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Steamed Bread Quality as Influenced by the Incorporation of Purple Sweet Potato Powders

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Abstract

As an attempt to develop a value-added food product, purple sweet potato powder was added in a model system of steamed bread as a healthy food ingredient and physicochemical properties such as moisture content, specific volume, spread ratio, color, texture as well as consumer preferences on the attributes such as uniformity, color, flavor, elasticity, chewiness, taste, and overall preference were evaluated. Moisture content ranged from 44.16 to 44.55% (wet basis) and appeared independent on the level of purple sweet potato (PSP) powder incorporation. As a result of the addition of PSP powder, the specific volume of steamed bread decreased from 3.22 to 2.55 mL/g, and value of 4.5% sample was significantly lower than other samples ($p < 0.05$). On the other hand, spread ratio ranged from 2.01 to 2.53, and appeared to decrease as the PSP powder concentration increased ($p < 0.05$), indicating a significant improvement. Lightness (L^*) decreased significantly as the PSP powder content increased ($p < 0.05$) for both dough and skin of the steamed bread. In addition, an increasing trend in redness (a^*-value) and a decreasing trend in yellowness (b^*-value) were noticed. Firmness increased significantly with the addition of PSP powder regardless of concentration ($p < 0.05$); however, firmness was not significantly different among samples containing 1.5-4.5% PSP powder ($p > 0.05$). Consumer acceptance test indicated that incorporation of 3% PSP powder in the formulation of steamed breads would be recommended.

Key words: steamed bread, purple sweet potato, incorporation, physicochemical, consumer acceptance

Introduction

Steamed bread is the traditional staple food in northern China (Lin et al., 2010) and about 40% of wheat flour is consumed to make the steamed bread (He et al., 2003; He et al., 2004; Zhang et al., 2007). In Korea, Japan, and south-east Asian countries, stuffed steamed breads which contains meat and vegetable, or sweet bean paste are also popular (Koike et al., 1998). Quality and taste preferences of steamed bread vary depending on the formulations and processing procedures between countries as well as within a country (Huang et al., 1993). A smooth and blister-free external surface are preferred while important texture quality factors to control are elasticity, cohesiveness, and stickiness (Huang et al., 1998).

Several studies have been reported for analyzing processing procedures and qualities of steamed bread. Many investigations were conducted to elucidate the effect of wheat varieties or flour on the quality of steamed bread (Lin et al., 1990; Koike et al., 1998; Kim et al., 2001a; Kim et al., 2001b; He et al., 2003; Chen et al., 2007; Peng et al., 2007; Zhang et al., 2007; Ying et al., 2008; Fan et al., 2009; Lin et al., 2010). In addition, optimization of processing procedures using the response surface methodology in steamed bread making (Huang et al., 1993; Huang et al., 1998; Oh et al., 2002), and storage of steamed bread (Choi et al., 2007) were also reported.

Purple sweet potato has been regarded as a good source of stable anthocyanins (Wang et al., 2010), and its color has been reported to exhibit multiple physiological functions such as antioxidant effects (Shin et al., 2007), antihyperglycemic effects (Matsui et al., 2002), and anti-inflammatory effects (Karlsen et al., 2007). The purple sweet potato color repairs D-galactose-induced spatial learning and memory impairment (We et al., 2008), suppresses lipopolysaccharide-induced acute inflammatory response in mouse brain (Wang et al., 2010), and protects mouse liver against D-galactose-induced apoptosis (Zhang et al., 2010). Due to its functional and sensorial properties, purple sweet potato has been utilized for many types of food; such as bread (Kim & Ryu, 1997), curd yogurt (Lee et al., 1999), yogurt (Jung & Ju, 1997; Chun et al., 2000), Korean traditional liquor (Han et al., 2002), *Yanggeng* (Lee & Choi, 2009), almond *Dasik* (Jang & Chung, 2009), and *Sulgidduk* (Ahn, 2010).

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Despite previous investigations and applications, no study has been reported on the effect of purple sweet potato powder on the quality of steamed bread to the best of our knowledge in the literature. An attempt was made to develop a value-added food product; purple sweet potato powder was added in a model system of steamed bread as a healthy food ingredient and physicochemical properties such as moisture content, specific volume, spread ratio, color, texture as well as consumer acceptances in terms of color, chewiness, flavor, taste, uniformity, springiness, and overall acceptance were evaluated.

Materials and Methods

Preparation of raw materials

Purple sweet potato powder, dried at 55°C for 3 days (Jisan Foods Co., Ltd., Hamyang, Gyeongnam, Korea) was purchased via Internet and sieved to obtain the particle sizes less than 425 μm. Fortified multipurpose medium flour (Samyang Corp., Seoul, Korea), baking powder (Sunin Co., Ltd., Chungnam, Korea), dry yeast (Societe Industrielle Lesaffre, France), salt (Daehan Salt Co., Ltd., Incheon), and water (Haitai Beverage Co., Ltd., Seoul, Korea) were procured from a local market and stored at room temperature except for dry yeast which was stored at 4°C before use.

Steamed bread making

Sieved dry ingredients (purple sweet potato powder, medium flour, baking powder, and salt) and dry yeast soaked in water for 5 min were mixed and kneaded in a bowl using a Kitchen Aid mixer (model 5K5SS, Whirlpool Corp., St. Joseph, MI, USA) with a flat beater attachment for 5 min at the second speed and additional 10 min at the third speed to form the mixture into dough. The dough was proofed for 30 min at 27°C and 80% relative humidity. The each piece of dough (80 g per piece) was rounded and molded manually and proofed again for 40 min at 35°C and 85% relative humidity. The proofed dough was steamed for 15 min using a steam tray and boiling water.

The effect of purple sweet potato powder was studied by adding the powder in the range of 0-4.5% based on the Baker's percentages as given in Table 1. The samples were cooled to room temperature for 15 min and packed in airtight bags for further analyses.

Specific volume, spread ratio and moisture content

After a cooling period of 15 min, the weight of the sample was measured with an electronic balance and the volume was determined by rapeseed displacement. The specific volume was calculated as the ratio of volume to weight. The width and height of each sample was measured at different locations, and the mean values were determined. Spread ratio was expressed as the sample width to height ratio. Moisture content was determined using a convection oven at 105°C overnight. All tests were performed in triplicate.

Table 1. Bread dough composition, added with different percentages of purple sweet potato powder

Ingredients (g)	Purple sweet potato powder level in steamed bread (%)			
	0	1.5	3	4.5
Purple sweet potato powder	0	3	6	9
Wheat flour	200	197	194	191
Baking powder	3	3	3	3
Dry yeast	3	3	3	3
Salt	2	2	2	2
Water	120	120	120	120

Color

CIE color characteristics (L^*, a^*, and b^*) of steamed bread were determined using a spectrophotometer (model CM-600d, Minolta Co., Osaka, Japan) calibrated with a white calibration plate. The spectrophotometer used xenon pulse-diffused illumination with silicon photodiode array detector set at 8° viewing angle. In addition, the machine was preset to use the 2° observer. Five measurements were made on the each test piece at the same location (one in center and four measurements at the edges for each top and bottom sides) using three doughs as well as steamed breads for each treatment and mean values were reported.

Texture

Within 1 hr of steaming, texture profile analysis of steamed bread was carried out using a computer-controlled Advanced Universal Testing System (LRXPlus, Lloyd Instrument Limited, Fareham, Hampshire, UK) at room temperature. A test speed of 1.0 mm/s and 1.2-cm diameter stainless steel cylinder probe was used for this purpose. The individual samples ($2.5 \times 2.5 \times 2.5$ cm) were compressed to 30% deformation. The peak force of the compression curve was reported as crumb firmness (kg_f). Twelve replicate tests were carried out for each condition.

Consumer acceptance tests

The consumer acceptability of the steamed breads made

with purple sweet potato powder was determined by a consumer hedonic testing using a nine-point hedonic scale (9=extremely like, 8=very much like, 7=moderately like, 6=slightly like, 5=neither like nor dislike, 4=slightly dislike, 3=moderately dislike, 2=very much dislike, and 1=extremely dislike). Forty-nine consumers, consisted of 25 male and 24 female aged from 20 to 29 years old, were asked to record their acceptability scores for the four samples with respect to color, flavor, taste, uniformity, chewiness, elasticity, and overall preference. After a cooling period of 15 min, steamed bread samples placed in a polyethylene bag for 2 hr at room temperature before they presented to the consumers. Each sample (quarter cut of each bread), randomly coded using a three-digit number, was evaluated in each session. Consumers received a tray containing the samples, a glass of water, and a evaluation sheet. Participants were asked to rinse their palates between samples and break for 30 s. Enough space was given to handle the samples and the questionnaire, and the evaluation time was not constrained.

Statistical analysis

The statistical analysis was done using the SAS Statistical Analysis System for Windows v9.1 (SAS Inst. Inc., Cary, N.C., U.S.A.). The means were compared with Duncan's Multiple Range test at the 5% level of significance and Pearson correlation coefficients were also determined.

Results and Discussion

Moisture content

Moisture content of steamed bread as influenced by the PSP powder incorporation is presented in Fig. 1. The values ranged from 44.16 to 44.55% and appeared independent on the addition of PSP powder in the formulation. On the other hand, Lee & Choi (2009) reported that moisture content of *Yanggeng* decreased from 45.47 to 33.40% with the incorporation of PSP powder up to 8%. The moisture content of *Sulgidduk* decreased from 39.63 to 36.03% with the addition of PSP powder up to 4% (Ahn, 2010).

Specific volume and spread ratio

Spread volume and spread ratio (width to height ratio, W/H) are the most important quality parameters for steamed bread (Su et al., 2005; Zhang et al., 2007). Spread volume and spread ratio of steamed bread as affected by PSP powder addition are shown in Fig. 2. As a result of the addition of PSP powder, the specific volume of steamed bread decreased from 3.22 to 2.55 mL/g, and value of 4.5% sample was significantly lower than other samples (p<0.05). The PSP powder contains a relatively lower amount of protein compared with other cereals (Kim & Ryu, 1995) but higher amount of starch which results in the weak gas holding capacity (Bekes et al., 1994; Yamada & Preston, 1994). The values fall within the range of specific volumes reported previously (Su et al., 2005; Choi et al., 2007). Wen et al. (1996) indicated that the specific volume is not a major concern unless it is less than 2.5 mL/g. On the other hand, spread ratio ranged from 2.01 to 2.53, and appeared to decrease as the PSP powder concentration increased (p<0.05), indicating a significant improvement. Huang et al. (1998) steamed bread quality is better with low spread ratio.

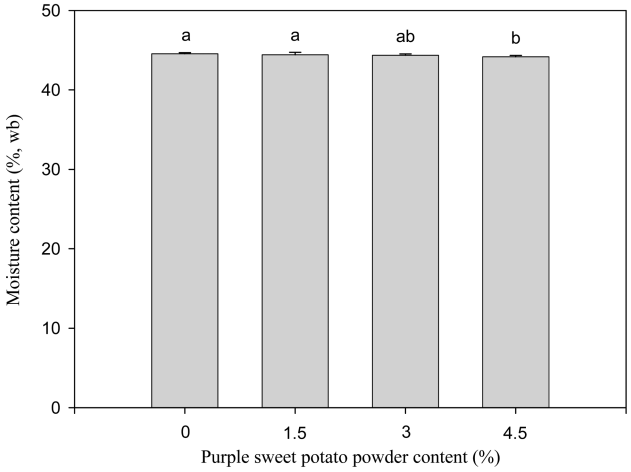

Fig. 1. Moisture content of steamed bread as influenced by PSP powder addition. Means without a common letter are significantly different (p<0.05).

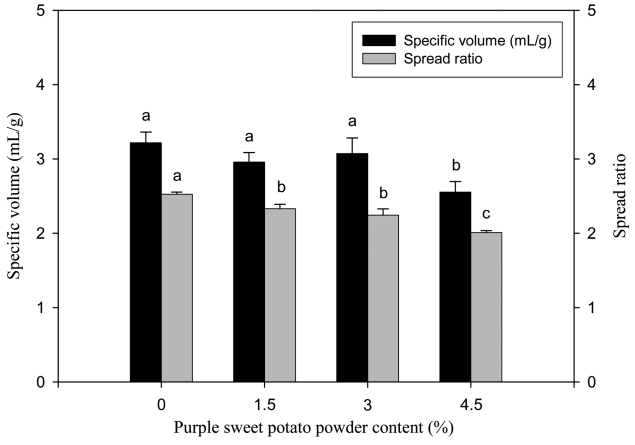

Fig. 2. Spread volume and spread ratio of steamed bread as influenced by PSP powder addition. Means within the same property without a common letter are significantly different (p<0.05).

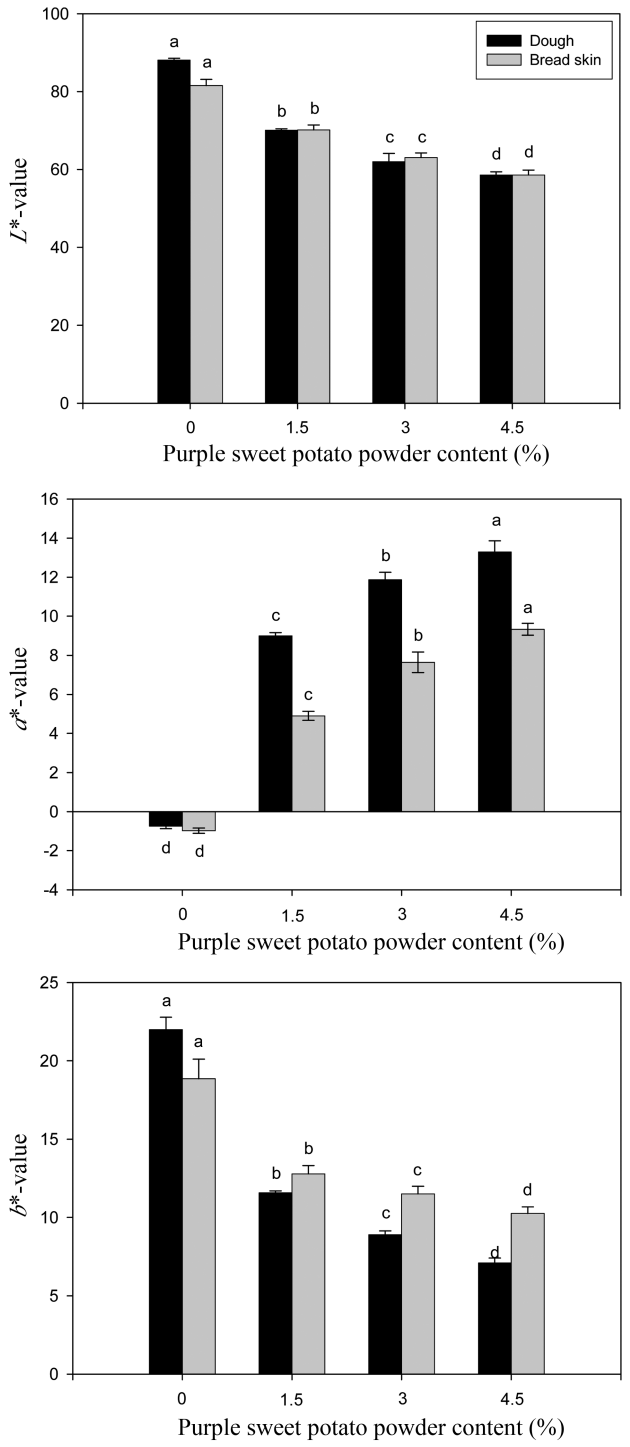

Fig. 3. Color characteristics of dough and skin of steamed bread as influenced by PSP powder addition. Means within the same sample without a common letter are significantly different (p<0.05).

Color

Changes in color parameters (L*-, a*-, and b*-value) of dough and steamed bread as influenced by PSP powder content are given in Fig. 3. Lightness (L*) decreased significantly as the PSP powder content increased (p<0.05) for both dough and skin of the steamed bread. The L*-values of the control dough and steamed bread were 88.07 and 81.56, which were significantly higher than other samples (p<0.05), and the value is comparable with the ones reported by others (Kim et al., 2001a; Jiang et al., 2010). In addition, an increasing trend in redness (a*-value) and a decreasing trend in yellowness (b*-value) were noticed. These similar results were previously reported when different levels of PSP powder were added for the making of pan bread (Kim & Ryu, 1997), Yogurt (Jung & Ju, 1997; Chun et al., 2000), almond *Dasik* (Jang & Chung, 2009), *Yanggeng* (Lee & Choi, 2009), and *Sulgidduk* (Ahn, 2010). Such changes in the color characteristics are inherent with distinctive color characteristics of food ingredients used in the formulation and it is partially due to the degradation of color pigments during steaming at such high temperature. These changes in color characteristics of dough and steamed bread can also be easily seen from the photos taken for comparison (Fig. 4).

Crumb firmness

Changes of crumb firmness as influenced by PSP powder incorporation are shown in Fig. 5. Firmness increased significantly with the addition of PSP powder regardless of concentration (p<0.05); however, firmness was not significantly different among samples containing 1.5-4.5% PSP powder (p>0.05). The firmness of the control increased by 16.67, 27.78, and 22.22% for samples with 1.5, 3, and 4.5% PSP powder addition, respectively. The less gas generated in samples containing the PSP powder may have contributed to the lower volume of the steamed bread, and this in turn results in the higher firmness (Yeh et al., 2009). Similar increases in the hardness or firmness as the PSP content increased were reported for bread (Kim & Ryu, 1997) and almond *Dasik* (Jang & Chung, 2009). It was speculated that PSP powder more tightly bonded with wheat flour which resulted in the increase in the firmness (Jang & Chung, 2009; Kim et al., 2009).

Consumer acceptance

A 9-point hedonic scale was used to determine which steamed breads incorporated with different levels of PSP powder were preferred by the majority of consumers. Table 2 shows the mean scores of consumer acceptance results on the several attributes including color, chewiness, flavor, taste, uniformity, springiness, and overall acceptability. In terms of color, 1.5% sample received the least favorable mean scores of

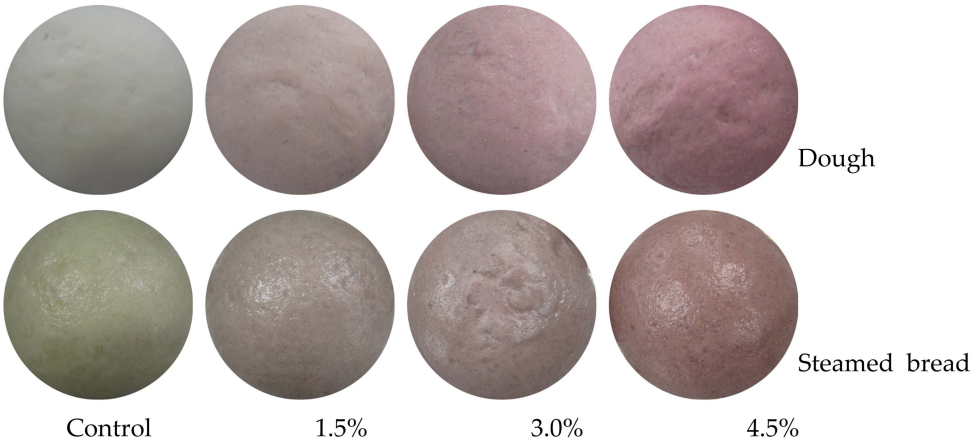

Fig. 4. Appearance of dough and steamed bread as influenced by PSP powder addition.

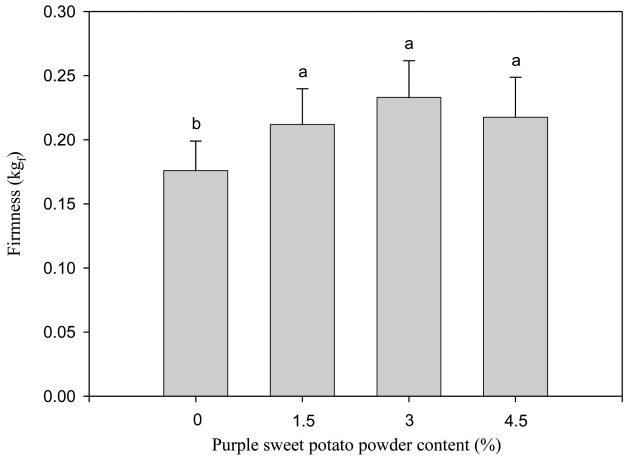

Fig. 5. Crumb firmness as influenced by PSP powder addition. Means without a common letter are significantly different (p<0.05).

Table 2. Effect of PSP powder incorporation on consumer acceptance of steamed bread

Attributes	PSP powder level in steamed bread (%)			
	0	1.5	3	4.5
Color	6.35±1.64^{a}	4.63±1.51^{b}	5.83±1.49^{a}	5.88±1.76^{a}
Chewiness	5.42±1.57^{a}	5.21±1.61^{a}	5.25±1.92^{a}	4.77±2.01^{a}
Flavor	5.38±1.75^{a}	5.17±1.46^{a}	4.92±1.71^{a}	4.23±1.67^{b}
Taste	5.27±1.62^{a}	5.04±1.34^{a}	5.23±1.60^{a}	4.85±1.60^{a}
Uniformity	5.67±1.45^{a}	5.67±1.64^{a}	5.50±1.47^{a}	4.63±1.77^{b}
Springiness	6.10±1.43^{a}	5.54±1.50^{ab}	5.65±1.76^{ab}	5.04±1.70^{b}
Overall acceptance	5.85±1.54^{a}	5.19±1.14^{b}	5.54±1.73^{ab}	4.50±1.69^{c}

$^{a-c}$Means (±standard deviation) within the same row without a common letter are significantly different (p<0.05).

4.63 while control, 3 and 4.5% samples were not significantly different among them (p>0.05). Nevertheless, control received the highest mean score of 6.35, probably due to the fact that consumers get used to the original white color of steamed bread.

The consumer preferences on chewiness, flavor, and taste were not significantly affected by the amount of PSP powder incorporated in the sample (p<0.05). The acceptability scores varied from 4.77 to 5.42, 4.23 to 5.38, and 4.85 to 5.27 for chewiness, flavor, and taste, respectively. Notwithstanding, decreasing trends for these attributes as the PSP powder content increased were noticed. In addition, the uniformity acceptance of 4.5% sample was significantly lower while springiness acceptance of the control was significantly higher than other samples (p<0.05).

With respect to overall acceptability, control sample received the highest mean score of 5.85 and it was not significantly different from that of 3% sample (p>0.05). Four point five % sample received the lowest mean score of 4.50, significantly lower score than other samples (p<0.05). It is noted that incorporation of 3% PSP powder in the formulation of steamed breads did not significantly influence the consumers' acceptability in all attributes. Therefore, incorporation of 3% PSP powder in the formulation of steamed breads would be recommended while taking advantages of health benefits of PSP powder without the sacrificing of consumers' acceptance.

Correlation

Correlation coefficients between physicochemical properties and consumer acceptances of steamed breads are given in Table 3. Traits showing non-significant correlations are not presented. The PSP powder concentration showed negative correlations with moisture content, spread ratio, L^*-value, and flavor acceptability but was significantly and positively correlated with a^*-value (p<0.05). This indicates that high PSP powder content will contribute to positively to the improvement of

Table 3. Correlation matrix linking physicochemical properties and consumer acceptances of steamed breads incorporated with different levels of PSP powder

Property/Attribute		PSP[1]	Physicochemical properties					Consumer attributes					
			MC[2]	Specific volume	Spread ratio	*L**	*a**	Chewiness	Flavor	Taste	Uniformity	Springiness	Overall acceptability
Physico-chemical	PSP								-0.955*				
	MC	-0.971*						0.972*	0.987*			0.968*	
	Specific volume		0.952*					0.995**		0.967*		0.972*	0.993**
	Spread ratio	-0.988*	0.994**						0.970*			0.963*	
	*L**	-0.980*			0.963*								
	*a**	0.962*				-0.007**							
	*b**					0.974*	-0.989*						
Consumer attributes	Chewiness		0.973*	0.995**							0.950*	0.968*	0.978*
	Flavor	-0.955*	0.987*		0.970*			0.965*			0.968*		
	Taste			0.967*									0.985*
	Uniformity							0.950*	0.968*				
	Springiness		0.968*	0.972*	0.963*			0.968*					0.977*
	Overall acceptability			0.993**				0.978*		0.985*		0.977*	

[1] PSP powder concentration, [2] Moisture content, * Significant at $p<0.05$, ** Significant at $p<0.01$.

steamed bread, but they could produce the steamed bread with poor flavor. In addition, significantly positive correlations between moisture content and specific volume, spread ratio, and acceptabilities of chewiness, flavor, and springiness were observed ($p<0.05$). Overall acceptability was significantly and positively correlated with specific volume and acceptabilities of chewiness, taste, and springiness ($p<0.05$).

Conclusion

PSP was successfully incorporated into a model system of steamed bread as a healthy food ingredient. Most physicochemical properties and consumer preferences were significantly influenced by the level of PSP incorporation. Based on the consumer acceptance test, incorporation of 3% PSP powder in the formulation of steamed breads would be recommended. These results would give a valuable information for the development of new type of value-added food product.

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