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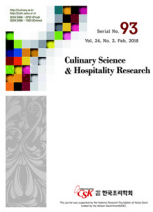

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Quality Characteristics of the *Sulggitteok* made by Chestnut Powder

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KEYWORDS

Chestnut,
Sulggi,
Quality properties,
Sensory test,
Texture,
Antioxidant activity.

ABSTRACT

The objective of this study was to assess the quality characteristics of *Sulggitteok* prepared with different ratios of chestnut powder: 0%, 5%, 10%, 15%, and 20%. The moisture content of the chestnut *Sulggi* without added chestnut powder was 38.24% than that of any other chestnut powder added groups and gradually decreased from 33.34～26.27% based on the addition of chestnut powder. In terms of color, the lightness (L) decreased significantly but redness (a) and yellowness (b) significantly (p<0.001) increased with increasing contents of chestnut powder. The total polyphenol content and DPPH free radical scavenging activity increased as the amount of chestnut powder increased and decreased. Total phenol contents of phenol contents was higher in the 10% added group (347.50 mg GAE/100 g) and DPPH radical scavenging activity was significantly higher in the 5% added group (69.35±2.02%) and 10% added group (74.33±2.29%). Texture profile analysis showed that the hardness, adhesiveness, chewiness were higher than that of the control. The result of sensory evaluation test and the overall acceptability showed that the taste, color, flavor, chewiness, softness and overall acceptability were the highest in the 10% added group while the color and flavor showed no significant different group. Based on these results, it is suggested that chestnut *Sulggi* with up 10% added chestnut powder can be developed as products.

1. INTRODUCTION

Chestnuts, a kind of nuts used as ingredients of food, are fruits of deciduous trees (Park et al., 2011) belonging to Fagacea Castanea, and they are divided into *Catanea cretanea vadulis* Nakai, *Catanea mollisima* Blume, *Catanea cretanea* 1ea Seib et Zucc and *Catanea sativa* Miller. *Catanea cretanea* vadulis Nakai especially is high in quality (Ahn, 2017), so it has been used uncooked and used for various food items, such as boiled rice, porridge, thin rice gruel, rice cakes, chestnut candies, chestnut balls, chestnut danja, stuffing for rice cakes and *dasik* (Lee, Jang, & Kim, 2016; Son et al., 2012), in the form of dried chestnuts, chestnut powder and chestnut inner skin. The inside skin and flesh of chestnuts, in particular, contain lots of antioxidants, including coumarin, gallic acid and catechin (Barreira et al., 2008; Lee et al., 2008), so it is said that they decrease neutral fat and total lipid in blood, improve anticoagulant activities (Kim et al., 2009), restrains cell proliferation in stomach cancer cell lines and promote apoptosis (Lee, Kim, & Kim, 2011). Leaves and roots of chestnut trees are effective for treating inflammation (Hong & Hwang, 2011; Kim, Ahn, Lee, & Lee, 1999) and good for skin care, recovery from fatigue and prevention of colds (Hong & Hwang, 2011) because of their effects for blood circulation and bleeding

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control. In addition, they have lots of essential amino acids, such as valine, leucine, isoleucine, threonine, histidine, phenylalanine, they are good as dietary supplements for children with poor nutritive conditions (Hong & Hwang, 2011). As people are growing more and more interested in promotion of health and recovery, their interests in functional foods also are getting keener. As the concept of wellbeing has recently been introduced in the nation, people have become to have more positive conceptions of *tteok*. *Tteok* has been considered as simple breakfasts and light meals for modern people (Kim, 2008). *Tteok* has been made and used since the ancient Bronze Age. *Tteok* has become a traditional dish of the nation with the passage of time and has been widely used for various events, ceremonies and holiday food (Lim, 2011). *Tteok* which has become food with Korea's unique and deep folkway and traditionality represents the nation's unique food customs. To make *tteok*, not only nonglutinous rice and glutinous rice but also minor grains, including beans, fruits, nuts, vegetables, herbal medicines and spices are added, so *tteok* is very excellent in terms of nutrition. *Sulggi* which is steamed after sugar is added to finely grinded rice powder and air and water are mixed, in particular, is very scientific and rational food to improve nutritive values and physiological functionality (Choi, Cho & Jhee, 2008; Cho et al. 2006; Jhee & Choi, 2008). Various ingredients are added to unglutinous powdered rice. For this study, chestnuts with diverse nutritional contents and health functionality are grinded into powder to be added to *baeksulggi* and then the effect of sulggi on physical and organic quality characteristics and the antioxidant activity depending on the ratio of added powder was compared and analyzed. Efforts were made to figure out the possibility to enhance values of chestnut power products and to develop those products into functional items.

2. MATERIAL AND METHODS

2.1. Materials

For the study, chestnuts of Okgwang (Gongju, produced in 2015) cultivars were used. Chestnuts were peeled and sliced in 2 mm thick, and then dried in hot air of 40℃ and grinded in less than 120 mesh, in order to be used for making *Sulggitteok*. Unglutinous rice (Cheonggyeolmi produced in 2015 in Icheon, Gyeonggi Province), sugar (CJ, Cheil Jedang) and salt (Haepyo, purity higher than 88%) used to make *Sulggitteok* had been kept in the room temperature.

Table 1. Fomula for chestnut *Sulggi* prepared with chestnut powder (g)

Ingredient	Samples[1)]				
	CS0	CS5	CS10	CS15	CS20
Rice powder	200	190	180	170	160
Raw chestnut powder	0	10	20	30	40
Sugar	20	20	20	20	20
Salt	2	2	2	2	2
Water	10	10	10	10	10

1) CS0: Chestnut *Sulggi* containing raw chestnut powder (0%), CS5: Chestnut *Sulggi* containing raw chestnut powder (5%), CS10: Chestnut *Sulggi* containing raw chestnut powder (10%), CS15: Chestnut *Sulggi* containing raw chestnut powder (15%), CS20: Chestnut *Sulggi* containing raw chestnut powder (20%).

2.2. Material Mixing Ratio of Chestnut *Sulggi*

This study first conducted a preliminary experiment based on the advanced research of *Ogapisulggi* (Jhee & Choi, 2008) and then made change and supplementation. After that, as shown in Table 1, chestnut powder 0%, 5%, 10%, 15%, and 20% were added, respectively, to make *Sulggitteok*.

2.3. Preparation of *Sulggi* added with Chestnut Powder

Unglutinous rice was washed five times and soaked in 18℃ water for five hours. After it, rice was put into a bamboo basket for to be dried for 30 minutes. Then rice was grinded twice using a roller mill and then was mesh-sifted in a 20-mesh wicker tray to be used as rice powder. Chestnut powder was added to rice powder in the ratio of 0%, 5% 10%, 15% and 20% and sugar was added. After it, they were mixed well and salty water was added into the mixture. Mixed powder was rubbed with hands to get rid of lumps and was mesh-sifted in the 20-mesh wicker tray two times. Wet cotton cloth was spread in a bamboo steamer of 18 cm across and 7 cm high and the sample was put into it. The upper side was flattened and water of 2 L was put into a pan. When steam came out, the bamboo steamer was put on the pan, and was steamed for 20 minutes and was let to settle by its own heat for five minutes. Completed *Sulggitteok* was taken out and cooled for 30 minutes to be used for a test. The control group used rice powder only.

2.4. Moisture

The moisture content of *Sulggitteok* made with chestnut

powder was measured using an infrared moisture meter (ML-50, A & D Company, Korea). Such a process was repeated three times and then the average value was found.

2.5. Color Evaluation

The chromaticity of *Sulggitteok* made with powdered chestnuts was measured using a color meter (Chroma meter CR-410, Minilta, Japan) three times each and the average value was shown in brightness (L value), red color (a value) and yellow color (b value). Correction of the standard white board used at this time were L=98.46, a=−0.23 and b=+1.02.

2.6. Content of Total Phenol Compounds

10 g of chestnut *Sulggi* was extracted for 24 hours (20℃) after 95% ethanol 90 mL was added, and then centrifugation was made for 10 minutes in 3,000 rpm and the supernatant liquid was used as a sample. The content of total phenol compounds was measured following the Folin-Denis's phenol method (Swain & Hillis, 1959). After 2N Folin-Ciocalteu reagent 0.2 mL was added in the sample liquid 0.2 mL, the mixture was left for three minutes. Then, 10% sodium carbonate (Na_2CO_3) 3 mL was added and it was made to react in the dark place for an hour and the absorbance was measured at 765 nm. A calibration curve was written using gallic acid (gallic acid, Sigma Chemical Co.) as a standard substance and then the polyphenol content was shown with mg gallic acid (mg GAE/100 g) in the sample 100 g. The experiment was repeated three times to show the average value and the standard deviation.

2.7. DPPH (1,1-diphenyl-2-picrylhydrazyl) Radical Scavenging Activity

The DPPH (1,1-diphenyl-2-picrylhydrazyl) radical scavenging ability of chestnut *Sulggi* was shown with relative comparison between the control group and the chestnut powder addition group. The antioxidant activity was compared and analyzed after measuring scavenging activities about DPPH radicals following the method of Lee et al. (2009). In other words, DPPH solution ($1.5x10^{-4}$) 1 mL was added in the sample liquid 4 mL and they were stirred. The mixture was left in the dark place for 30 minutes and the absorbance was measured at 517 nm. The absorbance of the control group for which etanol was added, instead of the sample liquid, was measured together and the DPPH radical scavenging activity was shown using the percentage.

$$\text{Free radical scavenging activity(\%)} = \left(1 - \frac{\text{Sample absorbance}}{\text{Control absorbance}}\right) \times 100$$

2.8. Texture Analysis

Such a process was repeated three times to show the average value and the standard deviation. texture analysis of chestnut *Sulggi* was measured using a texture analyzer (TA XT Express, Stable Micro Systems, UK) repeatedly three times following conditions of Table 2 to find the average value. At this time, the measured items were hardness, cohesiveness, gumminess, springiness and chewiness.

2.9. Sensory Evaluation Test

Chestnut *Sulggi* was steamed and then cooled for 30 minutes. Ten students of the Department of Practical Arts Education at Gongju National University of Education were given no food from 10:30 to 11:00 and a 7-point scoring method was executed about the color, smell, taste, softness, texture, wetness and general characteristics of chestnut *sulggi* three times. The degree of preference was evaluated using two conditions, 'dislike extremely' one point and 'like extremely' seven points. The suggested samples were shown with three-digit figures using a table of random numbers. The sample was cut in same size (2×2×2 cm), put on a white dish and provided with water. The students tasted one sample and then tasted another sample after rinsing their mouths cleanly. To reduce errors which could be caused by the order of

Table 2. Operation condition for texture profile analysis

Measurement	Condition
Pre-test speed	2.0 mm/sec
Test speed	2.0 mm/sec
Post-test speed	2.0 mm/sec
Test mode and option	T.P.A
Probe	P10(10 mm DIA cylinder)
Sample area	3.0 mm^2
Contact force	5.0 g
Threshold	20.0 g
Distance	25 mm
Strain deformation	50.0%

sample testing, there was a suggestion to test samples at random.

2.10. Statistical Analysis

All experiments were executed repeatedly three times or more and results were compared through average values and standard deviations using SPSS 20.0 (Statistical Package for the Social Sciences, IBM). Significance among average values was verified at around $p<0.05$ with the Duncan's multiple range test after conducting the ANOVA test.

3. RESULTS AND DISCUSSION

3.1. Moisture of Chestnut *Sulggi*

Results after measuring the water content in chestnut *Sulggi* were shown in Table 3. The moist content of *Sulggi* without chestnut powder was 38.24% and the figure decreased significantly gradualy to 33.34～26.27% depending on addition of chestnut powder ($p<0.001$). As the water content in chestnut powder was much smaller than rice powder, such a condition apparently affected the water content in the entire *Sulggi*, showing a same tendency with a study telling that more addition of powdered chestnut damaged water on the surface of *Sulggi* more because chestnut powder contained little water (Ahn & Lee, 2014; Ahn, 2017).

3.2. Color Evaluation

Results after measuring colors of chestnut *Sulggi* were show in Table 4. The L value showing brightness was highest, 89.63, in the control group which didn't add chestnut powder. The figure drew a significant downward curve as increasingly more chestnut powder was added ($p<0.001$), showing similar results to *Sulggitteok* with those from steamed chestnut powder (Ahn, 2017) and *sulggtteoki* with powdered gingko (Kim, Suh, Kim. & Kim, 2004). The a value showing the red color was −0.79 in the control group which didn't add chestnut powder. The figure drew a significant upward curve, compared with the control group, as increasingly more chestnut powder was added ($p<0.001$). The b value showing the yellow color was lowest, 8.20, in the control group which didn't add chestnut powder and the figure significantly increased compared with the control group as increasingly more chestnut powder was added ($p<0.001$). Kim et al. (2002) measured the chromaticity of *yanggaeng* containing mesh-sifted powders from safflower seeds and found the L and a values slightly decreased as the number of meshes increased, while the b value slightly increased, showing that characteristics of the sample chromaticity of added samples were reflected in the chromaticity of *Sulggitteok*.

Table 3. Value of moisture of chestnut *Sulggi* added with chestnut powder

	Samples[1)]					*F*-value
	CS0	CS5	CS10	CS15	CS20	
Moisture(%)	38.24±1.10[2)a]	33.34±0.47[b]	32.10±0.36[c]	31.03±0.55[d]	26.27±0.50[e]	131.566***

[1)] Sample at the same as in Table 1.
[2)] Means±standard deviation, *** $p<0.001$.
[a~e] Means with different superscript in the same column are significantly different ($p<0.05$) by the Duncan's multiple range test.

Table 4. Hunter's color value of chestnut *Sulggi* added with chestnut powder

		Samples[1)]					F-value
		CS0	CS5	CS10	CS15	CS20	
Color value	L value	89.63±0.89[2)a]	81.46±0.84[b]	80.73±0.30[b]	79.48±0.15[b]	76.30±0.49[c]	46.407***
	a value	−0.79±0.03[a]	0.52±0.01[b]	1.01±0.02[c]	1.09±0.05[c]	1.32±0.12[d]	559.606***
	b value	8.20±0.06[a]	9.39±0.54[b]	10.47±0.11[c]	10.83±0.06[c]	11.32±0.18[d]	67.861***

[1)] Sample at the same as in Table 1.
[2)] Means±standard deviation, *** $p<0.001$.
[a~d] Means with different superscript in the same column are significantly different ($p<0.05$) by the Duncan's multiple range test.

3.3. Content of Total Phenol Compounds and DPPH Radical Scavenging Activity

The total phenol compound content of chestnut *Sulggi* following the amount of added chestnut powder was studied from a standard curve prepared using the gallic acid as a standard solution and then the total phenol content of every 10 g of chestnut *Sulggi* was shown in Table 5. The total phenol content was 62.54 mg GAE/100 g in the control group and the figure significantly (p<0.01) increased and decreased as increasingly more chestnut powder was added. And it was significantly (p<0.01) as 347.50 mg GAE/100 g in 10% added group. As such a high polyphenol content, coumarin, gallic acid, catechin, etc. has positive effects on the antioxidant activity of chestnut *Sulggi*, the antioxidant activity is expected to expand through adding powdered chestnut in *Sulggi*.

The DPPH radical scavenging ability of *Sulggi* made with different amounts of chestnut powder was measured and the result is shown in Table 5. The figure was 52.01% in the control group which didn't add chestnut powder, but it significantly increased ans decreased as increasingly more chestnut powder was added (p<0.01) in the 5% added group (69.35) and the 10% added group (74.33). Such results were similar to *Sulggitteok* of Yoon and Lee (2016) containing balsam pear powder. It was found that chestnut powder was high in polyphenol content, which affected the free radical scavenging ability and reducing power. The antioxidant activity of chestnut *Sulggi* is expected to be improved through adding chestnut powder.

3.4. Texture Analysis

The result after measuring mechanical properties of chestnut *Sulggi* is shown in Table 6. Hardness increased as chestnut powder was added and began to decrease in *Sulggi* containing 20% of chestnut powder (p<0.001). Adhesiveness significantly increased compared with the control group (−213.58%) as increasingly more chestnut powder was added. Springiness increased as chestnut powder was added but decreased in the group of *Sulggi* containing 20% of chestnut powder, but there were not significant differences. Cohesiveness was significantly highest in the 20% addition group (p<0.01). Gumminess and chewiness decreased as chestnut powder was added but there were no significant differences.

Table 5. Total polyphenol content and DPPH radical scavenging activity of chestnut *Sulggi* added with chestnut powder

	Samples[1)]					*F*-value
	CS0	CS5	CS10	CS15	CS20	
Total polyphenol (mg GAE/100 g)	62.54±4.32[2)a]	277.50±2.50[d]	347.50±13.75[e]	157.27±0.40[c]	128.13±0.63[b]	935.16***
DPPH radical scavenging activity(%)	52.01±1.08[a]	69.35±2.02[c]	74.33±2.29[c]	54.97±5.91[ab]	60.35±2.15[b]	26.80***

[1)] Sample at the same as in Table 1.
[2)] Means±standard deviation, ** p<0.01.
[a~d] Means with different superscript in the same column are significantly different (p<0.05) by the Duncan's multiple range test.

Table 6. Texture properties of chestnut *Sulggi* added with chestnut powder

	Samples[1)]					*F*-value
	CS0	CS5	CS10	CS15	CS20	
Hardness (kg f)	2,354.53±521.71[2)a]	4,673.06±1458.83[b]	6,100.89±509.66[c]	8,300.38±564.21[d]	4,532.19±179.56[b]	23.969***
Adhesiveness (%)	−213.58±114.74[ab]	−272.72±25.35[a]	−193.59±7.82[ab]	−158.01±31.45[b]	−51.19±16.82[c]	6.678**
Springiness (%)	0.87±0.11[a]	1.26±0.58[a]	1.11±0.32[a]	1.28±0.52[a]	0.92±0.05[a]	0.754
Cohesiveness (%)	0.49±0.01[a]	0.48±0.01[a]	0.48±0.01[a]	0.42±0.03[a]	0.34±0.08[b]	7.668**
Gumminess (kg f)	812.96±719.52[a]	2,246.52±664.85[a]	1,990.54±1729.13[a]	1,142.53±1977.38[a]	375.67±334.97[a]	1.170
Chewiness (kg f)	654.65±574.53[a]	2,718.80±969.46[a]	2,349.45±2086.54[a]	1,136.50±1975.26[a]	342.35±311.55[a]	1.705

[1)] Sample at the same as in Table 1.
[2)] Means±standard deviation, ** p<0.01, *** p<0.001.
[a~d] Means with different superscript in the same column are significantly different(p<0.05) by the Duncan's multiple range test.

Table 7. Sensory evaluation of chestnut *Sulggi* added with chestnut powder

	Samples[1)]					*F*-value
	CS0	CS5	CS10	CS15	CS20	
Taste	6.00±1.04[2)a]	5.50±0.67[ab]	5.25±0.75[ab]	4.75±1.14[bc]	4.33±1.30[c]	4.937**
Color	4.08±1.00[a]	4.67±0.98[ab]	5.08±0.90[ab]	4.92±0.79[b]	5.08±1.16[b]	2.207
Flavor	4.92±1.08[a]	4.58±0.90[a]	5.08±0.90[a]	4.25±0.97[a]	4.58±1.16[a]	1.246
Chewiness	3.08±0.90[a]	4.25±0.75[b]	5.42±0.79[bc]	4.92±0.67[c]	5.50±1.24[c]	14.979***
Softness	5.17±0.94[a]	4.75±0.62[a]	5.00±0.74[a]	3.42±1.24[b]	3.50±1.68[b]	6.912***
Overall acceptability	5.33±1.15[a]	4.83±0.83[ab]	5.17±0.83[a]	4.00±1.21[b]	4.08±1.44[b]	3.605*

[1)] Sample at the same as in Table 1.
[2)] Means±standard deviation, * $p<0.05$, ** $p<0.01$, *** $p<0.001$.
[a~c] Means with different superscript in the same column are significantly different($p<0.05$) by the Duncan's multiple range test.

3.5. Sensory Evaluation Test

Regarding preference for chestnut *Sulggi*, a sensory test was executed about taste, color, flavor, chewiness, softness and the entire preference using a 7-point scale and results are shown in Table 7. According to the sensory test of taste, color, flavor, chewiness and softness of chestnut *Sulggi* and the entire preference for it, *Sulggi* containing no chestnut powder was significantly delicious ($p<0.01$) and color and flavor were high in the 10% addition group, but there were no significant differences. Chewiness was highest in the 20% addition group ($p<0.001$) and softness was significantly high ($p<0.001$) in the group without containing chestnut powder, apparently due to water content. The general preference was significantly low in the 15% addition group, indicating that to add chestnut less than 15% would favorably affect preference for chestnut *Sulggi*.

4. CONCLUSION

For this study, dried and powdered chestnuts produced in Gongju was added in the ratios of 0, 5, 10, 15 and 20% to make chestnut *Sulggi* and its water content, chromaticity, total phenol content, DPPH radical scavenging ability and mechanical texture were measured and a sensory test was executed. Results are as follows. Water content of *Sulggi* containing no chestnut powder was 38.24% and the figure gradually decreased to 33.34～26.27% as chestnut powder was added. Regarding the chromaticity, the L value was highest in the control group without chestnut powder and the a and b values were significantly high, compared with the control group, as chestnut powder was added. Regarding the total phenol compounds and antioxidant activity, phenol content increased and decreased as more chestnut powder was added, it was significantly ($p<0.01$) high with 347.50 mg GAE/100 g in the group containing 10% chestnut powder. And the DPPH radical scavenging ability was significantly high with in the group containing 5% (69.35±2.02%) and 10% (74.33±2.29%) chestnut powder. Regarding mechanical texture, hardness, adhesiveness and chewiness increased as chestnut powder was added, but cohesiveness, springiness and gumminess decreased. Taste, color, flavor, chewiness, softness and the entire preference were highest in the group containing 10% chestnut powder. Considering the above-mentioned results, the addition of 10～15% chestnut powder to the rice flour at the preparation of *Sulggitteok* added with chestnut powder may be suitable for quality, antioxidant activity and sensory properties. Gongju mass-produces high-quality chestnuts but most of it is consumed unprocessed, and only a part of it is processed food items, such as chestnut jelly, *makgeolli* and tea. To develop more diverse and more value-added food items will effectively expand chestnut consumption. *Sulggi* containing chestnut powder suggested by this study shows favorable results in mechanical tests and tests of antioxidant activity and preference tests, so the item will be good as functional food if it can be supplemented as an article of commerce.

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