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Color, Textural Characteristics and Sensory Quality of Strawberry Puree-Substituted *Kochujang* during Fermentation

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Abstract

Quality characteristics of *kochujang* prepared with strawberry puree (10, 20, and 30% on a total weight basis) were investigated at 30 and 300 days of fermentation. The highest *L-value was found in 30% strawberry *kochujang* at 300 days of fermentation. In contrast, the highest degree of redness (*a**) was observed in 30% strawberry *kochujang* at the early stage of fermentation. During the fermentation, values of *L**, *a**, and *b** increased except *a**-value of 30% strawberry *kochujang*, indicating proper substitution of strawberry puree could preserve the desired color of *kochujang*. After 300 days of fermentation, hardness, gumminess, and chewiness increased while adhesiveness decreased significantly ($p<0.05$). Taste score and Pearson coefficient between sensory and strawberry concentration revealed that 10% strawberry *kochujang* was more acceptable than the others, due to color and the formation of flavor compounds during the fermentation and these compounds enhanced the flavor of *kochujang*.**

Key words: color, texture, sensory properties, Pearson coefficient, strawberry, *kochujang*

INTRODUCTION

Kochujang is a fermented traditional Korean hot pepper paste which has long been used to provide hot, sweet, and savory tastes. *Kochujang* is made of hot red pepper, soybean, starch paste and its hot, sweet, and savory tastes originate from digestion of these ingredients (1-4). There is growing interest in *kochujang*, due to its effects on weight and blood-pressure reductions and high polyglutamate content. It also contains more vitamin B_1, B_2, C, and folic acid than *doenjang* (soybean paste) or *ganjang* (soy sauce) (3). Hot pepper paste is a food product also found in other countries such as Turkey, Spain, and Mexico (5). Among the various types of hot pepper paste, traditionally produced hot pepper paste was found to be more acceptable due to the formation of flavor compounds during the fermentation.

Recent studies related to *kochujang* are mainly focused on intervening in the aging process by adding chitosan (1), sake cake (6), natural preservatives (7), and alcohol (8). In addition, to improve the functionality of *kochujang*, various modifications have been were made by adding kiwifruit (9), *Lycium chinense* fruit (10), sea tangle chitosan (11), and apple and persimmon (12). There is also an increasing interest on the benefits of strawberry, which include increased plasma antioxidant capacity in humans (13), antioxidant activity for low density lipoproteins (14), and anti-carcinogenic activity against human and mouse cancer cells (15,16). Strawberry fruit is rich in ascorbic acid, which has protective roles against reactive oxygen compounds (17). As major contributors to the total phenolic contents, as well as important to fruit color, anthocyanins in the strawberry also have potent antioxidant properties (18) and reduce oxidative stress-induces neurotoxicity (19). Strawberry is also reported to serve as one of our most important dietary sources of phenolic compounds (20,21).

In this study strawberry puree of different concentrations were added to improve the functional properties of *kochujang* and the quality characteristics such as changes in color, textural characteristics, and sensory components during fermentation were investigated.

MATERIALS AND METHODS

Materials

Kochujang pre-mixture was obtained from Poorun Foods Co., Ltd., which was prepared by blending wheat powder (22%), wheat grain (20%), salt (10.5%), and purified water (47.5%). Wheat flour was first steamed with pressure after spraying the warm water and blended with ground wheat grain (inoculated with 0.05% spore suspension of *Aspergillus oryzae* starter and incubated at 35~40°C for 48~52 hr) evenly and salt, then stored

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in a fermentation tank for 1 month. Corn syrup (100% corn starch, TS Co., Ltd., Incheon, Korea), red pepper powder, mixed condiments (contained 38% red pepper powder, 15% salt, 7% garlic, and 4% onion), and spirits (Haitai Company, Seoul, Korea) were also obtained from Poorun Foods Co., Ltd. Fresh strawberry was obtained from a local market, which were cultivated at Koryeong (Gyeongbuk, Korea), washed with tap water, and drained. Strawberries were ground using a hand blender and simmered at 80°C for 15 min.

Kochujang preparation

Kochujang was prepared, using standard commercial manufacturing practices, by Poorun Foods Co., Ltd. Aged *kochujang* pre-mixture and 30% corn syrup were pasteurized at 70°C while blending 8% mixed condiments, 8.6% red pepper powder, 3% spirits, and different amount of strawberry puree (0, 10, 20, and 30%). The mixtures were then cooled down to 40～45°C, placed in a pot, and aged for up to 300 days at room temperature (23～24°C).

Color assessment

Color characteristics (CIE *L**, *a**, *b**) were measured using a Minolta Chroma Meter (model CR-200, Minolta Co., Osaka, Japan) calibrated with a calibration plate using *Y*=94.2, *x*=0.3131, and *y*=0.3201. Small amount (*ca.* 5 g) of *kochujang* was covered with slide glass then color parameters were measured five times. The measurements were done in quadruplicate. The results reported in this paper are the mean values of samples accompanied by their standard deviations.

Textural properties

Textural characteristics were evaluated by 30% compression of individual sample with a computer-controlled Advanced Universal Testing System (model LRXPlus, 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 60 mm/min. Nine samples for each replication were tested, and their mean values were compared.

Consumer test

Strawberry *kochujang* was evaluated by 30 consumer panelists. Four samples were presented in random order and the panelists were asked to evaluate the consumer preferences of taste, flavor, color, mouthfeel, and overall acceptability. Consumers evaluated each attribute using a structured numeric scale of five points (5-point hedonic scale), wherein 5=like extremely, 4=like moderately, 3=neither like or dislike, 2=dislike moderately, and 1=dislike extremely. Each sample (*ca.* 5 g), 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.

Statistical analysis

The statistical analysis was done using the SAS for Windows v8.1 (SAS Inst. Inc., Cary, NC, USA). The means were compared with Duncan's multiple range test at 5% level of significance.

RESULTS AND DISCUSSION

Color changes

Tristimulus colorimetry was used to access the extent of color changes in *kochujang* with different strawberry puree concentrations and storage periods. Table 1 shows the changes in color (CIE *L**, *a**, *b**) with different strawberry puree concentrations after being stored for 30 and 300 days. Strawberry puree concentration and storage time both had a significant effects on the lightness (*L**-value) of *kochujang* ($p<0.05$). A significant increase in lightness during fermentation, from 30 to 300 days was observed for all samples regardless of strawberry puree concentration ($p<0.05$). A similar increase in lightness throughout storage time was also reported by Shin et al. (2) with 4 different red pepper varieties; and by Kim et al. (22) with different *meju* and red pepper; and also by Choi et al. (23) with different mixtures of *meju* and *koji*. On the contrary, Lee et al. (24) reported that values of *L**, *a**, and *b** of *kochujang* decreased during the storage, and Kim et al. (25) also reported that hunter *L*, *a*, and *b* values of *kochujang* powder decreased during the storage. Lee and Lee (26) also reported that values of *L**, *a**, and *b** of *kochujang* prepared with *maesil* extract decreased during the storage.

*a**-value, a measure of redness, is highly correlated

Table 1. Changes in CIE color (*L**, *a**, and *b**) values of strawberry *kochujang* during fermentation

Strawberry puree (%)	Aging time (days)	Color		
		*L**-value	*a**-value	*b**-value
Control	30	24.41^{e}	13.32^{ab}	7.64^{a}
	300	24.85^{d}	9.66^{e}	4.94^{b}
10	30	24.45^{e}	12.51^{c}	7.78^{a}
	300	25.59^{c}	12.39^{c}	8.40^{a}
20	30	24.69^{de}	12.76^{bc}	7.84^{a}
	300	27.23^{b}	13.55^{ab}	9.04^{a}
30	30	25.43^{c}	13.83^{a}	8.87^{a}
	300	27.87^{a}	11.46^{d}	8.97^{a}

$^{a-e}$Values in the same column with different letters are significantly different ($p<0.05$).

with the color changes of strawberry *kochujang* during storage. The reddish color of *kochujang* usually comes from capsanthin of red pepper and has a big impact on the quality and marketability of *kochujang*. The changes in *a**-values between *kochujang* samples fermented for 30 and 300 days were not significant for samples containing 10 and 20% strawberry puree ($p>0.05$). On the other hand, the *a**-values decreased significantly when fermentation period increased from 30 to 300 days for control and sample containing 30% strawberry puree ($p<0.05$). Among samples fermented for 30 days, an increase in strawberry puree concentration from 10 to 30% led to a significant increase in *a**-values of strawberry *kochujang*, from 12.51 to 13.83 ($p<0.05$). However, that of 30% strawberry *kochujang* was not significantly different from that of control ($p>0.05$). At 300 days of fermentation, an increase in strawberry puree concentration also led to a significant increase in *a**-values of strawberry *kochujang* up to 20% and dropped in 30%, but *a**-values of 30% strawberry *kochujang* were significantly higher than that of control ($p<0.05$). The results indicate that adequate amount of strawberry puree could preserve the bright red color of *kochujang* even after 300 days of fermentation.

The decrease in values of *a** and *b** is due to the oxidation of carotenoids including capsanthin (12,24,26). The non-enzymatic browning reaction is also considered to be a limiting factor of hot pepper paste during the production and the storage periods. Maillard and ascorbic acid oxidation are the main non-enzymatic browning reactions that occur during these periods. Brown pigments, 5-hydroxyl furfural (HMF) and other products are formed due to the non-enzymatic browning reactions since hot pepper contains appreciable amounts of reducing sugars, ascorbic acid, and amino acids. Formation of these brown pigments decreased the desired the bright red color of hot pepper paste. Kim et al. (10) reported that the hunter *L*, *a*, and *b* values of *kochujang* with *Lycium chinense* decreased due to Maillard reaction during the storage. Jeong et al. (12) also reported similar results with *kochujang* prepared with apple and persimmon.

The changes in *b**-value during storage was much greater for the control than for those containing strawberry puree (Table 1). The *b**-value of control decreased significantly when the fermentation period increased from 30 to 300 days ($p<0.05$). For samples containing strawberry puree, the changes in *b**-values were not significantly affected by fermentation period ($p>0.05$). This perhaps suggests that substituting strawberry puree in the formulation of *kochujang* could effectively control the color change, especially *b**-values during fermentation. *L**, *a**, and *b**-values of strawberry *kochujang* were similar to those with various fruit juices (27), which were 22.4～23.9, 13.8～17.0, and 11.6～13.2, respectively.

Textural properties

The changes in textural properties of strawberry *kochujang* were shown in Fig. 1. At 300 days of fermentation, hardness, gumminess, and chewiness increased significantly while adhesiveness decreased significantly as compared with same properties of *kochujang* sample fermented for 30 days ($p<0.05$). The influence of strawberry puree at 30 days of fermentation was clear in all parameters, in which hardness, gumminess, chewiness, and adhesiveness decreased significantly with increasing strawberry puree concentration ($p<0.05$). On the other hand, chewiness and adhesiveness were not affected significantly by increasing strawberry puree concentration ($p>0.05$).

Sensory evaluation

Fig. 2 shows the sensory evaluation scores for strawberry *kochujang* fermented for 30 days. In terms of color, there were no significant differences among the samples even for 30% strawberry *kochujang* (Statistical results were not shown). On the contrary, flavor and mouthfeel scores of the control were significantly higher than those of all samples containing strawberry puree in which no significant differences found among them. Taste score of 10% strawberry *kochujang* was higher than the others except control, this could be due to the formation of flavoring compounds during the fermentation. The previous report (28) indicated amino nitrogen content of 10% strawberry *kochujang* was not significantly different from that of control after 30 days of fermentation. Strawberry puree-substituted *kochujang*, except at the 30% strawberry concentration, was found to be the best with respect to its overall preference scores.

Table 2 shows the Pearson coefficients calculated with data from strawberry *kochujang* fermented for 30 days. The correlation coefficients between strawberry puree concentration and sensory and textural properties ranged from -0.944 to -1.000, showing a strongly high negative linear relationship between these variables except for overall preference attribute. This indicates that sensory flavor, mouthfeel, and textural properties decreased as the strawberry puree concentration increased. The correlation coefficients between mouthfeel and textural properties (gumminess, chewiness, and adhesiveness) ranged from 0.955 to 0.983, showing a strongly high linear relationship between these variables ($p<0.05$). There were also highly positive linear correlations observed between overall preference and flavor, and between overall pref-

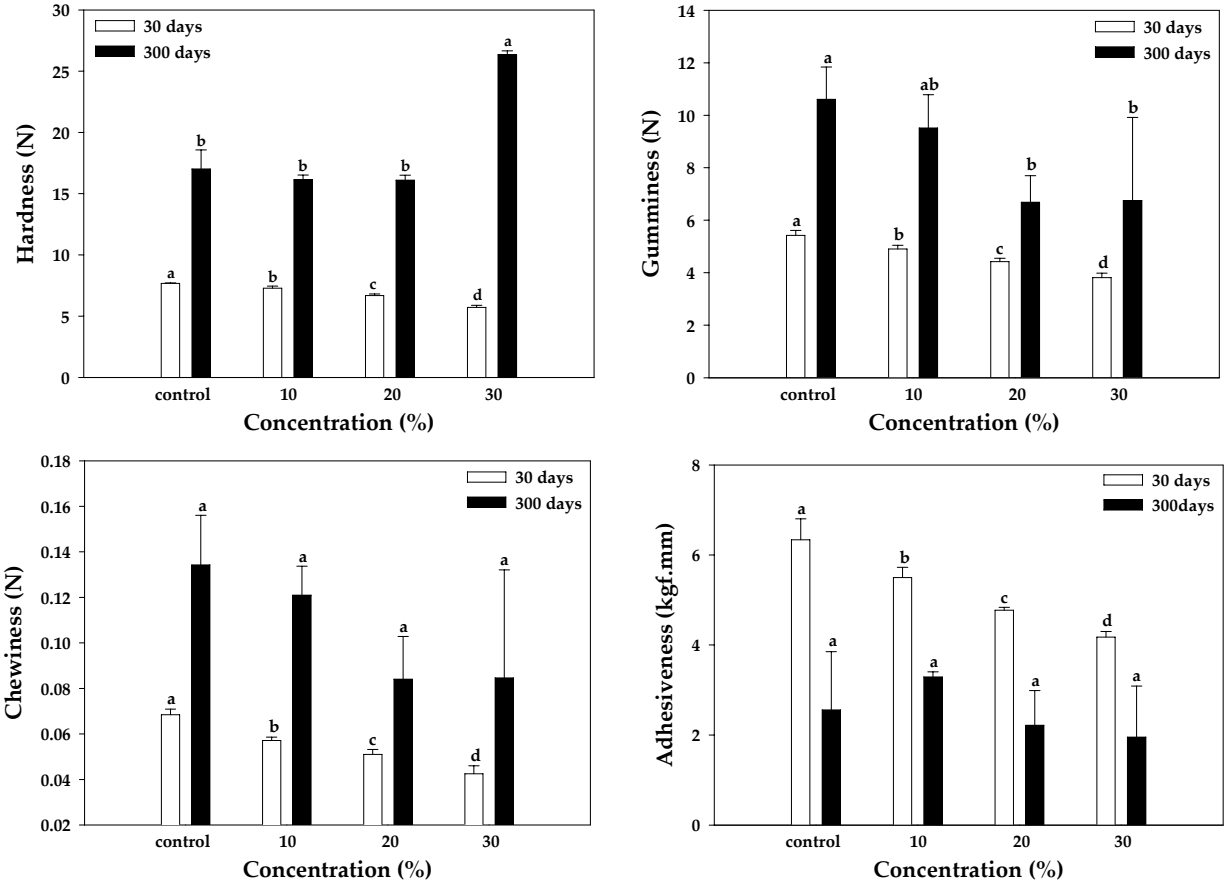

Fig. 1. Changes in textural properties of strawberry *kochujang* during fermentation.

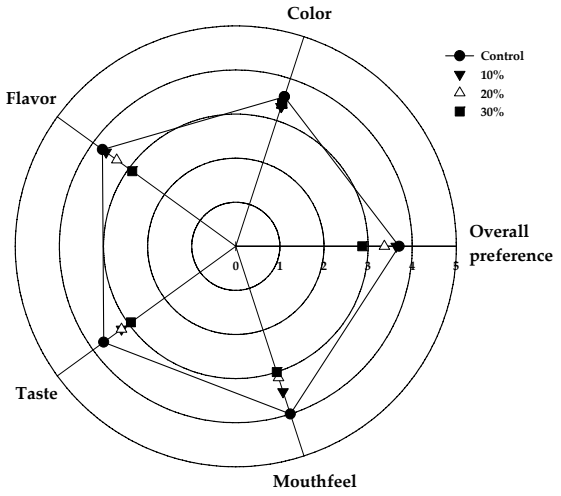

Fig. 2. Sensory evaluation scores for strawberry *kochujang* fermented for 30 days.

erence and textural parameters (hardness and gumminess).

With respect to the relationships indicated by Pearson coefficients and high amino nitrogen content (28), and taste score, 10% strawberry *kochujang* was more acceptable than the others, mainly due to the color which was expressed by the maintaining *a**-values after 300 days of fermentation and formation of flavor compounds during the fermentation and these compounds enhanced the flavor of *kochujang*.

Table 2. Pearson correlation coefficients between strawberry puree concentration and results on consumer test for *kochujang* fermented for 30 days

Attributes		Strawberry puree concentration	Consumer test	
			Mouthfeel	Overall preference
Objective property	Flavor	-0.966*	0.868^{ns}	0.996**
	Mouthfeel	-0.966*	1.000	0.826^{ns}
	Overall preference	-0.944^{ns}	0.826^{ns}	1.000
Subjective property	Hardness	-0.978*	0.891^{ns}	0.992**
	Gumminess	-0.999**	0.955*	0.956*
	Chewiness	-1.000***	0.966*	0.944^{ns}
	Adhesiveness	-0.997**	0.983*	0.915^{ns}

^{ns}not significant at 5% level of significance.
$^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$.

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