Food Engineering Progress
Vol. 14, No. 3. pp. 271~276 (2010.8)

산업식품공학
Food Engineering Progress

Research Note

Physicochemical and Sensory Properties of *Baikseolgi* Incorporated with Strawberry Powders

Jun Ho Lee* and Ji-Hye Kim

Department of Food Science and Engineering, Daegu University

Abstract

Strawberry powder was incorporated into *Baikseolgi* by substituting the non-glutinous rice flour in the range of 0-8% based on the total weight of the non-glutinous rice flour and the effects on physicochemical and sensory properties were investigated. pH decreased significantly with the higher amount of strawberry powder in the formulation whereas titratable acidity showed a reverse trend ($p<0.05$). Moisture content also decreased significantly with the increasing amount of strawberry. Lightness (L*-value) decreased significantly with higher strawberry powder concentration, indicating that the color of *Baikseolgi* became dark as also indicated by the visual observation. Redness (a*-value) and yellowness (b*-value), on the other hand, increased significantly with the substitution of strawberry powders up to 8% ($p<0.05$). Increases in strawberry powder concentration up to 8% in the *Baikseolgi* formulation significantly increased the intensities of sensory color, flavor, and taste attributes; on the other hand, the intensities of sensory moistness and chewiness decreased significantly ($p<0.05$). Results from the consumer test revealed that control received the highest acceptability scores in all attributes but 4% sample also obtained the competitive scores. Finally, Pearson correlation analysis revealed several very highly significant linear correlation between the means used to access physicochemical, sensory properties, and consumer preferences.

Key words: *Baikseolgi*, strawberry powder, physicochemical, sensory, consumer test, Pearson correlation

Introduction

Rice (*Oryza sativa*) is one of the most frequently used cereals and contains very low level of gluten, low levels of sodium, protein, fat, fiber and a high amount of easily digested carbohydrates (Sivaramakrishnan et al., 2004). Rice has been very important major staple crop in Korean diet; however, per capita consumption of rice has been decreased continuously. The surplus produce of rice has been an economical concern and it is necessary to develop a various type of rice processed products in order to promote its consumption.

Rice cake (*Dduk*) is one of the most important Korean traditional foods and there are more than hundreds various kinds available. Among them, *Baikseolgi* is most representative of Korean rice cakes, which made by steaming the rice flour. To make *Baikseolgi* more healthy functional food, various fruits and vegetables, and even herbal medicine were incorporated in their formulation (Hong et al., 1999).

A humber of researchers have investigated quality characteristics of *Baikseolgi* made by incorporation of persimmon leaves powder (Kim et al., 1999), *Lentinus edodes* Sing powder (Cho et al., 2002), *Poria cocos* Wolf powder (Chang, 2003), dried persimmon extract (Kim et al., 2005), *Rubus coreanum* Miquel (Cho et al., 2006), *Undaria pinnatifida* powder (Han et al., 2006), *Allium tuberosum* R. powder (Bae & Hong, 2007), barley powder (Joung, 2008), Perilla leaves (Hong, 2008), sunflower seed (Lim et al., 2008), apricot powder (Choi et al., 2009), cabbage powder (Yang, 2009), whey protein isolate (WPI) powder (Kim, 2009), ginseng powder (Kang et al., 2010), sweet potato flour (Lee & Kim, 2010), and whole wheat flour (Lee et al., 2010) in the formulation.

Strawberries are a good source of bioactive phenolic compounds such as hydroxycinnamic acids, ellagic acid, ellagitannins, flavan-3-ols, flavonoids, and anthocyanins (Määttä-Riihinen et al., 2004). The beneficial effects of strawberries include increased plasma antioxidant capacity in humans (Cao et al., 1998), antioxidant activity for low density lipoproteins (Heinonen et al., 1998), and anti-carcinogenic activity against human and mouse cancer cells (Smith et al., 2004; Wang et al., 2005). Strawberry fruits also have high ascorbic acid concentrations which have protective roles against reactive oxygen species (Davey et al., 2000). Identification of ways to incorporate strawberry fruit as a

Corresponding author: Jun Ho Lee, Department of Food Science and Engineering, College of Engineering, Daegu University, 15 Naeri, Jillyang, Gyeongsan, Gyeongbuk 712-714, Korea
Tel: +82-53-850-6535; Fax: +82-53-850-6539
E-mail : leejun@daegu.ac.kr
Received July 14, 2010; revised August 18, 2010; accepted August 19, 2010

value-added healthy food component in human diets could provide many health benefits (Lee & Kim, 2009).

Despite previous investigations, no study has been reported so far on the potential for incorporation of strawberry powder in *Baikseolgi* and its contribution to quality of the final product. Attempts were made to produce a rice cake having advantages of nutritional and functional properties of strawberry fruit. The present work aimed at providing reliable experimental data for *Baikseolgi* incorporated with strawberry powder and investigating the effects on the physicochemical and sensory properties.

Materials and Methods

Preparation of raw material

Thrice-prewashed rice (new rice, produced in Angye, Gyeongbuk in 2008) was soaked in the water for 12 hr and removed the excessive water by straining for 30 min. The samples were then ground and sieved through a 20 mesh laboratory sieve before use. Lyophilized strawberry powder (Segae FL Co., Ltd., Chungnam, Korea) was procured from a local market sieved through a laboratory sieve (40 mesh) and a fraction with particles less than 425 μm was used. Salt (Hanju Corp., Ulsan, Korea) and white sugar (CJ Corp., Incheon, Korea) were procured from a local market and kept at room temperature before use.

Preparation of *Baikseolgi*

Non-glutinous rice powder (400 g) was mixed with salt (4 g), water (60 g) and sugar (40 g) and appropriate amount of strawberry powder (0, 2, 4, 6, and 8%) as given in Table 1. The mixture was steamed in a stainless steel steam pan (34 cm in diameter, 24 cm in height) for 30 min at high power using a multi-functional oven (model GOR-704C, Tong Yang Magic Corp., Seoul, Korea). The sample was then cooled down for 30 min at room temperature prior to further analysis.

Table 1. *Baikseolgi* formulation used in this study

Ingredients (g)	Strawberry powder level in *Baikseolgi* (%)				
	0	2	4	6	8
Non-glutinous rice flour	400	392	384	376	368
Strawberry powder	0	8	16	24	32
Salt	4	4	4	4	4
Sugar	40	40	40	40	40
Water	60	60	60	60	60
Total	504	504	504	504	504

Physicochemical properties evaluation

The pH of *Baikseolgi* was determined by a pH meter (model 340, Mettler Delta Co., Halstead, UK) after mixing each 5 g of *Baikseolgi* sample with 45 mL of distilled water. Same sample was used to measure titratable acidity, amount of 0.1 N NaOH solution to titrate the sample beyond pH = 8.3. Moisture contents of *Baikseolgi* were measured using a dry oven at 105°C overnight. Color parameters (L^*, a^*, and b^*) of *Baikseolgi* were measured 10 times using a Chromameter (model CR-200, Minolta Co., Osaka, Japan) calibrated with a white tile (Y=94.2, x=0.3131, and y=0.3201). Texture characteristics were evaluated by 30% compression of individual *Baikseolgi* (3×2×2 cm) with a computer-controlled Advanced Universal Testing System (model LRX*Plus*, Lloyd Instrument Limited, Fareham, Hampshire, UK) at room temperature. A 100-Newton (N) load cell was used, and the crosshead speed was 60 mm/min. A 1.2-cm diameter stainless steel cylinder probe was used. Eight samples for each treatment were tested, and their mean values were compared. All measurements were repeated at least three times unless stated otherwise.

Sensory evaluation

Baikseolgi made with strawberry powder was submitted to sensory assessment by a panel constituted of 10 trained panelists (students majoring in Food Science and Engineering). Attributes evaluated were: color, flavor, taste, moistness, and chewiness. Panelists expressed judgements about samples using a structured numeric scale of seven points, wherein 7 = very much strong, 6 = moderately strong, 5 = slightly strong, 4 = neither strong or weak, 3 = slightly weak, 2 = moderately weak, and 1=very much weak, for each attribute evaluated. *Baikseolgi* samples wrapped with cheesecloth were cooled down for 20 min at room temperature before they presented to the panelists. Each sample (3×2×2 cm), randomly coded using a three-digit number, was evaluated in each session. Panelists received a tray containing the samples, a glass of water, and a evaluation sheet. The evaluation was done in duplicate.

Consumer test

The consumer test, an acceptance test, was conducted on randomly selected 30 university students. The consumers were informed that *Baikseolgi* was incorporated with different amount of strawberry powder. All samples were labeled with randomly generated three-digit numbers and five samples were presented in random order. Participants were asked to

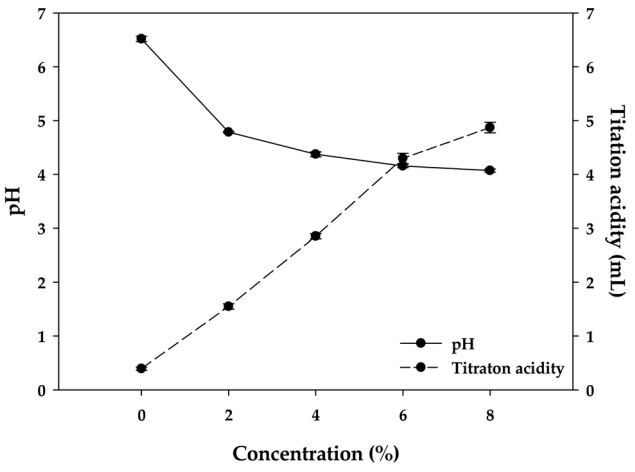

Fig. 1. Effects of strawberry powders on the pH and titratable acidity of *Baikseolgi*.

observe, smell, taste, and consume each sample of *Baikseolgi*. After evaluating each sample, participants judged sample color, flavor, taste, moistness, and chewiness using a structured numeric scale of seven points (7-point hedonic scale), wherein 7 = like very much, 6 = like moderately, 5 = like slightly, 4 = neither like or dislike, 3 = dislike slightly, 2 = dislike moderately, and 1=dislike very much. 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, N.C., U.S.A.). The means were compared with Duncan's Multiple Range test at $\alpha = 0.05$.

Results and Discussion

Physicochemical properties

Changes in pH and titratable acidity of *Baikseolgi* are shown in Fig. 1. pH of the control was 6.52 and that of 8% sample was 4.07. pH decreased significantly while titratable acidity increased significantly with the higher incorporation of strawberry powder in the formulation ($p<0.05$). Similar findings were reported for cookies incorporated with strawberry powder where pH of the sample decreased as the level of strawberry powder increased in the dough formulation up to 6% (w/w) (Lee & Ko, 2009). They explained that the decrease of pH was probably due to the higher concentration of organic acids such as citric and malic acids contained in the strawberry powder (Choo & Shin, 2000). Similar decrease in the pH was also reported for Mulberry *Sulgidduk* or *Baikseolgi* made with citric acid (Hong et al., 2003), citron (Lee & Hong, 2005), and *Lycium chinense* Mill. (Kim & Lee, 2006).

Moisture content and color characteristics of *Baikseolgi* as influenced by strawberry powder are summarized in Table 2. Moisture content of the control was 41.80% and that of 8% sample was 37.47%. The moisture content decreased significantly with the higher incorporation of strawberry powder in the formulation ($p<0.05$). A similar significant decrease in the moisture content was also reported for the *Sulgidduk* or *Baikseolgi* made with citric acid (Hong et al., 2003), citron (Lee & Hong, 2005), *Taraxacum officinale* leaves and roots powder (Yoo et al., 2005), and *Hovenia dulcis* (Ryu et al., 2007). Kim (2009) studied the quality characteristics of *Paikseolgi* containing various levels of whey protein isolate (WPI) powder, and speculated that WPI powders absorbed the moisture necessary for the starch gelatinization because of its high water binding capacity, which resulted in the moisture decrease.

Lightness (L^*-value) of the control was 86.52 and that of 8% sample was 58.75. Lightness decreased significantly with

Table 2. Moisture content and color characteristics of *Baikseolgi* as affected by strawberry powders

Strawberry powder (%)	Moisture content (%)	Color parameters			
		L^*-value	a^*-value	b^*-value	ΔE
Control	41.80±0.30[a]	86.52±1.09[a]	-1.88±0.08[d]	8.01±0.35[c]	-
2	40.56±0.13[b]	72.17±1.64[b]	6.59±0.26[c]	7.47±0.45[d]	16.67
4	39.13±0.52[c]	63.29±1.40[c]	14.60±0.60[b]	10.89±0.34[b]	28.69
6	37.73±0.72[d]	59.12±2.01[d]	14.81±0.97[b]	11.18±0.33[b]	32.09
8	37.47±0.33[d]	58.75±1.81[d]	17.29±0.60[a]	12.91±0.31[a]	33.79

[a-d]Means (±standard deviation) within the same column bearing unlike letters are significantly different ($p<0.05$).

Table 3. Sensory characteristics of *Baikseolgi* as affected by strawberry powders

Strawberry powder (%)	Color	Flavor	Taste	Moistness	Chewiness
Control	1.3±0.67[e]	1.3±0.48[d]	1.1±0.32[e]	6.1±0.57[a]	4.7±0.67[a]
2	2.3±1.06[d]	2.9±1.20[c]	2.5±0.85[d]	5.1±0.74[b]	5.1±0.74[a]
4	3.6±0.84[c]	3.5±1.08[c]	4.0±0.82[c]	4.0±0.82[c]	4.4±0.70[a]
6	4.6±0.52[b]	4.8±0.63[b]	4.7±0.67[b]	3.7±0.82[c]	2.9±0.57[b]
8	5.7±0.83[a]	5.8±0.42[a]	5.5±0.71[a]	1.9±0.74[d]	2.8±1.03[b]

[a-e]Means (±standard deviation) within the same column bearing unlike letters are significantly different (p<0.05).

Table 4. Consumer preferences of *Baikseolgi* as affected by strawberry powders

Strawberry powder (%)	Color	Flavor	Taste	Moistness	Chewiness
Control	4.9±1.20[a]	4.2±1.44[a]	4.7±1.36[a]	5.1±1.36[a]	5.0±1.51[a]
2	4.0±1.11[b]	4.3±1.20[a]	4.0±1.27[abc]	4.4±1.04[b]	4.7±1.11[a]
4	4.7±0.84[a]	4.2±1.18[a]	4.5±1.41[ab]	4.3±1.26[b]	4.6±1.03[a]
6	4.8±1.11[a]	3.8±1.70[a]	3.7±1.41[bc]	3.6±1.38[c]	3.3±1.18[b]
8	2.9±0.97[c]	3.7±1.88[a]	3.4±1.50[c]	3.0±1.69[c]	3.1±1.28[b]

[a-c]Means (±standard deviation) within the same column bearing unlike letters are significantly different (p<0.05).

the higher incorporation of strawberry powder in the formulation (p<0.05), indicating that the color of *Baikseolgi* became dark. Redness (a*-value) and yellowness (b*-value) of the control were -1.88 and 8.01 and those of 8% sample were 17.29 and 12.91, respectively. Redness and yellowness on the other hand increased significantly (p<0.05). Similar increases in lightness and redness were also observed for the cookies incorporated with strawberry powder up to 6% (w/w) (Lee & Ko, 2009). Those changes were probably due to the fact that anthocyanin pigments were thermally degraded during baking process and turned into orange color (Chae et al., 2000). Others also found similar color changes in Baik*seolgi* manufacturing due to the incorporation of food ingredients such as dried persimmon extract (Kim et al., 2005), perilla leaves (Hong, 2008), *Helianthus annuus* seeds (Lim et al., 2008), and apricot powder (Choi et al., 2009).

Textural properties including hardness (0.12-0.23 N), cohesiveness (0.39-0.51), springiness (3.68-4.41 mm), gumminess (53.70-115.38 g_f), chewiness (0.0020-0.0048 J), adhesiveness (0.0004-0.1067 N·mm), and stiffness (0.24-0.52 N/mm) were measured but not included due to no direct relationships between those properties and levels of strawberry powder incorporation were found. Nevertheless, others reported significant decreases in hardness and firmness with the incorporation of *Leonurus sibiricus* powder (Yoo et al., 2007), citric acid (Hong et al., 2003), sea tangle (Cho & Hong, 2006), persimmon paste (Hong & Kim, 2005), or *Lycium chinense* powder (Kim & Lee, 2006).

Sensory characteristics and consumer preference

The key sensory differences among samples are presented in Table 3. Intensity scores showed that sensory color, flavor, taste, moistness, and chewiness attributes were significantly affected by different levels of strawberry powder incorporated in the formulation of *Baikseolgi*. Increases in strawberry powder concentration up to 8% in the *Baikseolgi* formulation significantly increased the intensities of sensory color, flavor, and taste attributes; on the other hand, the intensities of sensory moistness and chewiness decreased significantly (p<0.05). For example, 8% sample was significantly stronger in strawberry color (5.7), flavor (5.8), and taste (5.5) attributes than other samples, whereas control was significantly higher in moistness (6.1) and chewiness (4.7) attributes than others (p<0.05).

Table 4 shows the results of the acceptance test. Control and 4% sample were those most appreciated by the subjects in terms of color (p<0.05), with the hedonic values of 4.9 and 4.7, respectively. With respect to flavor, no differences in preference were found among samples (p >0.05). The hedonic values of taste and chewiness were not significantly different each other among control, 2%, and 4% samples (p>0.05). On the other hand, 8% sample showed lower acceptances (p<0.05) in terms of color, taste, moistness, and chewiness with values of 2.9, 3.4, 3.0, and 3.1, respectively. Although the control received the highest scores in all attributes perhaps due to the fact that consumers were not experienced nor familiar with *Baikseolgi* incorporated with strawberry powders, 4% samples also received the competitive scores. Both samples

Table 5. Correlation between physicochemical, sensory properties, and consumer preferences for *Baikseolgi* incorporated with different levels of strawberry powder

		Conc.[1]	MC[2]	pH	TA[3]	Color parameters			Sensory attributes					Consumer preference		
						*L**	*a**	*b**	C[4]	F[5]	T[6]	M[7]	Ch[8]	F	T	M
MC																
pH		0.993***														
TA		-0.983**	0.896*	-0.997***												
Color	*L**	-0.927*	0.978**	-0.947*	0.962**											
	*a**	0.933*	-0.962**	0.941*	-0.954*	-0.990**										
	*b**	0.933*		0.925*	-0.916*											
Sensory	C	0.999***		0.993***	-0.984**	-0.929*	0.937*	0.945*								
	F	0.993***	-0.893*	0.986**	-0.977**	-0.937*	0.929*	0.884*	0.988**							
	T	0.987**	-0.919*	0.989**	-0.990**	-0.972**	0.978**	0.927*	0.989**	0.980**						
	M	-0.981**		-0.952*	0.934*	0.887*	-0.914*	-0.933*	-0.981**	-0.969**	-0.964**					
	Ch	-0.894*		-0.906*	0.891*			-0.885*	-0.894*							
Consumer	C															
	F												0.988**			
	T									-0.894*						
	M	-0.983**		-0.967**	0.949*	0.889*	-0.880*		-0.975**	-0.993***	-0.951*	0.965**		0.879*	0.928*	
	Ch	-0.941*		-0.946*	0.929*				-0.934*	-0.942*	-0.890*	0.880*	0.964**	0.966**	0.903*	0.955*

[1]Strawberry powder concentration, [2]Moisture content, [3]Titratable acidity, [4]Color, [5]Flavor, [6]Taste, [7]Moistness, [8]Chewiness
*Significant at $p<0.05$. **Significant at $p<0.01$. ***Significant at $p<0.001$.

were "liked slightly" by the consumer panels and incorporation of 4% strawberry powder in *Baikseolgi* formulation would provide health benefits and improved quality of the final product without sacrificing most of the consumer acceptance attributes.

Correlation

As shown in Table 5, Pearson correlation analysis revealed several very highly significant ($p<0.001$) linear correlation between the means used to access physicochemical, sensory properties, and consumer preferences. There were high positive correlations between strawberry powder concentration and pH, sensory color and flavor attributes, pH and sensory color, with correlation coefficients varying from 0.9929 to 0.9992. pH of the sample was negatively correlated with titratable acidity (r=-0.9971).

Further highly significant correlations ($p<0.05$, or $p<0.01$) existed between strawberry powder concentration and other attributes. Strawberry powder concentration was correlated with titratable acidity (r=-0.9827), *L** (r=-0.9274), *a** (r=0.9316), *b** (r=0.9329), sensory taste (r=0.9866), sensory moistness (r=-0.9805), sensory chewiness (r=-0.8936), moistness preference (r=-0.9829), and chewiness preference (r=-0.9413). Finally, *L**-value was negatively correlated with sensory color while *a** and *b**-values were positively correlated ($p<0.05$).

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