeth when chewed; it is soft to the bite.	1–15
Flavor	4.1–5: it has fermentation fragrance of steamed bread; 3.1–4: middling; 1–3: unpleasant fragrance of steamed bread.	1–5
Total score		100

Then, the slice was subdivided into 2.5 cm thick pieces (diameter of 4.5 cm). A standard two-cycle compression test was performed using a 35 mm cylindrical probe under the following conditions: load cell 5 kg, pretest speed 2 mm/s, test speed 1 mm/s, and posttest speed 1 mm/s. Each piece of sample was given 50% compression. Force versus time curve was obtained, and textural parameters, including hardness, chewiness, and cohesiveness, were calculated by the Texture Expert software.

2.6. Sensory Analysis. The scores of SB were evaluated by a 7-person evaluation panel according to previous reports [22, 23] with some modifications. The evaluation standards are listed in Table 1. SBs were scored for the following quality parameters, respectively: specific volume (20), exterior appearance (25), structure (35), taste (15), and flavor (5).

2.7. Morphology Analysis. A Carl Zeiss Jena scanning electron microscope (EVO LS15, Germany) (SEM) was used for morphology analysis. The equipment has an acceleration voltage between 0.2 and 30 kV, including sensors for secondary and backscattered electrons, working with high and low vacuum. The SB samples were initially treated with glutaraldehyde and ethylic alcohol (95%) and dried up to a critical point and finally metalized with gold.

2.8. Statistical Analysis. All experiments were performed in triplicate. ANOVA analysis was used for statistical analysis by SAS ver. 8.0. A P value of <0.05 was considered statistically significant.

3. Results and Discussion

3.1. Soy/Wheat Dough Properties. The wet gluten parameters are shown in Table 2. Gluten content was calculated as % of soy/wheat flour (GSW). With the level of substitution from 2.0 to 4.0%, CSP, 7S, or 11S significantly decreased GSW (from 33.4 to 29.0, 31.6 to 30.7, or 36.7 to 31.8%) ($P < 0.05$), when added to wheat flour. However, 11S with the addition of 2% and 3% significantly increased GSW (from 29.9 to 36.7 and 29.9 to 35.2%) ($P < 0.05$), while the CSP or 7S did not show significant differences compared to the wheat flour.

The change of wheat gluten content after adding CSP to wheat flour described herein was consistent with several studies, which reported that the decreased free water in the flour with soy addition under the tested conditions suggested a great competition for water between soy proteins and gluten proteins [24]. Ribotta et al. [10] reported that soy proteins were presented in the gluten fraction after dough washing, indicating strong association among proteins. 7S and 11S soy globulin are the major components of the soy protein. It is hypothesized that 11S is combined with water closer than 7S and CSP. So 11S increased the gluten content, while at the same level, the CSP or 7S did not show significant differences in comparison with the wheat flour. The other reason for the results in this paper may be the gluten network retained more 11S [25].

Table 2 summarizes the dough farinographic properties. The water absorption of 7S/wheat dough and 11S/wheat dough were increased in comparison with the wheat dough; the higher ratio of 7S and 11S/wheat, the higher water absorption capacity of 7S/wheat dough and 11S/wheat dough. In addition, CSP/wheat dough did not show significant differences. Dough stability (S) gives a representation of dough strength. CSP at 2% or 3% level significantly ($P < 0.05$) increased S (from 6.5 to 8.4 min and 6.5 to 8.5 min). 7S at the same level significantly ($P < 0.05$) decreased S (from 6.5 to 3.3, 6.5 to 2.4 min, and 6.5 to 2.4 min, resp.). Similarly, 11S at 2%, 3%, or 4% level significantly ($P < 0.05$) decreased S (from 6.5 to 3.4, 6.5 to 2.9 min, and 6.5 to 2.8 min, resp.). Degree of softening (DS) was decreased by CSP/wheat dough, compared with wheat dough. The higher ratio of CSP/wheat, the lower DS. However, 7S and 11S showed the opposite effect on DS.

The water absorption increased with the addition of CSP, 7S, and 11S. This was in accordance with Traynham et al. [26], who found that the water-absorbing capacity increased as the proportion of soy flour increased. The results were attributed to the increment in total protein proportion. CSP

Table 2: The effect of wet gluten and farinographic properties on soy/wheat dough.

		WAC/%	S/min	DS (12 min)/FE	GSW/%
	Wheat	60.1 ± 0.5^{b}	6.5 ± 0.5^{b}	71.0 ± 1.0^{e}	29.9 ± 1.5^{cd}
CSP	2.0%	60.1 ± 1.2^{b}	8.4 ± 0.1^{a}	68.0 ± 3.0^{ef}	33.4 ± 1.2^{abc}
	3.0%	60.5 ± 1.3^{b}	8.5 ± 0.2^{a}	64.0 ± 1.0^{gf}	31.0 ± 1.2^{cd}
	4.0%	60.8 ± 1.4^{b}	7.3 ± 0.1^{b}	62.0 ± 2.0^{g}	29.0 ± 1.1^{d}
11S	2.0%	62.7 ± 1.5^{ab}	3.4 ± 0.1^{c}	87.0 ± 3.0^{d}	36.7 ± 2.0^{a}
	3.0%	63.0 ± 1.5^{ab}	2.9 ± 0.1^{cd}	93.0 ± 1.0^{c}	35.2 ± 1.2^{ab}
	4.0%	64.9 ± 1.5^{a}	2.8 ± 0.2^{d}	107.0 ± 1.0^{c}	31.8 ± 1.4^{bcd}
7S	2.0%	61.2 ± 1.3^{ab}	3.3 ± 0.2^{c}	112.0 ± 1.0^{b}	31.6 ± 1.1^{bcd}
	3.0%	61.9 ± 1.3^{ab}	2.4 ± 0.2^{d}	113.0 ± 2.0^{ab}	31.0 ± 1.3^{cd}
	4.0%	62.1 ± 1.2^{ab}	2.4 ± 0.2^{d}	128.0 ± 2.0^{a}	30.7 ± 1.5^{cd}

WAC, water absorption; S, dough stability; DS, degree of softening (ICC/12 min after max.); GSW, gluten yield calculated from the weight of wet gluten and the weight of soy/wheat flour blend used; wheat, wheat flour; 2.0%, 3.0%, 4.0%, incorporation of 2.0%, 3.0%, and 4.0% of CSP, 7S, and 11S with wheat flour, respectively. Values followed by the same letter within a column are not significantly different ($P > 0.05$). The data was presented as the mean ± the standard deviation of three independent experiments.

Table 3: Sensory score of steamed bread.

Addition		Specific volume	Exterior appearance	Structure	Taste	Flavor	Total score
Control	Wheat	15.5 ± 0.8^{d}	19.7 ± 0.5^{c}	29.6 ± 0.1^{bc}	13.0 ± 0.2^{a}	4.3 ± 0.2^{ab}	82.1 ± 1.8^{c}
CSP	2.0%	15.3 ± 0.2^{d}	20.6 ± 0.3^{b}	29.3 ± 0.2^{cd}	13.0 ± 0.1^{a}	4.3 ± 0.2^{ab}	82.5 ± 1.0^{c}
	3.0%	14.9 ± 0.1^{d}	19.8 ± 0.4^{c}	28.9 ± 0.1^{e}	12.9 ± 0.2^{ab}	4.2 ± 0.1^{abc}	80.7 ± 0.9^{c}
	4.0%	13.1 ± 0.3^{e}	17.4 ± 0.7^{e}	29.0 ± 0.3^{de}	12.5 ± 0.1^{bc}	4.0 ± 0.1^{bc}	76.0 ± 1.5^{d}
11S	2.0%	17.8 ± 0.2^{bc}	22.4 ± 0.2^{a}	29.9 ± 0.1^{ab}	12.3 ± 0.4^{c}	4.3 ± 0.2^{ab}	86.7 ± 1.1^{b}
	3.0%	18.6 ± 0.5^{a}	23.1 ± 0.1^{a}	30.1 ± 0.1^{a}	12.9 ± 0.3^{ab}	4.4 ± 0.1^{a}	89.1 ± 1.1^{a}
	4.0%	17.5 ± 0.6^{bc}	19.2 ± 0.6^{c}	28.9 ± 0.3^{e}	12.6 ± 0.2^{abc}	4.0 ± 0.3^{bc}	82.2 ± 2.0^{c}
7S	2.0%	17.1 ± 0.1^{c}	18.3 ± 0.2^{d}	28.4 ± 0.2^{f}	12.8 ± 0.3^{ab}	4.2 ± 0.2^{abc}	80.8 ± 1.0^{c}
	3.0%	17.9 ± 0.1^{ab}	18.3 ± 0.4^{d}	29.3 ± 0.3^{cd}	13.0 ± 0.1^{a}	3.9 ± 0.1^{c}	82.4 ± 1.0^{c}
	4.0%	17.6 ± 0.5^{bc}	17.5 ± 0.3^{e}	29.0 ± 0.2^{de}	12.9 ± 0.1^{ab}	4.1 ± 0.2^{abc}	81.1 ± 1.3^{c}

Wheat, wheat flour; 2.0%, 3.0%, and 4.0%, incorporation of 2.0%, 3.0%, and 4.0% of CSP, 7S, and 11S with wheat flour, respectively. Values followed by the same letter within a column are not significantly different ($P > 0.05$). The data was presented as the mean ± the standard deviation of three independent experiments.

had a positive influence while 7S and 11S showed the opposite effect on farinographic S and DS. Flour mixed with 7S or 11S separately was able to decrease the soy/wheat dough quality. Maforimbo et al. [27] revealed that dough weakening was due to the increased -SH content. Moreover, substitution of gluten proteins by non-gluten-forming proteins caused a dilution effect and consequently weakened the dough. Ryan and Brewer [25] reported that soy protein isolates and the 11S soy globulin fraction, but not 7S soy globulin fraction, formed aggregates with wheat puroindolines from vitro studies. 11S, not the 7S, has some of sulfhydryl (-SH) and further the wheat dough when soy protein was added. Therefore, the proportion of 7S and 11S had a significant effect on soy protein quality.

3.2. Dynamic-Mechanical Analyses. The effect of soy products on dynamic-mechanical properties of dough is shown in Figure 2. When the level of CSP, 7S, or 11S is at 2%, CSP/wheat flour had the highest storage modulus and loss modulus, and the lowest storage modulus and loss modulus were found in 7S/wheat dough (Figures 2(a1) and 2(a2)). The storage modulus and loss modulus of soy/wheat dough were decreased in the order of CSP, control, 11S soy globulin, and 7S soy globulin (Figures 2(a1) and 2(a2)). The same regularity was also found in the samples with 3% and 4% of CSP, 7S, and 11S soy globulin (Figures 2(b1), 2(b2), 2(c1), and 2(c2)).

Roccia et al. [28] reported that there is a clear correlation between the storage or loss modulus and the typical viscoelastic behavior of dough. It indicated that the less destruction of gluten was obtained when the storage modulus and loss modulus were higher. A firmer and more consistent CSP/wheat dough was obtained, probably due to higher cross-linking of gluten and soy proteins. This result was consistent with the farinograph results.

3.3. Sensory Analysis. The sensory scores of SB are summarized in Table 3. When CSP and 7S were added at the level of 2% or 3%, the sensory scores of SB did not show significant differences ($P < 0.05$) in comparison with the control. When 11S soy globulin was at the level of 2% or 3%, the sensory scores of SB were higher than the control. The sensory score (89.1 points) of SB was the highest when 3% 11S was added

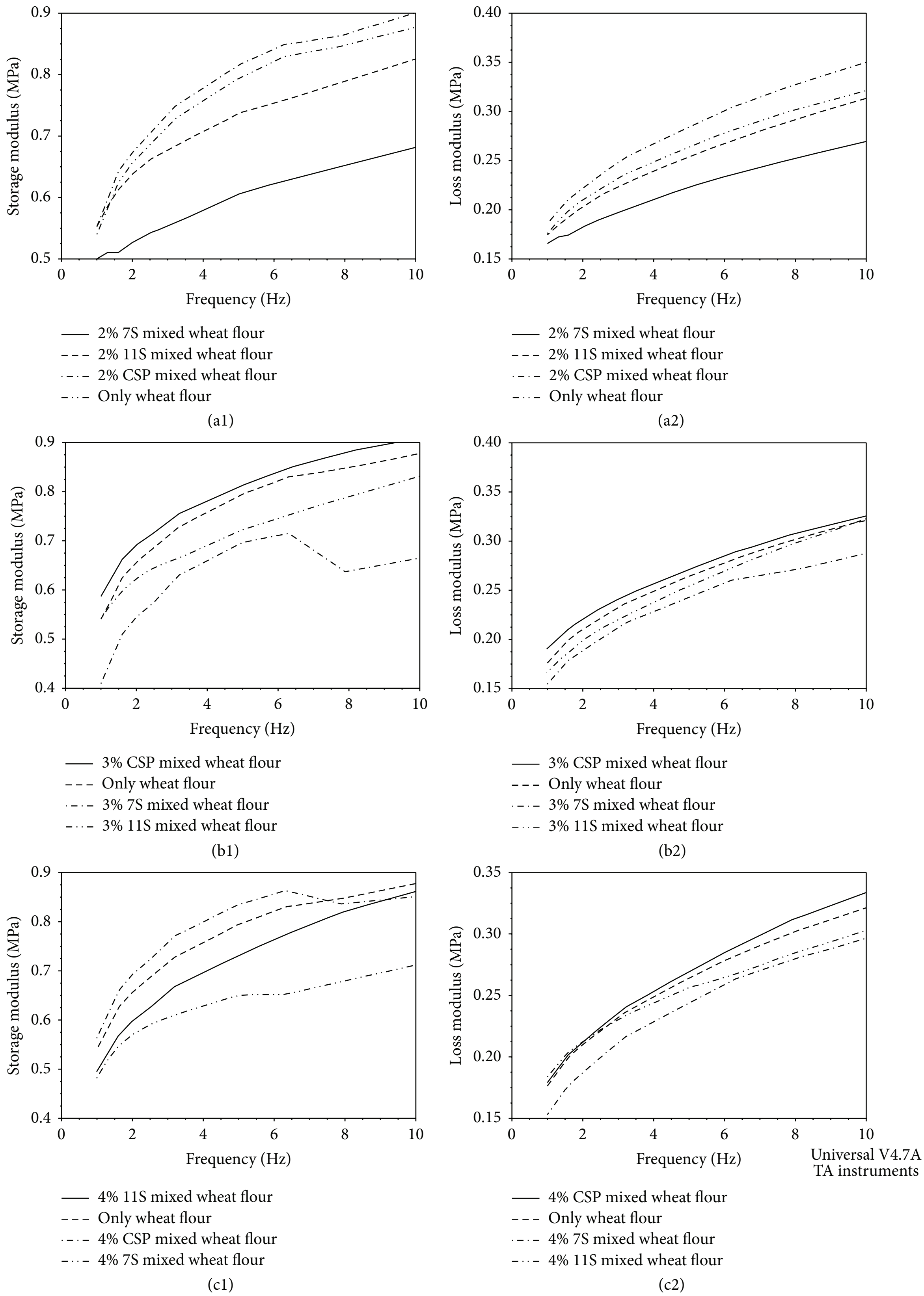


Figure 2: The effect of CSP, 7S, and 11S soy protein on dynamic-mechanical properties of dough. (a1) the effect of adding 2% CSP, 7S, and 11S soy protein on storage modulus of dough; (a2) the effect of adding 2% CSP, 7S, and 11S soy protein on loss modulus of dough; (b1) the effect of adding 3% CSP, 7S, and 11S soy protein on storage modulus of dough; (b2) the effect of adding 3% CSP, 7S, and 11S soy protein on loss modulus of dough; (c1) the effect of adding 4% CSP, 7S, and 11S soy protein on storage modulus of dough; (c2) the effect of adding 4% CSP, 7S, and 11S soy protein on loss modulus of dough.

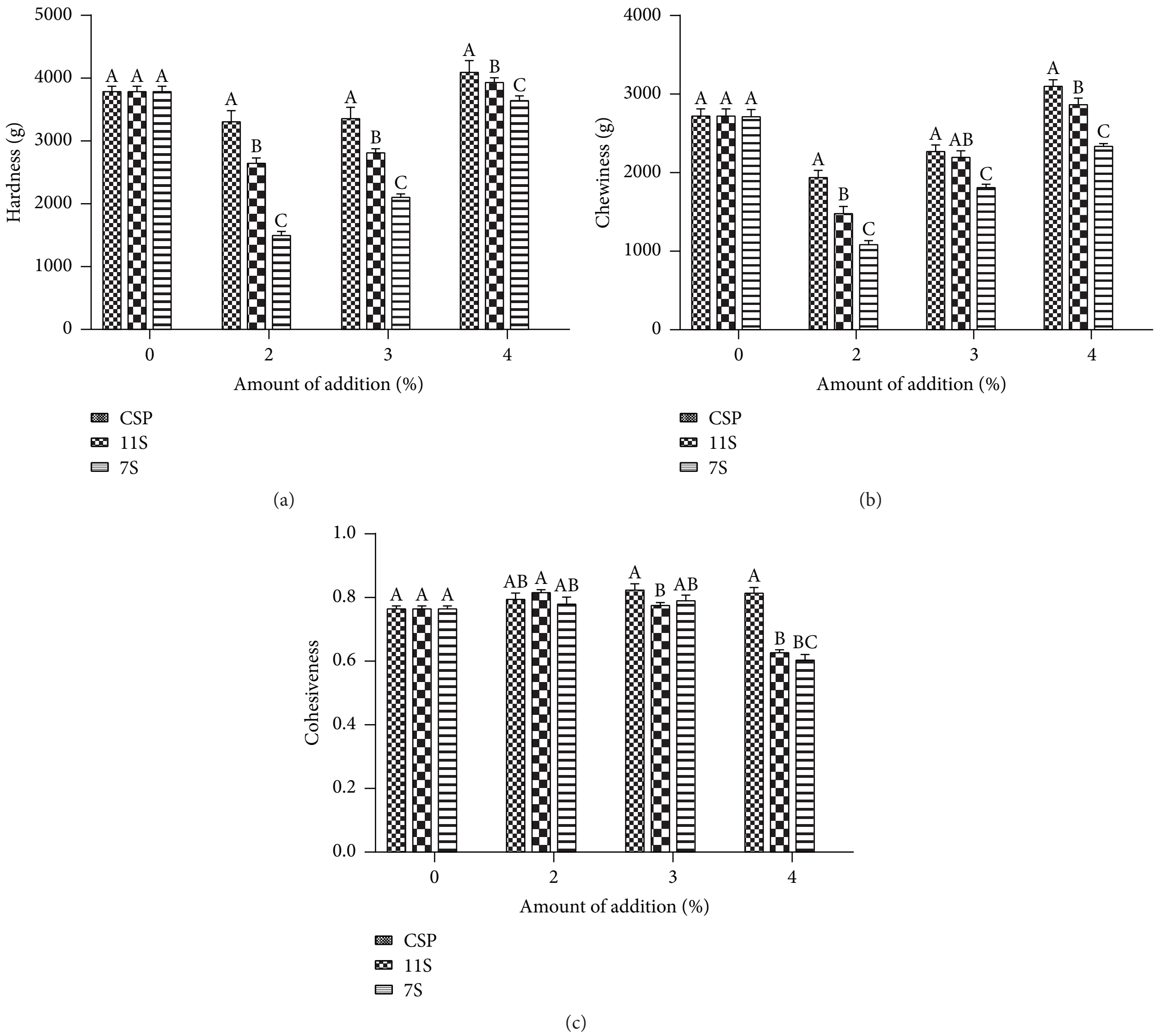


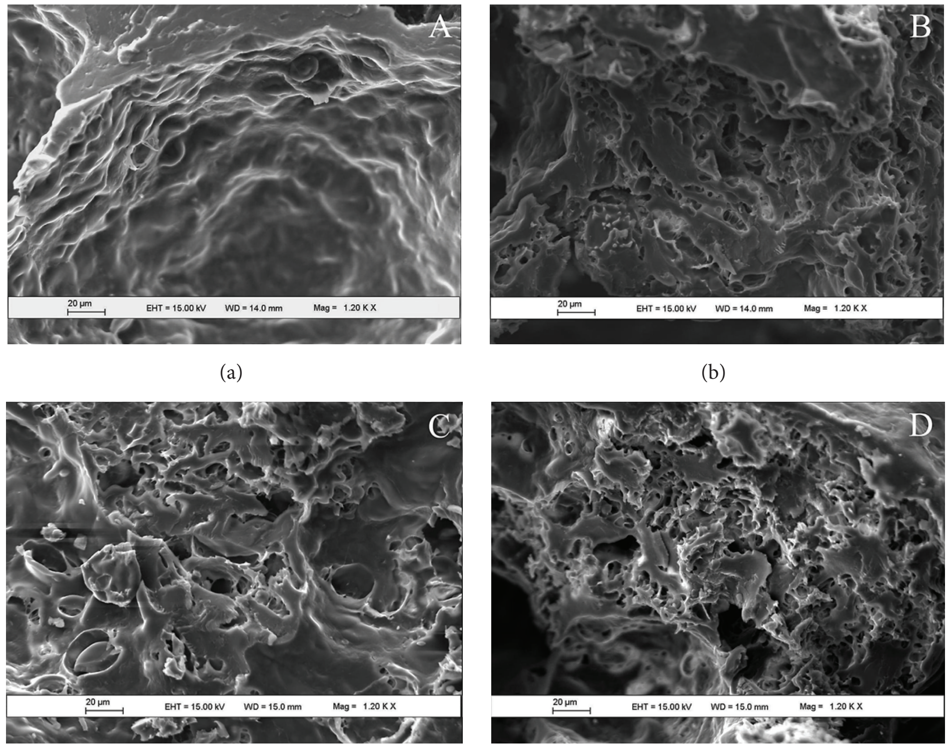
Figure 3: Influence of CSP, 7S, and 11S soy protein and their level of inclusion on hardness, chewiness, and cohesiveness of steamed bread (control, wheat flour; 2.0%, 3.0%, 4.0%, incorporation of 2.0%, 3.0%, 4.0% of CSP, 7S, and 11S with wheat flour, resp.). A, B, C, AB, and BC: values followed by the same letter within a column are not significantly different ($P > 0.05$).

to wheat flour. However, when CSP, 7S, and 11S were added to wheat flour at 4%, the sensory score of steamed bread was not higher than the control.

The quality of steamed bread decreased by 2%, 3%, or 4% of CSP, 7S, and 11S soy globulin, especially in specific volume and exterior appearance. Specific volume (volume/weight) and exterior appearance are an important factor for the quality of SB [9]. The sensory score (89.1 points) of steamed bread with 3% 11S was the highest. Results indicated that adding small amount (<4%) of 11S soy globulin improved the steamed bread quality. When 11S soy globulin added to wheat flour, the properties of the dough were weakened, but the specific volume of SB was improved. This attributed to the significantly negative correlation between the specific volume with stability (S).

3.4. Texture Analysis of SB. The effect of soy products on SB hardness is shown in Figure 3(a). The hardness of SB was increased when the CSP, 7S, or 11S was added to wheat dough. When the CSP, 7S, and 11S/wheat ratios were at 4%, the hardness of steamed breads was higher than the control. For incorporation of CSP, 7S, and 11S at the same level lower than 4%, the SB made of 7S/wheat flour had the lowest hardness. For SBs with CSP, 7S, and 11S at the same level lower than 4%, the hardness was decreased in the order of control, CSP, 11S, and 7S.

As shown in Figure 3(b), with the ratio of CSP, 7S, or 11S/wheat increasing, the chewiness of the SBs increased. For those that were added at 4%, the chewiness was higher than the control sample. For SBs with CSP, 7S, and 11S at the same level lower than 4%, the chewiness decreased in the order of control, CSP, 11S, and 7S.



(a) (b) (c) (d)

Figure 4: Scanning electron microscope graphs obtained from the steamed bread. (a) Steamed bread made of wheat flour; (b) Steamed bread made of wheat flour adding 3% CSP; (c) Steamed bread made of wheat flour adding 3% 11S soy protein; (d) Steamed bread made of wheat flour adding 3% 7S soy protein.

The effect of soy products on SB cohesiveness is shown in Figure 3(c). The wheat flour with 2% CSP, 7S, and 11S soy globulin had no significant changes in cohesiveness. The same results were also found in the samples with CSP, 7S, or 11S soy globulin at 3% level, while, for the wheat flour with CSP, 7S, and 11S soy globulin at 4% level, significant differences were shown in the cohesiveness compared to the control sample. For those at 4% level, steamed bread cohesiveness was decreased in the order of control, CSP, 11S, and 7S.

The TPA results suggested that, for SBs with CSP, 7S, and 11S at 3% level, no pernicious quality was shown compared with the control. The texture analysis data was consistent with the result of sensory analysis. TPA (texture profile analysis) is an objective method of sensory analysis. The texture analysis index was significantly associated with most taste test indicators, the hardness, chewiness, and cohesiveness affected by the comprehensive score of SB [1]. There is a linear relationship between hardness and chewiness in the SB (R value is 0.974). The crumb became harder (increased hardness), requiring more energy to disintegrate during chewing (increased gumminess) and a longer time for mastication (increased chewiness) [29]. SB chewiness has effects on the gluten network structure, which is associated with the degeneration of the steamed bread loose tastes. This result was consistent with the result of farinograph and DMA analysis. Good steamed bread should be the moderate chewiness, and the quality of steamed bread would be decreased, when the chewiness of SB was too big or too small.

3.5. Microphotographs of Steamed Bread (SB). The microstructure of SB in this study is shown in Figure 4. SB, which is made of wheat flour, had the continuity of gluten network structure when compared to the others. SB made of mixed flour with CSP, 7S, and 11S, had discontinuity gluten with higher quantity irregular cavity. Gluten network structure of SB was less damaged in the order of 7S, 11S, CSP, and control.

The result indicated that gluten network structure of SB with addition of 11S had a better continuity than the one with 7S soy globulin. These observations were consistent with the farinograph parameters and dynamic-mechanical analysis index.

4. Conclusions

Soy protein has been reported to improve the protein quality of wheat flour considerably and is mainly used for making pasta and bread. However, most studies used crude soy protein or soy flour, and the effect of soybean components on wheat dough and wheat products quality remained obscure. In this work, the CSP, 7S, and 11S soy globulin fraction obtained from commercial defatted soy flour were added to wheat flour. The mixing properties of the dough and the quality attributes of SB were investigated. It was demonstrated that the content of gluten was decreased with the increase of wheat substitution (CSP, 7S, or 11S). In addition, the storage modulus and loss modulus of soy/wheat dough were decreased in the order of CSP, control, 11S, and 7S. On the texture, microstructure, and sensory analysis of SB, the quality of streamed bread at 3% 11S to wheat flour was the highest.

In summary, small amount (<4%) of 11S soy globulin could improve the steamed bread quality and weaken the properties of the dough. So the flour with appropriate wet gluten content and moderate stability time could be made into the high-quality products. The addition of soy protein products in wheat flour can improve the protein quantity and quality of the SB. In view of the increasing popularity and demand of ready to eat convenient and nutritive foods, these steamed breads have been produced at a larger scale of factory level. These findings indicate that 11S has the potential to be used as a special soy protein for SB making. These results provide theoretical basis for the production of special soy protein.

Competing Interests

The authors have declared no competing interests.

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