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Physicochemical and Sensory Characteristics of Kakdugi in Which Red Pepper is Replaced with Red Pimiento

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Abstract

The physicochemical properties and sensory characteristics of red pimiento kakdugi (radish kimchi) during fermentation at 10°C were compared with red pepper kakdugi (control). The fermentation patterns of two kakdugies were similar, although total acidity, reducing sugar content and lactobacilli number of the red pimiento kakdugi were somewhat higher than those of control. The hardness and fracturability of the radish cubes of kakdugi were not significantly different from those of red pepper kakdugi during fermentation. The Hunter color L, a and b values of both kakdugies increased gradually until the 10th day, and then decreased thereafter. The ASTA value and redness of red pimiento kakdugi were consistently higher than those of control, which is consistent with the sensory results. While red pepper powder kakdugi contains high concentrations of capsaicin and dihydrocapsaicin, in pimiento kakdugi capsaicinoids were not detected by HPLC analysis. Also, capsainoids in red pepper kakdugi decreased gradually as fermentation proceeded. Sensory evaluation showed that the score of hot taste for red pimiento kakdugi was lower, compared with that of control ($p < 0.05$), whereas the score of over-all acceptability for red pimiento kakdugi was higher than that of control.

Key words: red pimiento kakdugi, capsaicin, physicochemical properties, sensory properties

INTRODUCTION

Kimchi is a traditional favorite fermented food in Korea. For kimchi preparation, various kinds of vegetables are used as major ingredients, whereas red pepper, garlic, green onion and ginger are essential spices for making all types of kimchi. Kimchi has been demonstrated to have various functional properties, including antimutagenic and anticancer effects (1), hypolipidemic activity (2), antioxidant and anti-aging properties (3) and activation of detoxifying enzymes (4). Korean traditional kimchi has become known throughout the world as a healthy food, and its exportation has greatly increased. However, in Korea the consumption of kimchi has gradually decreased among children and youth. The most common reason given for the dislike of kimchi is the hot taste, and most people surveyed reported that they wanted a milder tasting kimchi (5-7). Also, the sensory score for the pungency of kimchi was higher among Americans than Koreans (8), indicating a greater sensitivity to the pungent taste. For globalization of kimchi, a milder flavored kimchi needs to be developed.

The characteristic pungent flavor of kimchi is mainly derived from the hot red pepper, because the pungency of the other ingredients such as radish, garlic and green onion decreases during fermentation (9). In Korea, hot red pepper has been a valuable ingredient of kimchi, contributing its characteristic sensory attributes of red color and pungent taste (10). Within the genus *Capsicum* species, strong pungency is associated with C. *fructescens*, whereas C. *annum* is rather mild (11). Pimiento (*Capsicum annuum* var. *angulosum*), known as sweet pepper, is not hot. Pimiento has been used for various cooking purposes, mainly in Western countries, but recently its consumption has been increasing in Korea.

The purpose of this study was to characterize the physicochemical and sensory properties of kakdugi in which the traditional red pepper was replaced with red pimiento.

MATERIALS AND METHODS

Materials

Radish, red pimiento and other ingredients were purchased from a local market (Daejon, Korea) in September 1999. Fresh red pimientos were washed, cut into small pieces, and then dried in a convection drying oven at 60°C. For obtaining uniform size of powder, dried red pimiento pieces and red pepper powder were ground in a homogenizer and then sieved through 500 mesh. 3,

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5-Dinitrosalicylic acid was purchased from Sigma Chemical (St Louise, USA), and MRS agar from Difco (Difco Lab., USA). All other chemicals used were of reagent grade.

Preparation of kakdugi

Radish root was cut into 2×2×2 cm cubes, and then mixed well with the condiments shown in Table 1. Each kakdugi (200 g) was packed into glass jars and stored at 10°C (Incubator, LTI-1000SD, Eyela Co., Japan) for 30 days. For chemical analyses, 100 g of kakdugi was homogenized and filtered through cheese cloth and the filtrate was used.

pH and total acidity

pH was measured with pH meter (Hanna instruments, Singapore), and total acidity was measured by the titration of 10 mL filtrate with 0.1 N NaOH and expressed as the amount of lactic acid in kakdugi (12).

Reducing sugar

Reducing sugar was measured by its absorbance at 550 nm by spectrophotometer (Model 80-2088-64, Pharmacia Biotech. Co., Cambridge, England) using the 3,5-dinitrosalicylic acid (DNS) method, and expressed as the glucose concentration in kakdugi (13).

Enumeration of lactic acid bacteria in kakdugi

Liquid from the kakdugi was diluted with 0.85% sterilized saline. Total lactic acid bacteria was enumerated with *Lactobacillus* MRS agar (Difco Lab.) using the pour-plate method. Cells were grown at 38°C for 48 hr (14).

ASTA value

Extractable color of red pepper powders was evaluated by the American Spice Trade Association (ASTA) method. A 0.1 g of aliquot of kakdugi was put into a 100 mL volumetric flask and filled to volume with acetone. The flask was capped and then shaken for 1 min and left standing in a dark place for 16 hr, and then the absorbance was measured at 460 nm (15). ASTA value was calculated using the following equation.

$$\text{ASTA value} = \frac{A \times 16.4}{W}$$

A: Absorbance 460 nm, W: Sample weight (g)

Table 1. Ingredients of kakdugi preparation

Ingredient	Ratio (%)
Radish	100
Red pepper or red pimiento	3.5
Garlic	3.5
Green onion	3.5
Salt	3.5
Sugar	3.5
Water	0.6

Color

Hunter L (brightness), a (redness) and b (yellowness) values of the filtrate or homogenate were measured using a digital color measuring/difference calculation meter (Model ND-1001 DP, Nippon Denshoku Co., Ltd., Japan).

Analysis of capsaicinoid

Capsaicinoid content was analysed by HPLC according to slightly modified method of Hoffman et al. (16). An aliquot (1 mL) was added with acetoniltrile (5 mL), homogenized for 2 min and centrifuged at 3,000 rpm for 30 min. The supernatant was filtered through a membrane filter (0.45 μm) and eluted with acetonilrile. Liquid chromatography was performed using an HPLC system (column: Water Symmety 3.9×150 mm, Reversed phase-C_{18}). A 50 L aliquot was injected into the HPLC (Gilson HPLC Systems). The eluent was acetonitrile/water (50/50) at a flow rate of 1.5 mL/min. Detection column effluent was monitored by UV detection (L-4000 UV detector). Capsaicin (98%, Sigma) and dihydrocapsaicin (90%, Sigma) were used as known standards of both compounds. Standard curves were prepared using serial dilutions of 6.25, 12.5, 25, and 50 ppm.

Texture analyses

Cubed radish root (2×2×2 cm) of kakdugi were measured by Texture Profile Analysis using a texture analyzer (TA XT2, Microstable Systems, Co., England). Operation conditions of the texture analyzer were as shown in Table 2. Measurements were repeated ten to fourteen times.

Sensory evaluation

Ten trained panel members evaluated the kakdugi using a scoring method (unstructured line scale, 10 points) for evaluating color, smell, taste, texture, over-all acceptability (17). The higher the score for an attribute, the stronger the intensity of that attribute. Results of treatments were statistically analyzed using a significant-independent t-test, and results of fermentation time were done using Duncan's multiple range test and post-hoc ANOVA of SAS (18).

Table 2. Conditions of texture analyser for TPA

Force threshold	20 g
Contact area	0.15 mm^2
Contact force	5.0 g
Pretest speed	5.0 mm/sec
Posttest speed	5.0 mm/sec
Test speed	5.0 mm/sec
Strain	75%
Time	0.5 sec
Trigger type	Auto 10 g
Probe	Φ 5 mm

RESULTS AND DISCUSSION

pH and total acidity

Changing patterns of pH and total acidity during fermentation of kakdugi made with either red pepper or red pimiento are shown in Fig. 1. pH of red pimiento kakdugi at the start of fermentation was 5.90, which is similar to that of conventional kakdugi. After 3 days it decreased rapidly and reached dropped to about pH 3.9 at day 20 of fermentation, which is slightly lower than that of conventional kakdugi. Total acidity of freshly made red pepper kakdugi was 0.135% (lactic acid), while that of red pimiento kakdugi was 0.149%, which reflected the higher total acidity in red pimiento itself (0.336%) than in red pepper (0.198%). However, the total acidity of the red pepper kakdugi increased rapidly and reached 0.629% at 10 days of fermentation, which thought to be the optimal ripening time (14,19). Also at this time, total acidity of red pimiento kakdugi reached 0.630%, which was slightly higher than that of traditional hot red pepper kakdugi, although not significantly. These results suggest that microbial growth is more active in red pimiento kakdugi than in red pepper kakdugi. Saltiness of both types of kakdugies was maintained around 1.3% during the whole fermentation periods.

Reducing sugar amount

The trend for changes in reducing sugar content of red pimiento kakdugi was similar to that of red pepper, as depicted in Fig. 2. Reducing sugar content of red pimiento kakdugi at the start of fermentation was higher, at 52.5 mg/mL, compared with that of red pepper kakdugi at 42.5 mg/mL, which could be attributed to red pimiento being a sweeter pepper containing higher concentrations of reducing sugar than red pepper (20). However, the amount of reducing sugar in red pimiento kakdugi decreased more rapidly after 3 days of fermentation, and after 10 days of fermentation reached 33.0 mg/mL, similar to that of red pepper kakdugi. After reaching optimal ripening time, the decreasing rate of reducing sugar content in the two kakdugies were similar.

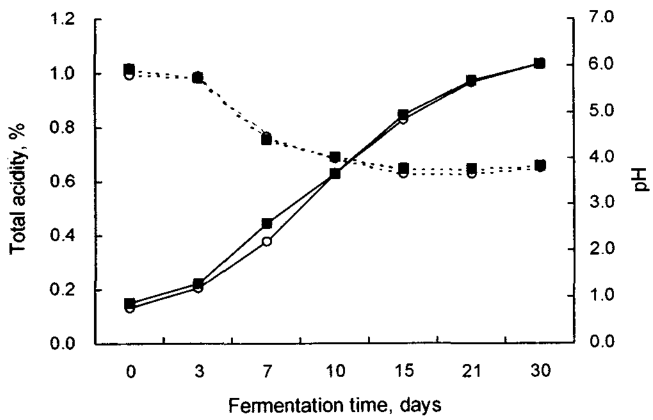

Fig. 1. Changes in pH and total acidity of kakdugi with red pepper powder replaced with red pimiento powder.
○, Red pepper; ■, Red pimiento; ···, pH; —, Total acidity.

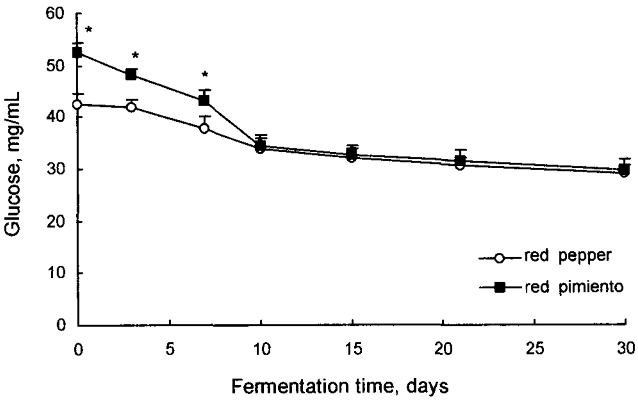

Fig. 2. Changes in reducing sugar amount of kakdugi with red pepper powder replaced with red pimiento powder. *Significance at $p<0.05$.

Lactic acid bacteria change

Total number of lactic acid bacteria in red pimiento kakdugi and red pepper kakdugi are shown in Fig. 3. Total number of lactic acid bacteria in red pimiento kakdugi increased more rapidly and reached a maximum at 15 days of fermentation at 10°C; the bacteria count at that time was 1.6×10^{10} (CFU/mL), which was higher than for red pepper kakdugi (2.3×10^{9} CFU/mL). This result is consistent with that of reducing sugar amount in kakdugi (Fig. 2) as well as with that of a previous report (21). At the initial fermentation period, higher amounts of reducing sugar in red pimiento kakdugi seem to cause lactic acid bacteria to grow more rapidly than in red pepper kakdugi.

Color and ASTA value

Red pimiento kakdugi showed significantly higher values for a (redness) and L (brightness) in both liquid and

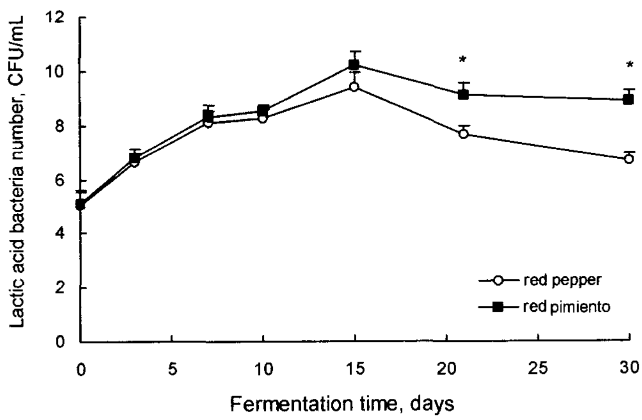

Fig. 3. Changes in lactic acid bacteria number in kakdugi with red pepper powder replaced with red pimiento powder. *Significance at $p<0.05$.

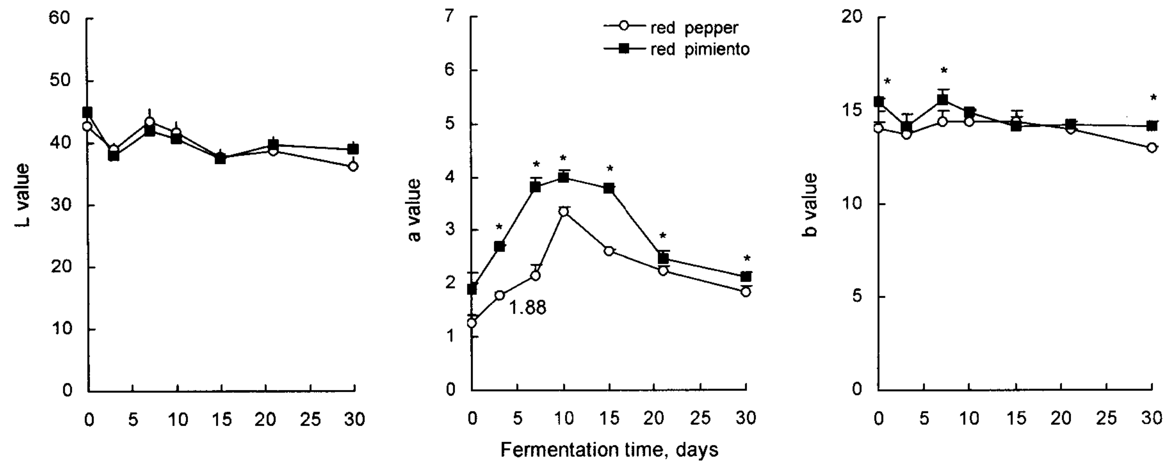

Fig. 4. Changes in Hunter color of L, a and b value of kakdugi with red pepper powder replaced with red pimiento powder. *Significance at $p<0.05$.

solid kakdugi than in red pepper kakdugi, as shown in Fig. 4. Changing patterns of red pepper kakdugi during fermentation were consistent with previous reports (22,23). Salted or fermented radish cubes of kakdugi are easily colored with red from pimiento powder, as in the case for red pepper powder. However, the intensity of redness in radish cubes of pimiento kakdugi was stronger and more stable during the entire fermentation period than in red pepper kakdugi (Fig. 5).

Capsaicinoid content

Capsaicinoid contents of both red pepper and red pimiento kakdugies are shown in Fig. 6. Capsaicin and dihydrocapsaicin were not detected in red pimiento kakdugi, as expected. However, the amount of capsaicin, the major contributor to pungency (24) decreased gradually in red pepper powder kakdugi during fermentation. In freshly prepared red pepper powder kakdugi, the amount

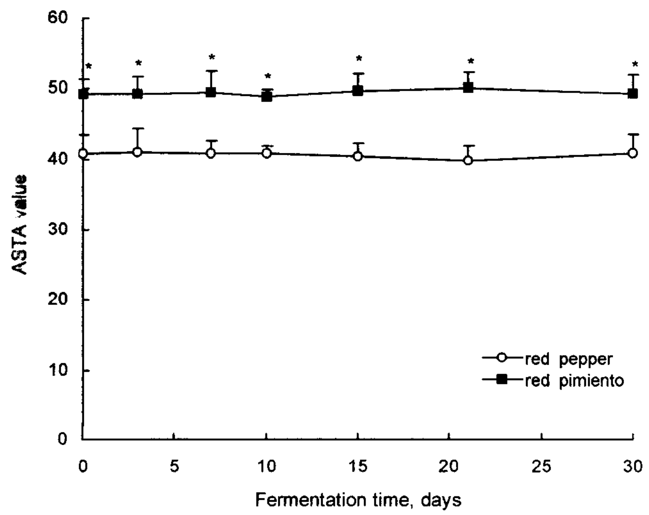

Fig. 5. Changes in ASTA value of kakdugi with red pepper powder replaced with red pimiento powder. *Significance at $p<0.05$.

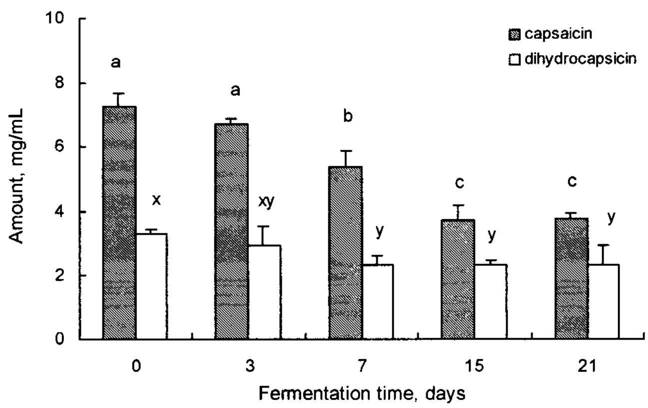

Fig. 6. Changes in capsaicin and dihydrocapsaicin content of red pepper powder kakdugi. a and x: Significance at $p<0.05$.

of capsaicin and dihydrocapsaicin were estimated to be 7.26 mg% and 3.32 mg%, respectively. As fermentation proceeded, capsaicin decreased to 3.74 mg% at 21 day of fermentation, whereas dihydrocapsaicin content did not change greatly. Decreases in capsaicin content in red pepper powder kakdugi might be due to microbial degradation during fermentation (25).

Texture

Textural properties of radish cube of kakdugi throughout the fermentation period were measured by a texture analyzer (Fig. 7). Hardness and fracturability increased slightly in both types of kakdugi until the optimum ripening time, and decreased thereafter. These results are similar to those of the previous report (23). However, no significant changes were observed in the hardness of the radish cubes throughout the fermentation period between red pimiento kakdugi and red pepper kakdugi. Also, there were no significant changes in fracturability between red pepper kakdugi and red pimiento kakdugi.

Sensory characteristics

Sensory evaluation results of both types of kakdugi

Table 3. Mean scores of sensory attributes of kakdugi replaced red pepper with red pimiento during fermentation at 10°C

Treat-ments	FT[1)]	Color		Appearance		Odor			Taste				Texture	Over-all
		Liquid	Solid	Liquid	Solid	Sour	Moldy	Hot	Sweet	Sour	Savory	Hot	Hardness	accept-ability
Red pepper	0	[2)] $^{C}6.3\pm1.4^{a}$ [3)]	$^{B}1.3\pm0.4^{d}$	$^{B}5.4\pm1.6^{a}$	$^{B}4.4\pm1.4^{a}$	$^{A}0.8\pm0.6^{c}$	$^{A}0.5\pm0.5^{e}$	$^{A}7.7\pm1.2^{a}$	$^{B}3.8\pm1.4^{b}$	$^{A}1.3\pm0.7^{c}$	$^{B}2.3\pm1.1^{c}$	$^{A}8.2\pm0.5^{a}$	$^{A}8.2\pm0.5^{a}$	$^{B}4.6\pm1.7^{bc}$
	3	$^{C}5.1\pm1.3^{b}$	$^{B}3.9\pm1.4^{c}$	$^{B}4.8\pm1.6^{ab}$	$^{B}4.2\pm1.4^{a}$	$^{A}1.5\pm1.0^{c}$	$^{A}0.8\pm0.7^{de}$	$^{A}7.1\pm1.1^{ab}$	$^{B}4.7\pm1.6^{ab}$	$^{A}1.6\pm0.7^{c}$	$^{B}1.9\pm0.7^{c}$	$^{A}7.5\pm0.9^{ab}$	$^{A}7.5\pm0.9^{ab}$	$^{A}5.4\pm0.8^{ab}$
	7	$^{B}4.1\pm1.5^{bc}$	$^{B}6.2\pm0.9^{a}$	$^{B}4.6\pm1.6^{ab}$	$^{B}4.7\pm1.6^{a}$	$^{A}3.3\pm1.2^{b}$	$^{A}1.7\pm0.7^{c}$	$^{A}6.2\pm1.5^{bc}$	$^{B}3.6\pm0.9^{b}$	$^{A}4.9\pm1.1^{b}$	$^{B}4.1\pm1.5^{b}$	$^{A}6.9\pm1.1^{bc}$	$^{A}6.9\pm1.1^{bc}$	$^{B}5.2\pm1.3^{ab}$
	10	$^{B}4.6\pm1.1^{b}$	$^{B}5.4\pm0.7^{ab}$	$^{B}5.1\pm1.1^{ab}$	$^{B}5.4\pm1.5$	$^{A}6.1\pm1.2^{a}$	$^{A}1.8\pm1.2^{c}$	$^{A}6.6\pm1.2^{bc}$	$^{B}4.7\pm0.8^{ab}$	$^{C}4.5\pm0.9^{b}$	$^{AB}6.5\pm1.4^{a}$	$^{A}7.3\pm1.2^{abc}$	$^{A}7.3\pm1.2^{abc}$	$^{B}6.1\pm1.2^{a}$
	15	$^{B}4.6\pm1.0^{b}$	$^{B}5.4\pm0.7^{ab}$	$^{B}4.7\pm1.2^{ab}$	$^{B}4.7\pm1.3^{a}$	$^{A}6.8\pm0.7^{a}$	$^{A}2.2\pm1.3^{c}$	$^{A}5.1\pm1.1^{d}$	$^{A}4.7\pm1.1^{ab}$	$^{A}7.3\pm1.0^{a}$	$^{A}5.9\pm1.0^{a}$	$^{A}6.6\pm0.9^{c}$	$^{A}6.6\pm0.9^{c}$	$^{B}5.4\pm1.1^{ab}$
	21	$^{B}3.3\pm1.5^{c}$	$^{B}5.0\pm1.2^{b}$	$^{B}3.8\pm1.6^{b}$	$^{B}4.3\pm1.3^{a}$	$^{A}7.0\pm1.0^{a}$	$^{A}4.1\pm1.0^{b}$	$^{A}5.7\pm1.0^{cd}$	$^{B}5.4\pm1.4^{a}$	$^{A}7.4\pm0.9^{a}$	$^{A}6.3\pm1.3^{a}$	$^{A}6.4\pm0.9^{c}$	$^{A}6.4\pm0.9^{c}$	$^{B}3.7\pm1.7^{cd}$
	31	$^{B}1.7\pm0.9^{d}$	$^{B}3.1\pm1.8^{c}$	$^{B}2.0\pm0.8^{c}$	$^{B}2.2\pm1.0^{b}$	$^{B}2.4\pm1.0^{b}$	$^{A}6.7\pm1.9^{a}$	$^{A}3.5\pm0.9^{e}$	$^{B}1.9\pm0.8^{c}$	$^{A}6.8\pm1.1^{a}$	$^{A}3.9\pm1.8^{b}$	$^{A}4.1\pm1.1^{d}$	$^{A}4.1\pm1.1^{d}$	$^{B}2.8\pm0.7^{d}$
Red pimiento	0	$^{A}8.3\pm0.8$	$^{A}2.5\pm1.0^{c}$	$^{A}8.2\pm1.0^{a}$	$^{A}7.7\pm1.4^{ab}$	$^{A}0.7\pm0.6^{c}$	$^{A}0.4\pm0.4^{c}$	$^{B}0.9\pm1.0^{c}$	$^{AB}5.1\pm1.6^{b}$	$^{A}1.1\pm0.7^{c}$	$^{AB}3.0\pm1.6^{b}$	$^{B}1.7\pm0.9^{a}$	$^{A}7.1\pm1.0^{a}$	$^{A}6.0\pm1.7^{b}$
	3	$^{A}8.6\pm0.7$	$^{A}5.7\pm1.4^{b}$	$^{A}7.9\pm1.3^{a}$	$^{A}7.9\pm1.2^{ab}$	$^{A}1.8\pm0.9^{c}$	$^{A}1.0\pm0.6^{bc}$	$^{B}1.1\pm1.0^{c}$	$^{A}6.6\pm1.2^{a}$	$^{A}2.0\pm1.2^{c}$	$^{B}2.9\pm1.1^{b}$	$^{B}1.3\pm0.9^{a}$	$^{A}5.7\pm1.1^{bc}$	$^{A}6.5\pm1.1^{ab}$
	7	$^{A}8.4\pm0.7$	$^{A}8.3\pm1.0^{a}$	$^{A}8.6\pm0.9^{a}$	$^{A}8.4\pm0.6^{a}$	$^{A}4.2\pm1.4^{b}$	$^{A}1.9\pm0.7^{b}$	$^{B}2.1\pm1.0^{ab}$	$^{A}6.4\pm1.3^{a}$	$^{A}5.0\pm1.1^{b}$	$^{A}5.4\pm1.3^{a}$	$^{B}1.8\pm1.0^{a}$	$^{A}5.6\pm1.1^{bc}$	$^{A}7.0\pm1.6^{ab}$
	10	$^{A}8.1\pm0.7^{a}$	$^{A}7.3\pm1.2^{a}$	$^{A}8.1\pm1.2^{a}$	$^{A}8.5\pm0.7^{a}$	$^{A}6.9\pm1.6^{a}$	$^{A}1.2\pm1.0^{bc}$	$^{B}2.3\pm0.8^{a}$	$^{A}6.2\pm1.2^{ab}$	$^{B}5.7\pm1.3^{ab}$	$^{B}5.4\pm1.3^{a}$	$^{B}1.5\pm0.8^{a}$	$^{A}6.1\pm1.2^{b}$	$^{A}7.4\pm0.7$
	15	$^{A}7.9\pm1.1^{a}$	$^{A}7.7\pm1.1^{a}$	$^{A}8.0\pm0.9^{a}$	$^{A}6.9\pm1.4^{b}$	$^{A}7.4\pm1.3^{a}$	$^{A}2.0\pm1.1^{b}$	$^{B}1.8\pm1.0^{abc}$	$^{A}5.7\pm0.8^{ab}$	$^{A}6.4\pm1.4^{a}$	$^{A}5.7\pm1.3^{a}$	$^{B}1.7\pm1.0^{a}$	$^{AB}4.9\pm1.0^{c}$	$^{A}6.6\pm1.1^{abc}$
	21	$^{A}8.1\pm0.9^{a}$	$^{A}7.9\pm1.1^{a}$	$^{A}7.7\pm1.5^{a}$	$^{A}7.1\pm1.3^{b}$	$^{A}7.3\pm1.5^{a}$	$^{A}3.8\pm1.6^{a}$	$^{B}1.7\pm0.9^{abc}$	$^{AB}6.3\pm1.2^{ab}$	$^{A}6.7\pm1.7^{a}$	$^{A}5.6\pm1.1^{a}$	$^{B}1.5\pm0.8^{a}$	$^{A}3.7\pm1.6^{d}$	$^{A}5.4\pm1.9$
	31	$^{A}5.3\pm1.5^{b}$	$^{A}5.5\pm1.9^{b}$	$^{A}5.1\pm1.1^{b}$	$^{A}4.7\pm1.4^{c}$	$^{A}4.1\pm1.3^{b}$	$^{B}3.7\pm1.8^{a}$	$^{B}1.2\pm0.9^{bc}$	$^{A}3.3\pm1.2^{c}$	$^{A}6.5\pm1.4^{a}$	$^{A}3.0\pm1.3^{b}$	$^{B}2.1\pm1.2^{a}$	$^{AB}3.5\pm1.0^{d}$	$^{A}4.1\pm0.8^{d}$

[1)] FT: Fermentation time (days).
[2)] Any two means in same row (between the same fermentation time) followed by the same superscripts are not significantly different ($p<0.05$) by Duncan's multiple range test.
[3)] Any two means in the same column (among the same treatment) follwed by the same superscripts are not significantly different ($p<0.05$) by Duncan's multiple range test.

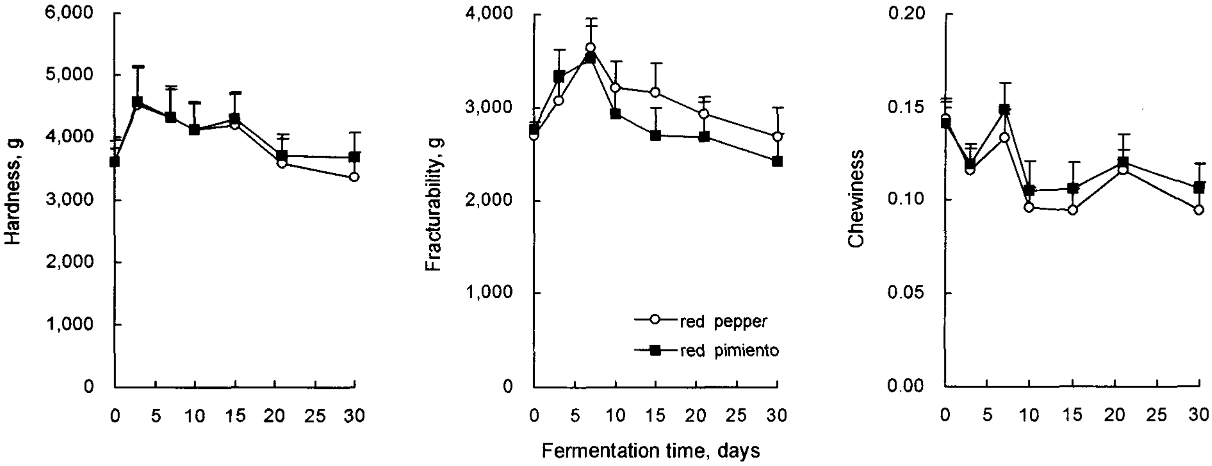

Fig. 7. Changes in hardness, fracturability and chewiness of kakdugi with red pepper powder replaced with red pimiento powder.

during fermentation are described in Table 3 and Fig. 8. As fermentation was proceeding, sour odor and sour taste continually increased ($p<0.05$), but there were no significant changes between red pepper kakdugi and red pimiento kakdugi. Also, no significant changes were observed in the hardness of the radish cube throughout the fermentation period between red pimiento kakdugi and red pepper kakdugi. Color of kakdugi is a very important attribute, especially in kakdugi. The color of pimiento kakdugi was scored significantly higher than that of red pepper kakdugi ($p<0.05$). These sensory results are consistent with those of instrumental analysis of color (Fig. 4). Furthermore, acceptability of appearance of red pimiento kakdugi during the entire fermentation period was significantly better than that of red pepper kakdugi ($p<0.05$). Hot odor and taste in red pimiento kakdugi were sensed very weakly during the fermentation periods, whereas very strongly in red pepper kakdugi ($p<0.05$). However, the scores of pungent taste and odor gradually

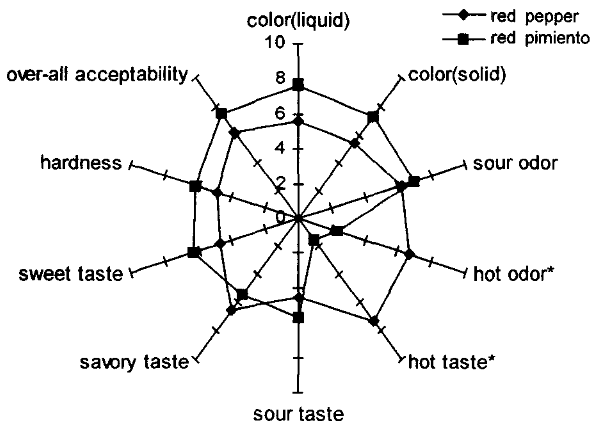

Fig. 8. Spider web diagram of mean scores of sensory evaluation of kakdugi with red pepper powder replaced with red pimiento powder on the 10th day of fermentation at 10°C. *Significance at $p<0.05$.

decreased as fermentation proceeded ($p<0.05$). Over-all acceptability was scored slightly higher in red pimiento kakdugi throughout the fermentation period than in red pepper kakdugi, but was not statistically significant. It can be concluded that red pimiento kakdugi is similar to traditional red pepper kakdugi, although red pimiento kakdugi has more red color and a milder flavor. These results were derived from the panel members composed of Koreans. Separately, we selected nine foreign faculty members as sensory panelists and for a preference test for the two kakdugies with a nine point scale. The results turned out that red pimiento kakdugi had a higher score than that of red pepper kakdugi ($p<0.05$, unpublished data). From these results, it was thought that red pimiento kakdugi might be more acceptable to people who dislike hot taste of traditional hot kakdugi.

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