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Physicochemical Properties of *Baikseolgi* Made with *Ikmocho* (*Leonurus sibiricus* L.) Powder

Young-Sun Yoo[1], Hye Ran Kim[2] and Jun Ho Lee[2†]

[1]*Shinseage Food, 3-Team, Seoul, Korea*
[2]*Department of Food Science and Engineering, Daegu University, Gyeongsan, Gyeongbuk 712-714, Korea*

Abstract

Baikseolgi was prepared with *Ikmocho* powder to improve its functional properties. Appropriate amount of *Ikmocho* powder (0-8%) was mixed with rice flour, sugar, salt, and water. Their physicochemical properties were measured after steaming for predetermined time. pH decreased significantly with the addition of *Ikmocho* ($P<0.05$) whereas titratable acidity showed reverse trend. Moisture content of the control was significantly higher ($P<0.05$) than those of *Ikmocho* powder-added samples; however, there were no significant differences ($P>0.05$) among samples made with *Ikmocho* powder. Lightness (L-value) decreased significantly with the addition of *Ikmocho* ($P<0.05$), 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 as the amount of *Ikmocho* powder increased in the sample ($P<0.05$). Both hardness and firmness decreased significantly with the addition of *Ikmocho* powder ($P<0.05$).

Introduction

Leonurus sibiricus L. (*Ikmocho*) is an evergreen biennial shrub indigenous to tropical Asia, Africa, and America (Islam *et al.*, 2005). The dried plant has been used in oriental medicine as a tonic, and general remedy in puerperal and menstrual diseases. In the local traditional medicine practice, leaves are used to treat postpartum female disorders, liver disease, myocardial ischemia and good for blood circulation, myocardial infarction or microvascular anastomoses inhibition (Kim, 2001). An *et al.* (1996) also reported the desmutagenic effect of *Leonurus sibiricus* L. to aflatoxin B_1. Islam *et al.* (2005) investigated analgesic and anti-inflammatory activity and Ahmed *et al.* (2006) studied antibacterial activity of *Leonurus sibiricus* L.

Rice cake (*Dduk*) is one of the most important Korean traditional foods and more than hundreds of varieties are available. Among them, *Baikseolgi* is most representative of Korean rice cake, which made by steaming the rice flour. The *Baikseolgi* has different kinds of name depending upon what is added. Fruits, vegetable, and even herbal medicine can be added and this makes *Baikseolgi* one of the healthy functional foods (Hong *et al.*, 1999).

A number of researchers have been investigated quality characteristics of *Baikseolgi* made with green tea powder (Hong *et al.*, 1999), chitosan (Chong *et al.*, 2001), *Opuntia Ficus indica var. Saboten* powder (Joung, 2004), tapioka flour (Hyun *et al.*, 2005), and sea tangle (Cho and Hong, 2006). Despite previous investigations, no study has been reported so far in the literature on the quality of *Baikseolgi* added with *Ikmocho* powder. To broaden the availability of *Baikseolgi,* attempts were made to produce a rice cake having advantages of potentially preventive and therapeutic properties of *Ikmocho.* The present work aimed at providing reliable experimental data for *Baikseolgi* made with *Ikmocho* powder and investigating the effects on the physicochemical properties.

*Corresponding author: Jun Ho Lee, Department of Food Science & Engineering, Daegu University, Gyeongsan, Gyeongbuk 712-714, Korea.
Phone: +82-53-850-6535, Fax: +82-53-850-6539
E-mail: leejun@daegu.ac.kr

Materials and Methods

Preparation of raw material

Prewashed rice (produced in Sangbaek, Gyeongbuk, Korea) was soaked in the water for 12 hours and removed the excessive water by straining for 30 min. The samples were then ground before use. Dried *Ikmocho* (*Leonurus sibiricus* L.; produced in Yeongcheon, Gyeongbuk) was ground using an analytical mill (model M20, IKA Works, Inc., Wilmington, NC, USA) at maximum speed for 5 min and sieved through a laboratory sieve (40 mesh) and a fraction with particles less than 425 μm was used. Salt and sugar were procured from a local market.

Preparation of *Baikseolgi*

Nonglutinous rice powder (322-350 g) was mixed with salt (3.5 g), water (28 g), sugar (42 g), and appropriate amount of *Ikmocho* powder (0-28 g) according to Table 1. The mixture was steamed in a stainless steel steam pan (25×25×15 cm) with 580 mL of water for 20 min at high power, 10 min at low power, and then 5 min conditioning using a multi-functional oven (model GOR-704C, Tong Yang Magic Corp., Seoul, Korea).

Table 1. Formula used for *Baikseolgi* making based on nonglutinous rice flour weight

Composition	Sample				
	0%	2%	4%	6%	8%
Nonglutinous rice flour (g)	350	343	336	329	322
Ikmocho powder (g)	0	7	14	21	28
Salt (g)	3.5	3.5	3.5	3.5	3.5
Sugar (g)	42	42	42	42	42
Water (g)	28	28	28	28	28
Total (g)	423.5	423.5	423.5	423.5	423.5

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 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. Texture characteristics were evaluated by 30% compression of individual *Baikseolgi* (3×2×2 cm) using a computer-controlled Advanced Universal Testing System (model LRX*Plus*, Lloyd Instrument Limited, Fareham, Hampshire, UK) at room temperature with a 1.2-cm diameter stainless steel cylinder probe. A 100-Newton (N) load cell was used, and the crosshead speed was 10 mm/min. Five samples for each treatment were tested, and their mean values were compared. Color parameters (*L*, *a*, and *b*) of *Baikseolgi* were measured 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). All measurements were repeated at least three times.

Statistical analysis

The statistical analysis was done using the SAS Statistical Analysis System for Windows v8.1 (SAS Inst. Inc., Cary, N.C., U.S.A.). The means were compared with Duncan's Multiple Range test at α=0.05. Regression analyses were also conducted to obtain the prediction equations using the SAS.

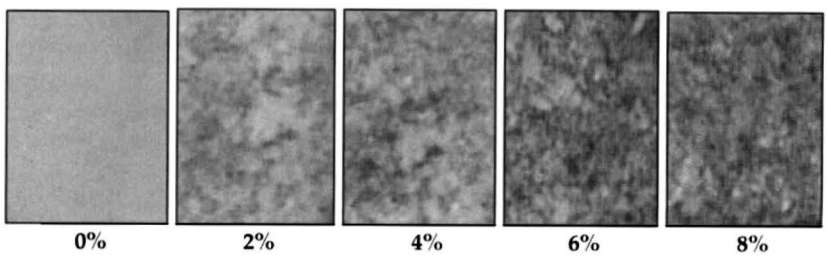

Fig. 1. Photographs taken for *Baikseolgi* as influenced by *Ikmocho* powder.

Results and Discussion

Visual observation

Photographs taken for each *Baikseolgi* as affected by the addition of *Ikmocho* powder are shown in Fig. 1. Apparently they showed a distinctive color with the addition of *Ikmocho* powder and the color became darker with higher amount of *Ikmocho* powder in the *Baikseolgi*. In addition, more particles of *Ikmocho* powder are shown on the surface of the sample as the *Ikmocho* concentration increased.

pH and titratable acidity

Changes in pH and titratable acidity of *Baikseolgi* are shown in Figs. 2 and 3, respectively. pH of the control was 6.43 and that of 2% sample was 5.82, respectively. pH decreased abruptly with the addition of 2% *Ikmocho* powder and after that the reduction was relatively small but significant ($P<0.05$) and appeared to be curvilinear. Apparently acidic characteristics of *Ikmocho* whose pH is 5.54 affected the pH of *Baikseolgi*. The overall changes in pH can be well described by a following quadratic equation:

$$pH = 0.020\ \text{Ikmocho}\ (\%)^2 - 0.238\ \text{Ikmocho}\ (\%) + 6.368\ (R^2 = 0.9025)$$

On the other hand, titratable acidity (TA) increased significantly with the addition of *Ikmocho* powder ($P< 0.05$). TA of the control was 0.33 mL and it increased to 1.43 mL for 8% sample. Similar findings were reported for Mulberry *Baikseolgi* added with citric acid (Hong *et al.*, 2003) and *Baikseolgi* added with citron (Lee and Hong, 2005). Cho and Hong (2006); however, reported no significant changes in pH with the addition of up to 35% of sea tangle (whose pH is 6.33) in *Baikseolgi*. The change in TA was almost linear and can be well estimated by the following linear equation:

$$TA = 0.133\ \text{Ikmocho}\ (\%) + 0.410\ (R^2 = 0.9779)$$

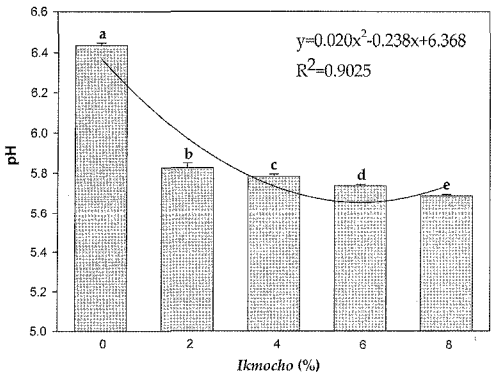

Fig. 2. pH of *Baikseolgi* as influenced by *Ikmocho* powder.

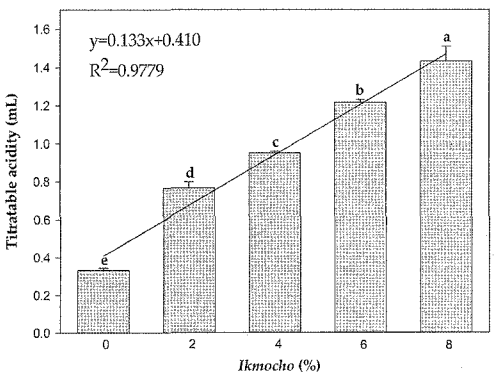

Fig. 3. Titratable acidity of *Baikseolgi* as influenced by *Ikmocho* powder.

Moisture content and color

Moisture content and color characteristics of *Baikseolgi* as influenced by *Ikmocho* powder are summarized in Table 2. The addition of 2 or 4% *Ikmocho* powder significantly affected the moisture content ($P<0.05$) although no significant differences were found among sample with 4, 6, or 8% samples. Several other researchers reported decrease in the moisture content with the addition of citric acid (Hong *et al.*, 2003), hericium erinaceus powder (Yoon and Lee, 2004), and citron preserved in sugar (Lee and Hong, 2005). However, a significant increase in the moisture content was also reported for the *Baikseolgi* make with sea tangle (Cho and Hong, 2006), or waxy sorghum flour (Yeon and Hong, 2006). This is due to the fact that concentration of added materials was relatively higher, ranged from 30 to 50% as compared to this research, which was up to 8%. Those materials have high amount of fibers, which increases water binding capacity.

Lightness, redness, and yellowness of *Ikmocho* powder was 55.75, -7.33, and 18.05, respectively.

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

Property		Concentration of Ikmocho				
		0%	2%	4%	6%	8%
Moisture content		38.33±0.24[a]	34.76±0.83[b]	33.48±0.30[b]	32.76±0.97[b]	32.65±0.19[b]
Color	*L*-value	81.13±1.12[a]	77.84±0.71[b]	74.53±0.71[c]	71.69±0.68d	70.61±0.67[d]
	a-value	-3.28±0.02[e]	-1.78±0.11[d]	-1.41±0.08[c]	-1.02±0.06b	-0.86±0.07[a]
	b-value	6.16±0.39[e]	13.15±0.28[d]	15.42±0.61[c]	17.01±0.30b	18.77±0.62[a]

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

Table 3. Textural characteristics of *Baikseolgi* as affected by *Ikmocho*

Characteristics	Concentration of *Ikmocho*				
	0%	2%	4%	6%	8%
Cohesiveness	0.38±0.03[a]	0.37±0.02[a]	0.41±0.03[a]	0.41±0.04[a]	0.41±0.03[a]
Springiness (mm)	6.18±0.31[b]	6.38±0.33[b]	6.77±0.268[a]	6.79±0.13[a]	6.99±0.27[a]
Gumminess (N)	1.62±0.29[a]	1.45±0.23[ab]	1.43±0.31[ab]	1.18±0.10[bc]	1.03±0.18[c]
Chewiness (Nm)	0.010±0.02[a]	0.009±0.02[ab]	0.010±0.02[ab]	0.008±0.01[ab]	0.007±0.01[b]
Adhesiveness (Nmm)	0.27±0.05[a]	0.11±0.05[b]	0.05±0.02[c]	0.00±0.01[d]	-0.01±0.01[d]

[a-d]Means (±standard deviation) within the same row bearing unlike letters are significantly different (*P*<0.05).

Lightness (*L*-value) of *Baikseolgi* decreased significantly with the addition of *Ikmocho* powder (P<0.05), indicating that the color of *Baikseolgi* became dark as also indicated by the visual observation earlier. Redness (*a*-value), on the other hand, increased significantly as the amount of *Ikmocho* powder increased in the sample (P<0.05). Similar changes in the lightness and redness were reported (Hyun *et al.*, 2005; Lee and Hong, 2005; Hong and Kim, 2005; Yeon and Hong, 2006). Again, yellowness (*b*-value) significantly increased with increase in *Ikmocho* powder content (P<0.05). This is due to the natural color of *Ikmocho* powder. It appeared that color characteristics of *Ikmocho* powder were well carried onto the *Baikseolgi*. This natural color can be easily measured and can be controlled to produce desired sample by changing the amount of *Ikmocho* powder added in the sample.

Textural properties

Hardness and firmness of *Baikseolgi* as influenced by *Ikmocho* powder are shown in Figs. 4 and 5, respectively. From a typical force-deformation curve, hardness and firmness were derived using the following relationship:

Hardness = Maximum force (N) / Maximum deformation (cm) [=] N/cm

Firmness = Maximum force [=] N

Both hardness and firmness decreased significantly with the addition of *Ikmocho* powder (P<0.05). Others also reported similar decrease in the hardness with the

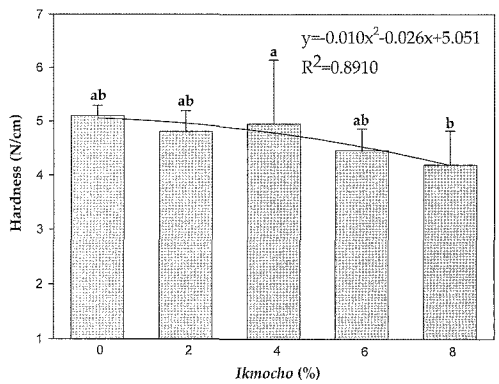

Fig. 4. Hardness of *Baikseolgi* as influenced by *Ikmocho* powder.

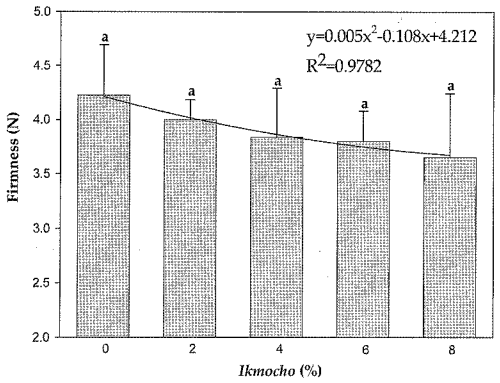

Fig. 5. Firmness of *Baikseolgi* as influenced by *Ikmocho* powder.

addition of citric acid (Hong *et al.*, 2003), sea tangle (Cho and Hong, 2006), persimmon paste (Hong and Kim, 2005), or *Kugija* powder (Kim and Lee, 2006).

The changes in the hardness and firmness can be described by curvilinear relationship and can be readily estimated by the following quadratic equations:

Hardness (N/cm) = -0.010 Ikmocho $(\%)^2$ - 0.026 Ikmocho (%) + 5.051 (R^2 = 0.8910)

Firmness (N) = 0.005 Ikmocho $(\%)^2$ - 0.108 Ikmocho (%) + 4.212 (R^2 = 0.9782)

Springiness is "the rate at which a deformed material goes back to its undeformed condition following removal of the deforming force"; gumminess is ìthe energy required to disintegrate a semisolid food to a state ready for swallowingî; chewiness is "the energy required to disintegrate a solid food to a state ready for swallowing"; adhesiveness is "the work necessary to overcome the attractive forces between the surface of the food and other surfaces with which the food comes in contact"; and cohesiveness is "the strength of internal bonds" (Szczesniak, 1963).

Springiness increased while other textural parameters such as gumminess, chewiness, and adhesiveness decreased with the addition of *Ikmocho* powder (Table 3). Similar results were reported for *Baikseolgi* made with *Kugija* powder (Kim and Lee, 2006). On the other hand, Han and Kim (1997) reported that gumminess and adhesiveness of *Paeksolgi* increased as the amount of sugar increased from 5% to 20%. Paik *et al.* (2005) also reported that gumminess of *Jeolpyon* increased with the addition of Buckwheat flour up to 15%.

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