

# Quality Characteristics of *Kochujang* Prepared with Peach Jam and Salt Replacement

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**Abstract:** *Kochujang*, hot pepper paste, is a widely consumed Korean traditional food and also makes a typical Korean meal. The objective of the present study was to investigate the quality characteristics of *kochujang* prepared with salt replacement (SR) as a substitute of ordinary salt (OS) since intake of high sodium is not good for health. Reducing sugar (29.35%) and amino nitrogen (82.6%) contents of SR *kochujang* were significantly high compared to OS *kochujang* (24.82 and 68.6%, respectively), however, sodium content was significantly lower in SR *kochujang* (1292.26 mg/100 g) than in OS *kochujang* (1568.71 mg/100 g). Free sugars like fructose and glucose contents were also significantly high in SR *kochujang*. Similarly, antioxidant potentials in terms of DPPH and ABTS were significantly high for SR *kochujang* (30.13 and 27.31%) compared to OS *kochujang* (27.05 and 24.72%), respectively. In addition, the score for overall acceptance of SR *kochujang* (4.81) was higher than that of OS *kochujang* (3.13). Results of the present study suggested that nutritious *kochujang* having significantly higher antioxidant potentials and lower sodium content could be prepared using salt replacement as a substitute of ordinary salt.

**Keywords:** *Kochujang*, Peach Jam, Quality Characteristics, Salt Replacement, Sodium

## Introduction

*Kochujang*, hot pepper paste is a Korean traditional food (Lee, 1979) with a sweet and palatable taste that is prepared by fermentation of glutinous rice with red pepper powder, *meju* and salt. It has been widely used in Korean people's daily meals. It is the fourth and most enjoyed traditional food component that makes a typical Korean meal (Kwon et al., 2015). As mentioned in the previous report (Kwon et al., 2014) *kochujang*, along with *kimchi*, another fermented traditional food is one of the most symbolic fermented food of Korea (Shin et al., 2011). Westernization of Korean lifestyles and the increasing tendency to nuclear family have influenced the use of improved factory made *kochujang* rather than traditional one. *Kochujang* quality is determined by the type and ratio of ingredients in the mixture (Cho et al., 1981; Kim et

al., 2008), microbial strain (Oh et al., 2000), and the proportion of salt (Kim and Yang, 2004).

The studies on *kochujang* have been concentrated basically on the different starch sources (Moon and Kim, 1988; Shin et al., 1997) used in its preparation, and followed by addition of different secondary ingredients such as fig (Kim and Song, 2002), Japanese apricot (Lee, 2008), and *red koji* (Hyun et al., 2007) to improve the quality or to alter its physicochemical properties during fermentation and/or aging processes. In addition, to enhance the quality of *kochujang* so as to make it a global seasoning, low-salt *kochujang* is desirable in order to decrease the consumption of sodium. However, the concentration of salt influences (Oh et al., 2002) the fermentation and aging of *kochujang*, for instance if the proportion of salt is low, the fermentation during aging and/or during storage might not take place appropriately. Yamamoto et al. (1984) reported that if

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Published at: <http://www.ijsciences.com/pub/issue/2017-07/>

DOI: 10.18483/ijSci.1359; Online ISSN: 2305-3925; Print ISSN: 2410-4477



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alcohol is used in the preparation of *kochujang*, the unfavorable activities of microorganisms could well be controlled during aging as well as storage and thus low-salt *kochujang* could be prepared. There are other reports on *kochujang* about addition of spices like garlic (Kim and Lee, 2001), mustard and horseradish (Shin et al., 2000; Oh et al., 2006) and also the mixtures of these anti-microbial materials (Kim, 2005; Park and Kim, 2007) during its preparation.

*Kochujang* is a sweet-hot-salty seasoning with good nutrient composition. However, high intake of sodium may cause elevated osmotic pressure of extracellular fluid, increased blood sodium, and aggravation of heart and kidney's burden, leading to high blood pressure and heart diseases (Meneton et al., 2005). Researches have been conducted to replace the concentration of ordinary salt in *kochujang*. For instance, Kim (2001) used antimicrobial alcohol, mustard, or chitosan as the substitute of a part of ordinary salt during *kochujang* preparation. Similarly, Seo et al. (2014) added various antimicrobial materials to the low-salt *kochujang* during preparation and at eight weeks of its aging. In the present study, half or whole of the

ordinary salt in *kochujang* was substituted with 'salt replacement' which was prepared with fermented vegetables and unsterilized brown-rice vinegar.

## Materials and methods

### Materials

Hot pepper powder, grain syrup (Daesang, Seoul, Korea), glutinous rice powder, meju (Korean-style soybean koji), peach jam (Cheongdo Peach Research Institute, Cheongdo, Korea) and ordinary salt were purchased from local stores. Anhydrous ethanol was obtained from Duksan Pure Chemicals (Ansan, Kyunkido, Korea).

### Preparation of peach *Kochujang*

*Kochujang* was prepared by gelatinizing a mixture of glutinous rice powder, hot pepper powder, grain syrup, meju, ethanol and peach jam. Ordinary salt and/or salt replacement was used to prepare *kochujang* samples. The samples containing 4% ordinary salt, 2% ordinary salt and 2% salt replacement, and 4% salt replacement were named as PK-1, PK-2, and PK-3, respectively. The detail of ingredients are mentioned in Table 1.

Table 1. Formulae for peach *kochujang* prepared with different proportions of ordinary salt and salt replacement

Ingredients (%)	Sample <sup>1)</sup>		
	PK-1	PK-2	PK-3
Hot pepper powder	15	15	15
Grain syrup	32	32	32
Glutinous rice powder	10	10	10
Meju (Korean-style soybean koji)	3	3	3
Ethanol(Spirit)	5	5	5
Peach jam	31	31	31
Sun-dried salt	4	2	0
Salt replacement	0	2	4

<sup>1)</sup>PK-1: *Kochujang* containing 4% ordinary salt, PK-2: *Kochujang* containing 2% ordinary salt and 2% salt replacement, and PK-3: *Kochujang* containing 4% salt replacement.

### Physicochemical parameters

The pH of *Kochujang* was measured using a portable pH meter (Thermo Scientific, Orion Star A221, Waltham, Massachusetts, USA). Total acid (malic acid) was measured by adding 5 g of *kochujang* sample to 125 mL of deionized water and titrating with 0.1 N sodium hydroxide to an endpoint pH 8.2. The content of amino nitrogen was analyzed according to the formal titration method as described by AOAC (1984). The total reducing sugar was measured using DNS (Dinitrosalicylic acid) method (Ghose, 1987) at 540 nm. To measure reducing sugar, 1.5 mL aliquot of the hydrolysate were sampled and

centrifuged at 1660 × g for 10 min, supernatant was filtered through a 0.2 µm syringe filter.

### Sodium content

Sodium content in the *Kochujang* was measured using chemical analysis and salinity measurement (Shin et al., 2014). The chemical analysis was conducted using an inductively coupled plasma optical emission spectrometer (IRIS II XSP; Thermo Scientific, USA). The salinity measurement was measured using salinometer (GMK-530; G-Won Hitech Co, Korea) as described by Lee (1997).

**DPPH radical scavenging activity**

The radical scavenging potential of peach *kochujang* was measured using 1,1-diphenyl-2-picrylhydrazyl (DPPH) according to the methods described by Blois (1958). One hundred microliters of 0.1% DPPH methanol solution was mixed with 0.1 mL of sample. The mixture was allowed to react at room temperature in dark for 30 min and absorbance was measured at 517 nm (Multiskan GO Microplate Spectrophotometer; Thermo Fisher Scientific). The radical-scavenging activity (RSA) was calculated as a percentage inhibition using the following equation.

$$\% \text{ inhibition} = (1 - \text{Sab}/\text{Cab}) \times 100$$

where, Sab is the absorbance of the sample and DPPH solution; Cab is absorbance of DPPH solution without sample.

**ABTS cation radical-scavenging assay**

The ABTS cation radical-scavenging assay was carried out following a previous report (Re et al., 1999). Briefly, stock solution was prepared by reacting 7 mM ABTS with 2.45 mM potassium persulfate to generate the ABTS cation chromophore. The mixture was diluted with absolute ethanol to give an absorbance of 1.5-2 at 414 nm. An aliquot of the samples (10-40  $\mu$ L) was added to 3 mL of ABTS reagent and the absorbance was taken using an UV/visible spectrophotometer (Shidmazu UV-1601, Japan) after initial mixing and up to 90 min until it reached a plateau. Total antioxidant capacity was calculated relative to the reactivity of ascorbic acid as a standard under the same conditions.

**Quantification of free sugars**

Free sugar content was analyzed following the method of Génard and Souty (1996). The sample (5 g) was mixed with 10 mL of distilled water and homogenized. The volume of was adjusted to 20 mL by adding distilled water. The mixture was centrifuged at  $16000 \times g$  for 30 min. The collected supernatant was filtered through a cartridge (Sep-Pak C18, WAT023501, Waters, USA) and a 0.45  $\mu$ m syringe filter (PVDF, Whatman, Tokyo, Japan). Free sugars were quantified by HPLC (Model 9300, Younglin Co., Anyang, Korea) consisting of a refractive index detector (Triathlon M730D, Younglin Co.), a column heater set at 85°C, and Sugar-Pak (6.5  $\times$  300 mm, Alltech, Staten Island, NY, USA); the mobile phase was deionized-distilled H<sub>2</sub>O delivered at 0.5 mL/min. The glucose, fructose, sucrose, and maltose obtained from Aldrich Chemical Co. Inc. (Milwaukee, WI, USA), were used as reference sugars for identification; mannitol was used as an internal standard. Free sugar content was expressed as g/100 g sample.

**Color measurement**

L\* (lightness), a\* (redness, + or greenness, -), and b\* (yellowness, + or blueness, -) values of *kochujang* were measured using a chroma meter (CR-300; Minolta Corp., Osaka, Japan). A Minolta calibration plate (YCIE=94.5, XCIE=0.3160, YCIE=0.330) and a Hunter Lab standard plate (L\*=97.51, a\*= -0.18, b\*= +1.67) were used to standardize the instrument using a D65 illuminant (Kim et al, 2014). Color values were measured directly from 3 zones of peach *kochujang* and mean values were calculated.

**Evaluation of sensory properties**

Samples were rated for taste, color, flavor, and overall taste using scale of 1=dislike very much, 2=dislike moderately, 3=dislike slightly, 4=neither like nor dislike, 5=like slightly, 6=like moderately, 7=like very much. All the sensory properties were evaluated by 20 volunteer panelists (10 women and 10 men) selected from the list of graduate students of College of Food Technology of Kyungpook National University, Daegu, Korea. Mean values of 10 evaluations for each sensory property were reported as scores.

**Statistical analysis**

Data were subjected to analysis of variance using the SAS version 9.2 (SAS Institute Inc., Cary, NC, USA). Differences between means at  $p < 0.05$  were analyzed using Tukey test

**Results and Discussion****pH, total acid, and reducing sugar contents**

The pH value and total acid and reducing sugar contents of *kochujang* are shown in Table 2. The pH value of three *kochujang* samples were not significantly different. However, total acid value of PK-3 was significantly high as compared to two other samples. Total acid and amino nitrogen contents of *kochujang* samples were in order of PK-3>PK-2>PK-1. Reducing sugar content of PK-2 (31.51%) was the highest followed by that of PK-3 (29.35%). The significant variation in the physicochemical characteristics among *kochujang* samples might be due the addition of salt replacement, which was prepared with fermented vegetables and brown-rice vinegar. Sweetness of peach *kochujang* could be modified with the use of salt replacement as the reducing sugar is a main contributor to *kochujang* sweet taste (Seo et al., 2014). Addition of salt replacement could enhance the taste of peach *kochujang* since it increased the amino-type nitrogen, which increases the taste of *kochujang* (Seo et al., 2014). High total acid value of PK-3 might be due to higher total acid content of rice vinegar (Chen et al., 2012) than that of ordinary salt.

Table 2. Physicochemical characteristics of peach *kochujang*

Sample <sup>1)</sup>	pH	Total acid <sup>2)</sup> (%)	Reducing sugar (%)	Amino nitrogen (mg/g)
PK-1	5.02±0.05 <sup>a3)</sup>	5.61±0.01 <sup>c</sup>	24.82±0.20 <sup>c</sup>	68.60±9.90 <sup>b</sup>
PK-2	5.02±0.04 <sup>a</sup>	6.14±0.01 <sup>b</sup>	31.51±0.05 <sup>a</sup>	75.60±0.00 <sup>b</sup>
PK-3	5.01±0.02 <sup>a</sup>	7.62±0.07 <sup>a</sup>	29.35±0.26 <sup>b</sup>	82.60±0.00 <sup>a</sup>

<sup>1)</sup>Sample are defined in Table 1.

<sup>2)</sup>As malic acid.

<sup>3)</sup>Quoted values are means±SD of triplicate measurements. Values followed by different superscripts in the same column are significantly different ( $p<0.05$ ).

### Salinity and sodium contents

The salinity value and sodium content of PK-3 (4.13% and 1292.26 mg/100 g) were significantly low as compared to PK-1 (4.21% and 1568.71 mg/100 g), respectively (Table 3). Low sodium content in PK-3 might be due to substitution of ordinary salt with salt

replacement. Thus high quality *Kochujang* could be prepared by using salt replacement as intake of more sodium may cause aggravation of heart and kidney's burden, leading to high blood pressure and heart diseases (Meneton et al., 2005).

Table 3. Sodium values in peach *kochujang*

Sample <sup>1)</sup>	Salinity (%)	Sodium content (mg/100 g)
PK-1	4.21±0.01 <sup>a2)</sup>	1568.71±189.20 <sup>a</sup>
PK-2	4.20±0.01 <sup>a</sup>	1358.33±210.94 <sup>ab</sup>
PK-3	4.13±0.01 <sup>b</sup>	1292.26±125.12 <sup>b</sup>

<sup>1)</sup>Sample are defined in Table 1.

<sup>2)</sup>Quoted values are means±SD of triplicate measurements. Values followed by different superscripts in the same column are significantly different ( $p<0.05$ ).

### Color values and free sugar content

Color of *kochujang* is important factor for consumer preference. The L-value (lightness) and a-value (redness) of *kochujang* samples were significantly decreased, however, the b-value (yellowness) was increased with the addition of salt replacement to substitute ordinary salt (Table 4). Addition of salt substitute showed a tendency to increase a lighter

yellow shade as compared to that with ordinary salt containing *kochujang*. Park and Kim (2007) reported to have increased a- and b-values during fermentation while adding anti-microbial materials to *kochujang*. In the present study b-value was increased with the addition of salt substitute indicating the color of *kochujang* could be developed a little similar to that of fermented one.

Table 4. Hunter color values of peach *kochujang*

Sample <sup>1)</sup>	Color value <sup>2)</sup>		
	L*	a*	b*
PK-1	27.08±1.70 <sup>a3)</sup>	8.74±0.29 <sup>a</sup>	2.49±0.78 <sup>c</sup>
PK-2	25.69±0.31 <sup>b</sup>	8.24±0.16 <sup>b</sup>	2.79±0.50 <sup>b</sup>
PK-3	25.83±0.39 <sup>b</sup>	7.66±0.17 <sup>c</sup>	3.14±0.80 <sup>a</sup>

<sup>1)</sup>Sample are defined in Table 1.

<sup>2)</sup>L\*, lightness (100, white; 0, black); a\*, redness (-, green; +, red); b\*, yellowness (-, blue; +, yellow).

<sup>3)</sup>Quoted values are means±SD of triplicate measurements. Values followed by different superscripts in the same column are significantly different ( $p<0.05$ ).

Fructose, glucose, and maltose were the major free sugars found in the *kochujang* samples (Table 5). Levels of fructose and glucose were increased, however that of maltose was not significantly

affected by substituting the ordinary salt with salt replacement. Major free sugar in peach *kochujang* in the present study was maltose. Maltose was also the major free sugar in the *kochujang* prepared with

apple and persimmon (Jeong et al., 2000). Glucose, fructose, and maltose are the major free sugars, which are resulted from amylolytic enzymes of

microorganisms in *kochujang* (Lee and Kim, 1991; Kim et al., 1994).

Table 5. Free sugar content (g/100 g) of peach *kochujang*

Sample <sup>1)</sup>	Fructose	Glucose	Sucrose	Maltose
PK-1	6.60±0.00 <sup>b2)</sup>	11.11±0.03 <sup>b</sup>	ND <sup>3)</sup>	15.10±0.00 <sup>a</sup>
PK-2	10.81±0.30 <sup>a</sup>	12.89±0.16 <sup>a</sup>	ND	16.24±5.99 <sup>a</sup>
PK-3	10.55±0.41 <sup>a</sup>	13.31±0.22 <sup>a</sup>	ND	15.61±1.30 <sup>a</sup>

<sup>1)</sup>Sample are defined in Table 1.

<sup>2)</sup>Quoted values are means±SD of triplicate measurements. Values followed by different superscripts in the same column are significantly different ( $p<0.05$ ).

<sup>3)</sup>ND: Non detected.

#### Antioxidant properties

DPPH and ABTS radical scavenging properties of *Kochujang* prepared with salt replacement (30.13 and 27.31%) were significantly high compared to that prepared with ordinary salt (27.05 and 24.72%,

respectively) (Table 6). High antioxidant potential for *Kochujang* prepared with salt replacement might be due to the vegetables present in it as vegetables are rich in antioxidants (Cho et al., 2017).

Table 6. DPPH and ABTS radical scavenging activity of peach *Kochujang*

Sample <sup>1)</sup>	DPPH (% Inhibition)	ABTS (% Inhibition)
PK-1	27.05±0.56 <sup>c2)</sup>	24.72±0.51 <sup>b</sup>
PK-2	33.12±0.21 <sup>a</sup>	24.69±0.31 <sup>b</sup>
PK-3	30.13±1.01 <sup>b</sup>	27.31±1.02 <sup>a</sup>

<sup>1)</sup>Sample are defined in Table 1.

<sup>2)</sup>Quoted values are means±SD of triplicate measurements. Values followed by different superscripts in the same column are significantly different ( $p<0.05$ ).

#### Sensory characteristics

Evaluation of sensory characteristics of *kochujang* sample is shown in Table 7. The scores for taste (4.63), flavor (4.88), and color (5.38) were significantly high for *kochujang* prepared with salt replacement and consequently the overall acceptance (4.81) of the sample was also high as compared to

those of *kochujang* prepared with ordinary salt (2.81, 2.94, 2.13, and 3.13, respectively). Addition of salt replacement, which was prepared with fermented vegetables and vinegar, was likely the reason of the high evaluation in terms of taste, flavor, color, and overall acceptance.

Table 7. Sensory characteristics of peach *kochujang*

Sample <sup>1)</sup>	Sensory characteristics			
	Taste	Flavor	Color	Overall acceptance
PK-1	2.81±0.86 <sup>c2)</sup>	2.94±0.58 <sup>c</sup>	2.13±0.78 <sup>c</sup>	3.13±0.70 <sup>c</sup>
PK-2	3.59±1.16 <sup>b</sup>	4.03±0.76 <sup>b</sup>	3.97±1.28 <sup>b</sup>	4.00±4.47 <sup>b</sup>
PK-3	4.63±1.41 <sup>a</sup>	4.88±0.78 <sup>a</sup>	5.38±1.22 <sup>a</sup>	4.81±0.63 <sup>a</sup>

<sup>1)</sup>Sample are defined in Table 1.

<sup>2)</sup>Quoted values are means±SD of triplicate experiments ( $n=20$ ) based on 7 point scores (1, dislike very much; 2, dislike moderately; 3, dislike slightly; 4, neither like nor dislike; 5, like slightly; 6, like moderately; 7, like very much). Values followed by different superscripts in the same column are significantly different ( $p<0.05$ ).

#### Conclusion

Peach *kochujang* was prepared using ordinary salt (OS) or substituting it with salt replacement (SR) in

part or whole. Reducing sugar and amino-type nitrogen contents of SR *kochujang* were significantly high compared to OS *kochujang*, however, sodium



content was significantly low in SR *kochujang*. Similarly, antioxidant potentials were significantly high for SR *kochujang*. In addition, overall acceptance score of SR *kochujang* was higher than that of OS *kochujang*. The present study showed that substitution of ordinary salt with low sodium containing SR could be possible to prepare nutritious *kochujang* having significantly high antioxidant potentials.

### Conflict of interest

The authors declare no conflict of interest.

### Acknowledgements

This work was supported by grants from the [RDA Research Program (PJ012004), 'The development of low salted Korean sauces in peach'] through the provincial government in North Gyeongsang, funded by the Rural Development Administration, Republic of Korea.

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