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Influence of Buckwheat Flour on Physicochemical Properties and Consumer Acceptance of Steamed Bread

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Abstract

Buckwheat flour was incorporated into steamed breads by adding the flour in the range of 0～9% based on the Baker's percentages and the physicochemical properties and consumer acceptance were investigated. After mixing, kneading, proofing, and molding, bread dough was steamed for 15 min using a steam tray and boiling water. The samples were cooled to room temperature for 15 min and packed in airtight bags for further analyses. pH of the steamed bread decreased slightly while titratable acidity increased significantly from 1.02 to 1.37 mL with the incorporation of more buckwheat flour in the formulation ($p<0.05$). Water activity was not affected by the buckwheat flour level ($p>0.05$). Moisture content slightly decreased from 43.72 to 42.30% while soluble solids content increased from 0.63 to 0.85 as the buckwheat flour concentration increased. As a result of the addition of buckwheat flour, the specific volume decreased from 3.31 to 2.57 mL/g; on the other hand, the spread ratio ranged from 2.17 to 2.21 without significant differences among them ($p>0.05$). At the higher level of buckwheat content, lower scores of all color parameters (*L, *a**, and *b**-values) were observed. Firmness increased significantly with an increase in buckwheat flour content ($p<0.05$). Consumer acceptance tests indicated that incorporation of up to 3% buckwheat flour in the formulation of steamed breads did not significantly influence the consumers' acceptability in all attributes tested, except for color and elasticity.**

Key words: steamed bread, buckwheat, physicochemical, consumer acceptance

INTRODUCTION

Steamed bread is the traditional staple food in northern China and about 40% of wheat flour is consumed to make the steamed bread (1,2). In Korea, Japan, and Southeast Asian countries, streamed breads with various types of fillings are also popular (3). Quality and taste preferences of streamed bread vary, depending on the formulations and processing procedures not only between countries but also within a country (3). A smooth and blister-free external surface is preferred, and eating qualities such as elasticity, cohesiveness, and stickiness are important factors to control the quality of steamed bread (4).

Several studies have been reported for analyzing processing procedures and qualities of streamed bread. Zhu et al. (5) investigated the protein content of flour and the composition of high-molecular-weight glutenin subunits in relation to the quality of Chinese streamed bread. The effect of wheat varieties or flour on the quality of streamed bread (6-9), optimization of processing procedures using the response surface methodology in streamed bread making (3,9), and storage of steamed bread (10) were also reported.

Buckwheat belongs to the family of *Polygonaceae*, and contains starch (65～75%), proteins (10～12.5%), lipids (4.7%), many valuable compounds such as minerals (Mg, P, and K) (11), essential amino acids, phytosterols, dietary fibers, low molecular weight sugars, rutin (flavonal glycoside), and antioxidant compounds (12-15). Because of its functional and sensorial properties, buckwheat has been utilized for many types of food, such as bread (16,17), noodle (18), *Gochujang* (19), *Jeolpyon* (20), soba noodles (21), yellow layer cake (22), steamed cake (23), *Sulgidduk* (24), and spaghetti (11).

Despite these previous investigations and applications, no study, to our knowledge, has the investigated the effect of buckwheat flour on the quality of steamed bread. We are attempting to develop a value-added food product, such that buckwheat flour was added in a model system of steamed bread as a healthy food ingredient. The physicochemical properties such as pH, titratable acidity, water activity, moisture content, soluble solids content, specific volume, spread ratio, color, texture as well as consumer preferences in terms of color, texture, flavor, taste, uniformity, chewiness, elasticity, and overall preference were evaluated.

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MATERIALS AND METHODS

Preparation of raw materials

Buckwheat flour (Bongpyeong Co-op., Bongpyeong, Gangwon, Korea), medium flour (Q.one, Chungnam, Korea), baking powder (Sunin Co., Ltd., Chungnam, Korea), dry yeast, salt, and water (Haitai Beverage Co., Ltd., Seoul, Korea) were procured from a local market and stored at room temperature before use.

Steamed bread making

Sieved dry ingredients (buckwheat flour, medium flour, baking powder, and salt) and dry yeast soaked in water for 5 min, then 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 piece 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 buckwheat flour was studied by adding the flour in the range of 0～9% 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.

pH and total titratable acidity

pH and total titratable acidity (TTA) of dough and steamed bread were determined according to Bastetti (25). The samples (10 g) were homogenized with 90 mL of double distilled water. The pH value was recorded using a PHM210 Standard pH meter (Radiometer Analytical, Lyon, France) and the acidity was titrated with 0.1 N NaOH to a final pH 8.5. The TTA was expressed in mL of 0.1 N NaOH. All measurements were done in triplicate.

Water activity, moisture content, and soluble solids content

Water activity was determined at 25°C using a Novasina Thermo-constanter (TH-500, Novasina, Zurich, Switzerland). Moisture content was determined using a convection oven at 105°C overnight. Soluble solids content (°Brix) was determined using a refractometer (PR-201, Atago Co., Ltd., Tokyo, Japan) after same treatments for pH measurement. All measurements were done in triplicate.

Specific volume and spread ratio

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. All tests were performed in triplicate.

Table 1. Bread dough composition, added with different percentages of buckwheat flour

Ingredients (g)	Buckwheat flour level in steamed bread (%)			
	0	3	6	9
Buckwheat flour	0	6	12	18
Wheat flour	200	200	200	200
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 dough and surface 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 steamed breads for each treatment and mean values were reported.

Texture

Within 1 hr of steaming, the 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 ($2 \times 2 \times 2$ cm) were compressed to 30% deformation. The peak force of the compression curve was reported as crumb firmness (kg_f). Ten replicate tests were carried out for each condition.

Consumer acceptance tests

After a cooling period of 15 min, steamed bread samples were placed in a polyethylene bag for 4 hr at room temperature before they were presented to the consumers. The consumer acceptability of the steamed breads made with buckwheat flour 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-seven consumers, consisting of 31 males and 16 females, aged from 20 to 27 years old, were asked to record their acceptability scores for the four samples with respect to color, texture, flavor, taste, uniformity, chewiness, elasticity, and overall preference. 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 an evaluation sheet. Participants were asked to rinse their palates between samples and break for 30 seconds. 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, NC, USA). The means were compared with Duncan's Multiple Range test at the 5% level of significance.

RESULTS AND DISCUSSION

pH and TTA

The pH of the dough ranged from 5.55 to 5.74, which is within the optimal range for yeast to grow (26). Changes in pH and TTA of steamed bread are shown in Fig. 1. pH of the control was 5.90 and that of 9% sample was 5.70. pH decreased slightly, while titratable acidity increased significantly, from 1.02 to 1.37 mL, with the higher incorporation of buckwheat flour in the formulation ($p<0.05$). Similar findings were reported for yogurt incorporated with 0～10% (w/w) buckwheat sprout, where pH of the sample decreased from 6.37 to 6.16 while TTA increased from 0.138 to 0.453% at same conditions (27).

Water activity, moisture content, and soluble solids content

Water activity, moisture content, and soluble solids content of steamed bread as influenced by buckwheat flour incorporation are presented in Table 2. Water activity of steamed bread varied from 0.593 to 0.596 and was not affected by the buckwheat flour levels ($p>0.05$). Moisture content decreased slightly from 43.72 to 42.30 % whilst soluble solids content increased from 0.63 to 0.85 as the buckwheat flour concentration increased. A similar increase in the soluble solids content was reported for steamed bread made by the addition of 0～18% fermented pine needle extract syrup (26).

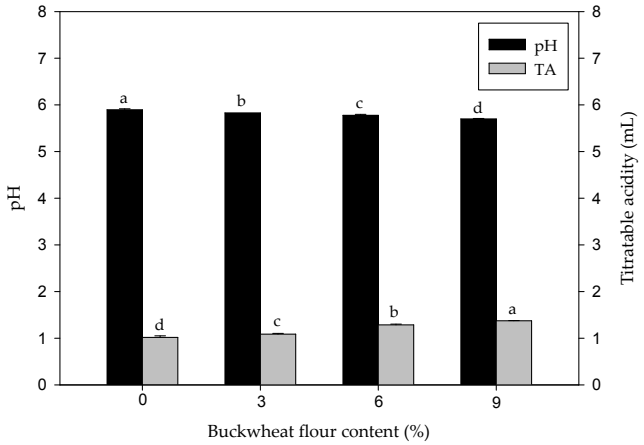


Fig. 1. pH and titratable acidity of steamed bread as influenced by buckwheat flour addition. Means within the same property without a common letter are significantly different ($p<0.05$).

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 (2,28). Spread volume and spread ratio of steamed bread as affected by buckwheat flour addition are shown in Fig. 2. As a result of the addition of buckwheat flour, the specific volume of steamed bread decreased from 3.31 to 2.57 mL/g. The values fall within the range of volumes reported previously (6,26,28). The specific volume is not a major concern unless it is less than 2.5 mL/g (29). On the other hand, the spread ratio ranged from 2.17 to 2.21 without significant differences among the different buckwheat concentrations ($p>0.05$).

Color

Changes of color parameters (L^*-, a^*-, and b^*-value) as influenced by buckwheat flour content are given in Table 3. Lightness (L^*) decreased significantly as the buckwheat flour content increased ($p<0.05$), for the

Table 2. Effect of buckwheat flour incorporation on water activity, moisture content, and soluble solids content of steamed bread

Property	Buckwheat flour level in steamed bread (%)			
	0	3	6	9
Water activity	0.596 ± 0.005^a	0.593 ± 0.005^a	0.596 ± 0.002^a	0.593 ± 0.006^a
Moisture content (%, w.b.)	43.72 ± 0.54^a	43.65 ± 0.31^a	42.52 ± 0.59^b	42.30 ± 0.50^b
Soluble solids content (^{o}Brix)	0.63 ± 0.06^b	0.70 ± 0.10^b	0.83 ± 0.06^a	0.85 ± 0.07^a

[a,b]Means (±standard deviation) within the same row without a common letter are significantly different ($p<0.05$).

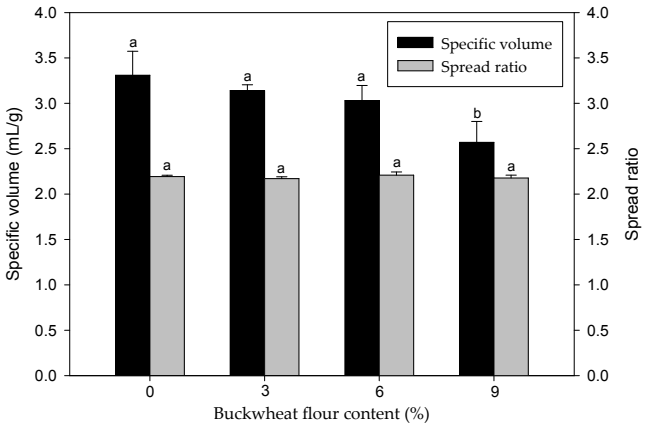


Fig. 2. Specific volume and spread ratio of steamed bread as influenced by buckwheat flour addition. Means within the same property without a common letter are significantly different ($p<0.05$).

dough as well as the surface of the steamed bread. The *L**-values of the control dough and steamed bread were 86.77 and 81.57, which were significantly higher than those of 9% sample ($p<0.05$). This change in value with the addition of buckwheat is comparable to reports by others (6,30). Similarly, a deceasing trend in *L**-value of noodle samples was reported when fermented-buckwheat flours were added (21). The results are also in good accordance with the changes in *L**-values of pan bread prepared with buckwheat-wheat flour (16) as well as *Sulgidduk* prepared with buckwheat powder (24). In addition, a decreasing trend in both redness (*a**-value) and yellowness (*b**-value) was noticed. These changes in color characteristics are inherent with distinctive color characteristics of food ingredients used in the formulation and are partially due to the degradation of color pigments during steaming at such high temperature. These changes in color characteristics of steamed bread can also be seen from the photos taken for comparison (Fig. 3).

Texture

Changes of crumb firmness as influenced by buckwheat flour incorporation are shown in Fig. 4. Firmness increased significantly with increase in buckwheat flour content ($p<0.05$). The crumb firmness of the control increased by up to 84.3% with 9% of buckwheat flour addition. The reduced amount of gas generated in the 9% sample could contribute to the lower volume of the steamed bread, and this, in turn, could result in the significantly higher firmness (31). Similar increases in hardness were reported for bread made with buckwheat-wheat flour (16), wet noodles prepared with 0～8% buckwheat sprout powder (18), and *Jeolpyon* added with 0～15% buckwheat flour (20).

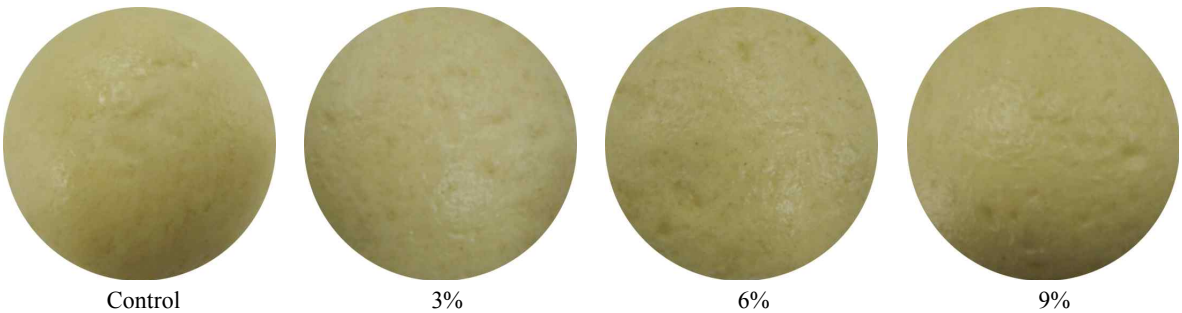
Consumer acceptance

A 9-point hedonic scale was used to determine which steamed breads incorporated with different levels of buckwheat flour were preferred by the majority of

Table 3. Effect of buckwheat flour incorporation on color characteristics of the dough and surface of steamed bread

Sample	Property	Buckwheat flour level in steamed bread (%)			
		0	3	6	9
Dough	*L**	86.77±0.97^{ab}	87.20±0.42^{a}	86.02±0.56^{b}	84.45±0.28^{c}
	*a**	-0.96±0.10^{c}	-0.51±0.08^{b}	-0.54±0.13^{b}	-0.33±0.14^{a}
	*b**	22.44±0.48^{a}	22.91±0.51^{a}	21.55±0.55^{b}	22.88±0.36^{a}
	ΔE	−	0.78	1.39	2.44
Bread	*L**	81.57±0.85^{a}	81.48±1.25^{a}	78.39±1.48^{b}	78.43±0.97^{b}
	*a**	-1.41±0.08^{c}	-1.14±0.14^{b}	-1.06±0.13^{b}	-0.66±0.47^{a}
	*b**	20.79±0.94^{a}	20.35±0.97^{a}	19.24±0.76^{b}	18.91±0.89^{b}
	ΔE	−	0.52	3.55	3.74

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



Control 3% 6% 9%

Fig. 3. Appearance of steamed bread as influenced by buckwheat flour addition.

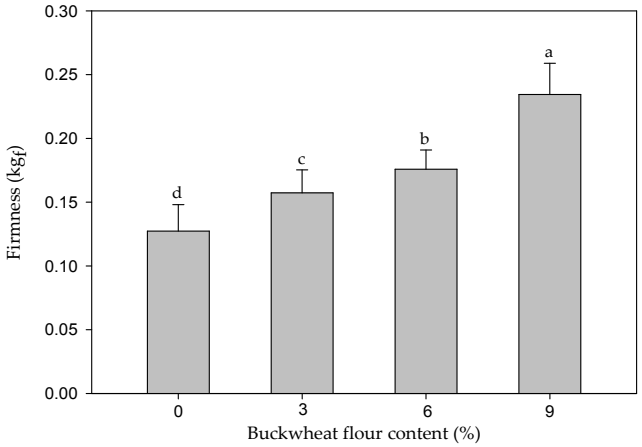


Fig. 4. Crumb firmness as influenced by buckwheat flour addition. Means without a common letter are significantly different ($p<0.05$).

consumers. Table 4 shows the mean scores of consumer acceptance results on several attributes, including: color, chewiness, flavor, taste, uniformity, elasticity, and overall acceptability. In terms of color, control received the most favorable mean scores of 7.02, which was not significantly different from others ($p>0.05$), followed by 3% sample. On the other hand, the 9% sample received the lowest mean score of 3.96 with respect to color among all samples tested ($p<0.05$). In fact, color acceptance decreased significantly as the percent of buckwheat incorporation increased in the formulation. Similar results were reported for spaghetti containing various levels of buckwheat (11). This is probably due to the facts that consumers are used to the original white color of steamed bread, and they might not prefer dark color induced by the buckwheat flour (32).

The consumer preference on chewiness was also significantly affected by the amount of buckwheat flour incorporated in the sample ($p<0.05$). The score of chewiness acceptability varied from 4.66 to 5.72, and steamed breads incorporated with 0 and 3% of buckwheat flour showing significant higher flavor acceptability than those of 6 and 9% samples ($p<0.05$). On the other hand, the consumer preferences on flavor, taste, and uniformity were not significantly affected by the amount of buckwheat flour incorporated in the sample ($p>0.05$). Notwithstanding, decreasing trends in customer favorability as the buckwheat flour level increased were observed.

With respect to overall acceptability, the control sample received the highest mean score of 6.00; however, that result is not significantly different from that of the 3% sample ($p>0.05$). The 9% samples received the lowest mean score of 4.57, a significantly lower score than the others, except for the 6% sample ($p<0.05$). It is noted that incorporation of buckwheat flour up to 3% in the formulation of steamed breads did not significantly influence the consumers' acceptability in all attributes tested except for color and elasticity. Therefore, incorporation of 3% buckwheat flour in the formulation of steamed breads would be recommended to take advantage of the health benefits of buckwheat flour without a major sacrifice of consumers' acceptance.

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Table 4. Effect of buckwheat flour incorporation on consumer acceptance of steamed bread

Attributes	Buckwheat flour level in steamed bread (%)			
	0	3	6	9
Color	7.02 ± 1.44^{a}	5.70 ± 1.38^{b}	4.49 ± 1.32^{c}	3.96 ± 1.44^{c}
Chewiness	5.72 ± 1.64^{a}	5.66 ± 1.42^{a}	4.72 ± 1.50^{b}	4.66 ± 1.90^{b}
Flavor	5.49 ± 1.71^{a}	5.15 ± 1.50^{a}	5.02 ± 1.76^{a}	4.94 ± 1.47^{a}
Taste	5.23 ± 1.70^{a}	5.21 ± 1.67^{a}	4.72 ± 1.48^{a}	4.72 ± 1.58^{a}
Uniformity	5.68 ± 1.60^{a}	5.30 ± 1.64^{a}	5.55 ± 1.43^{a}	5.36 ± 1.77^{a}
Elasticity	6.77 ± 1.64^{a}	5.87 ± 1.56^{b}	4.96 ± 1.82^{c}	4.11 ± 1.76^{d}
Overall acceptance	6.00 ± 1.40^{a}	5.77 ± 1.25^{a}	4.79 ± 1.31^{b}	4.57 ± 1.49^{b}

[a-d]Means ($\pm$standard deviation) within the same row without a common letter are significantly different ($p<0.05$).

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