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RESEARCH NOTE

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Quality Characteristics of Colored Soybean Curd Containing Paprika (*Capsicum annuum* L.)

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Abstract This study was conducted to examine the quality characteristics of soybean curd containing red paprika juice (RPJ) and green paprika juice (GPJ). The proximate compositions of RPJ showed higher levels of ash, carbohydrate, and vitamin C than GPJ. The yield of soybean curd was not significantly different with the level of RPJ and GPJ. However there was a significant decrease in the pH and an increase in the acidity with the addition of RPJ and GPJ. The L, a, and b values of soybean curd containing RPJ and the L value of soybean curd containing GPJ were significantly different. The hardness and chewiness of soybean curd containing RPJ and GPJ increased significantly with the level of juice.

Keywords: paprika juice, colored soybean curd

Introduction

Paprika (*Capsicum annuum* L.), which is a fruit vegetable classified as an *Annuum* species of the *Capsicum* genus from the Solanaceae family, is also known as sweet pepper and pimento (1). In Korea, bell-type sweet peppers are referred to as paprika and are available in various colors including red, green, orange, yellow, purple, and white (1-3). The color of paprika is determined by the presence of carotenoids such as capsanthin, β-cryptoxanthin, and zeaxanthin (4-7). Paprika, which is an alkalic boosting food rich in vitamin A, B_1, and C, is not spicy, but has a sweet smell and taste. Therefore it is widely used to bring out the color in salad and various foods (8-11). The production of paprika in Korea is gradually increasing, and the level of paprika exports and domestic consumption is increasing accordingly (2).

Soybean curd is a traditional Korean food that is produced by converting glycinin, into a gel. This is accomplished by mashing soybeans into soymilk to form a colloidal suspension, adding a coagulant such as $CaCl_2 \cdot 2H_2O$, $Mg\ Cl_2 \cdot 2H_2O$ or $CaSO_4 \cdot 2H_2O$ to the mixture, and then allowing the mixture to settle and congeal (12). Soybean curd, which is rich in essential amino acids, is a high-quality protein source with a digestive absorption rate of 96% (13,14).

As the economy and quality of life in Korea improve, people are becoming more interested in the aesthetic aspects of food. Therefore, many studies have been conducted to evaluate the characteristics of soybean curd containing ingredients such as cucumber and carrot (15), herbs (16), powdered green tea and spinach juice (17), pomegranate juice (18), and Canadian blackberry (*Rubus Coreanus*) (19). However, no study has been conducted on soybean curd containing paprika. Since it is anticipated that the Korean soybean curd market will become more quality and specialty oriented, it is necessary to develop a colored soybean curd that contains natural colors while satisfying consumers.

Therefore, this study was conducted to examine the quality characteristics of soybean curd that had red and green paprika juice added to it.

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Materials and Methods

Materials Red and green paprika used for this experiment was harvested in October, 2007 and purchased from the Unbong Agricultural Cooperative located in Jeonbuk, Korea. Soybeans that were harvested in Yeongam, Korea were purchased in Mokpo, Jeonnam, and $CaCl_2 \cdot 2H_2O$, which was used as the coagulant, was purchased from Sigma-Aldrich (St. Louis, MO, USA).

Preparation of paprika juice For juice preparation, stored paprikas (10±1°C) were washed, dewatered, and the inside seeds and stems were then removed. The paprikas were then blended using a hand blender (Type HR 1366; Philips, Warran Electric Mfg. Ltd., China) set to the turbo function for 3 min. The blended paprika was strained through a gauze, and then a 100-mesh sieve.

Preparation of paprika soybean curd Soybean curd was produced by SoyLove (IOM-201B; Ronic Co., Ltd., Gyeonggi, Korea). Briefly, 100 g of soybean were washed, dewatered for 24 hr, and then boiled in 1,700 mL of water to obtain soymilk. The obtained soymilk was then strained twice with filter gauze, which gave 1,300 mL of soymilk that was used to obtain the soybean curd. The soymilk was warmed in a water bath and maintained at 75-80°C, and then either 0, 5, 10, or 15% red paprika juice (RPJ) or green paprika juice (GPJ) was added to the soymilk. The mixture was then stirred in one direction 2 or 3 times, and then 1% coagulant was added to the soymilk with stirring.

The solution was maintained at 75-80°C for 5 min, then cooled at room temperature for 5 min, followed by pouring it into a soybean curd mold laid in a filter gauze. A weight was then applied to the soybean curd mold and the mixture was allowed to stand for 20 min. The molded soybean curd was then soaked in distilled water for 30 min, and kept in a tilted tray for 15 min. The surface water was then removed and the soybean curd was used for subsequent experiments.

Yield of paprika soybean curd The yield of the soybean curd (%) was determined by calculating the weight of the total soybean curd obtained from the 1,300 mL of soymilk obtained per 100 g of raw soybeans.

PH, acidity, and color values of paprika soybean curd The pH of the soybean curd was measured 3 times using a pH meter (HI9321; Hanna, Woonsoket, RI, USA) after homogenizing a 10 g aliquot of the soybean curd and 20 mL of distilled water according to the method described by Choi *et al.* (20). Acidity was converted into lactic acid in accordance with AOAC (21). To measure the color values of the soybean curd, aliquots of the soybean curd were cut into a regular size (5×5×1 cm^3), and the L, a, b, and ΔE were measured 10 times using a spectro colorimeter (Jx-777; Color Techno System Co., Ltd., Tokyo, Japan). The L, a, b, and ΔE standard color value of standard plate was 98.47, 0.01, −0.24, and 98.69, respectively.

Texture analysis of paprika soybean curd To measure the texture characteristics of soybean curd, it was cut into a regular size (3×3×1.5 cm^3) and then measured 5 times using a rheometer (COMPAC-100II; Sun Sci. Co., Tokyo, Japan) under the following conditions: distance=5 mm, adaptor type=circular, plunger Φ=50 mm, and table speed =120 mm/min. The values of hardness, springiness, cohesiveness, chewiness, brittleness, and adhesiveness were then determined.

Statistical analysis The mean, standard deviation, and analysis of variance (ANOVA) were determined using SPSS (Statistics Package for Social Science, Ver. 12.0 for Windows; SPSS Inc., Chicago, IL, USA). Statistical significance was then tested at $p<0.05$ using Duncan's multiple-range test.

Results and Discussion

Yield of paprika soybean curd The total weight of soybean curd produced from 1,300 mL of soy milk containing RPJ and GPJ is shown in Table 1. Although the yield of soybean curd containing RPJ was somewhat lighter than that of control soybean curd, this difference was not significant. The yield of soybean curd containing GPJ also tended to be somewhat less than that of control soybean curd. The difference in the yield of soybean curd with and without RPJ was not significant, however, there was a significant difference between the yield of soybean curd containing GPJ and control soybean curd.

These results are consistent with those of Choi *et al.* (20), which showed that the added natural products (carrot, cucumber, spinach, and green tea) did not combine with proteins, but instead disturbed their combination, thereby decreasing the yield rate of the final product. These results are also consistent with those of Jung *et al.* (22), which showed that with the addition of *Schizandra chinesis* baillon (*omija*) and *Pruns mume* (*maesil*), the yield rate decreased. Furthermore, these results are also consistent with the studies conducted by Shin *et al.* (13) and Jung and Cho (23), which found that adding spinach juice and green tea powder to soybean curd, respectively, resulted in decreasing yield rate of the final product. It is thought that these results may have occurred as a result of an increase in the concentration of organic acid, which caused the protein to congeal rapidly, making the lump bigger and decreasing the water holding capacity.

pH and acidity of paprika soybean curd The pH and acidity of soybean curd containing RPJ and GPJ are shown in Table 1. There was a significant decrease in the pH of soybean curd with the addition of up to 10% RPJ. The pH of soybean curd containing GPJ tended to significantly decrease as the level of added juice increased. The acidity of RPJ and GPJ as significantly increased as the level of juice increased.

These results are consistent with the results of a study conducted by Jeon and Kim (16), which found that, although there was no significant difference between the pH of herb added soybean curd and that of the control group, soybean curd containing herbs tended to have a lower pH value than that of the control group. In addition, Kim and Park (18) found that the pH of soybean curd containing pomegranate juice decreased from 5.25 to 5.00 when the concentration of juice increased from 1 to 5%. Above results indicated that the pH of paprika juice caused a decrease in the pH of soybean curd. The lower pH and the higher acidity of RPJ and GPJ- added soybean curd may prolong shelf-life due to the inhibition of microorganism propagation (22).

Table 1. Yield, pH, and acidity of soybean curd added red paprika juice (RPJ) and green paprika juice (GPJ)

Added level (%) \ Sample	Soybean curd added RPJ			Soybean curd added GPJ		
	Yield	pH	Acidity	Yield	pH	Acidity
0	207.67±2.52$^{a1)}$	5.66±0.50$^{c1)}$	0.26±0.03^{a}	207.67±2.52^{b}	5.66±0.50^{d}	0.26±0.03^{a}
5	205.67±1.53^{a}	5.55±0.08^{b}	0.31±0.04^{ab}	195.67±0.58^{a}	5.10±0.13^{c}	0.32±0.02^{b}
10	205.67±0.58^{a}	5.33±0.44^{a}	0.34±0.04^{b}	194.33±2.08^{a}	4.97±0.17^{b}	0.35±0.02^{b}
15	205.33±0.58^{a}	5.26±0.31^{a}	0.37±0.04^{c}	194.00±2.00^{a}	4.85±0.05^{a}	0.40±0.01^{c}

$^{1)}$Mean±SD, n=3; values with different superscripts within columns are significantly different by Duncan's multiple-range test at $p<0.05$.

Table 2. Hunter's color values of soybean curd added red paprika juice (RPJ) and green paprika juice (GPJ)

Added level (%) \ Color value	Soybean curd added RPJ				Soybean curd added GPJ			
	ΔE	L	a	b	ΔE	L	a	b
0	90.35±0.24$^{c1)}$	87.70±0.28^{d}	2.76±0.75^{a}	17.52±0.22^{a}	90.35±0.24$^{c1)}$	87.70±0.28^{d}	2.76±0.75^{d}	17.52±0.22^{a}
5	88.71±0.14^{b}	83.33±0.17^{c}	13.80±0.12^{b}	25.35±0.10^{b}	85.84±1.02^{b}	82.17±0.93^{c}	-1.15±0.15^{c}	20.86±0.29^{b}
10	84.55±1.08^{a}	76.92±1.09^{b}	17.80±0.31^{c}	27.66±0.88^{c}	86.03±0.15^{b}	80.85±0.14^{b}	-3.64±0.89^{a}	24.03±0.20^{c}
15	84.36±0.28^{a}	74.34±0.31^{a}	22.08±0.83^{d}	32.16±0.19^{d}	83.25±0.85^{a}	78.00±0.83^{a}	-3.46±0.75^{b}	24.04±0.35^{c}

$^{1)}$Mean±SD, n=10; values with different superscripts within columns are significantly different by Duncan's multiple-range test at $p<0.05$.

Table 3. Texture characteristics of soybean curd added red paprika juice (RPJ) and green paprika juice (GPJ)

Added level (%)		Hardness (g/cm^2)	Springiness (%)	Cohesiveness (%)	Chewiness (g)	Brittleness (g)	Adhesiveness (g)
RPJ	0	1.23±0.12$^{a1)}$	82.09±0.65^{c}	63.39±0.59^{d}	301.71±0.33^{a}	24771.72±0.16^{b}	-23.08±0.12^{c}
	5	1.33±0.02^{b}	84.30±0.11^{d}	57.13±0.13^{c}	312.58±0.57^{c}	26351.21±0.24^{d}	-21.02±0.24^{d}
	10	1.36±0.01^{c}	81.67±0.16^{b}	54.93±0.30^{a}	302.13±0.26^{b}	24671.52±0.26^{a}	-24.99±0.68^{b}
	15	1.37±0.02^{d}	81.61±0.48^{a}	55.61±0.21^{b}	316.97±0.15^{d}	25866.51±0.11^{c}	-31.02±0.78^{a}
GPJ	0	1.23±0.12$^{a1)}$	82.09±0.65^{a}	63.39±0.59^{d}	301.71±0.33^{b}	24771.72±0.16^{b}	-23.08±0.12^{a}
	5	1.34±0.03^{b}	83.73±0.16^{b}	38.00±0.11^{a}	210.23±0.21^{a}	17600.86±0.49^{a}	-21.00±0.77^{b}
	10	1.50±0.01^{c}	86.29±0.11^{d}	54.16±0.19^{c}	340.68±0.15^{c}	29396.61±0.19^{c}	-21.01±0.22^{b}
	15	1.65±0.02^{d}	85.37±0.19^{c}	51.65±0.38^{b}	349.84±0.19^{d}	29869.03±0.40^{d}	-13.01±0.67^{c}

$^{1)}$Mean±SD, n=5; values with different superscripts within columns are significantly different by Duncan's multiple-range test at $p<0.05$.

Hunter's color values of paprika soybean curd The Hunter's color values of soybean curd containing RPJ and GPJ are shown in Table 2. There was a significant difference between the L, a, and b value of soybean curd with and without RPJ. The L, a, and b value of soybean curd that contained 0% RPJ was 87.0±0.28, 2.76±0.75, and 17.52±0.22, respectively, whereas these values were 74.34±0.31, 22.08±0.83, and 32.16±0.19, respectively, for soybean curd with 15% RPJ. Although the L value was found to decrease as the level of RPJ added increased, the a and b value increased. This suggested that the addition of paprika juice to soybean curd had a very strong effect on the color of soybean curd. Similarly, there was a significant difference in the ΔE and L value of soybean curd containing GPJ, with the ΔE and L being 90.35±0.24 and 87.70±0.28, respectively, for the addition of 0% GPJ and 83.25±0.85 and 78.00±0.83, respectively, in soybean curd added 15% GPJ. Although the a value decreased as juice was added, the b value increased, suggesting that the change in the color values of soybean curd was very sensitive to the addition of paprika juice.

According to Jeong *et al.* (8), who conducted a study on sponge cake that was amended with red paprika powder, and Hwang and Jang (1), who conducted a study on wet noodles containing paprika juice, the L value decreased as paprika was added, but the a and b value increased. In addition, Jung *et al.* (24) found that the L value of steamed rice cakes with orange paprika decreased, but the b value increased. The results of the aforementioned studies were consistent with the results of this study. Furthermore, studies have shown a decrease in the L value of soybean curd with powdered tea, spinach juice (17) green tea powder (23) and herbs (16), but the b value was increased in these types of soybean curd. The color of soybean curd is one of the most important quality factors and has a strong impact on the scale of visual preference (25), therefore, the addition of paprika to soybean curd may influence the preference of soybean curd because of the change in color it induces.

Texture characteristics of paprika soybean curd The texture characteristics of soybean curd with red and green paprika juice are shown in Table 3. Soybean curd with RPJ had significantly greater hardness and chewiness than control soybean curd. Similarly, soybean curd with GPJ also had significantly greater hardness than soybean curd. Springiness and adhesiveness were also significantly greater in soybean curd with GPJ. These results were consistent with the study conducted by Hwang and Jang (1) in which hardness was found to be significantly greater in wet noodles with paprika juice than that of control. In addition, Park and Hwang (26) reported that the manner in which soybean curd congeals was influenced by the solid content as well as the content of protein within the soybean curd. Furthermore, soybean curd with added pomegranate juice has been shown to be harder than control soybean curd (18), which was also consistent with the results of this study. Conversely, springiness, cohesiveness, and adhesiveness tended to be decreased in soybean curd with added paprika juice. In conclusion, red and green paprika juice can be used controled soybean curd, which satisfies consumer's acceptance.

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