Food Engineering Progress
Vol. 12, No. 2. pp. 128~132 (2008.5)

산업식품공학
Food Engineering Progress

Effect of *Prunus mume* Extract on the Physicochemical Properties of Korean Hot Pepper-Soybean Paste

Jun Ho Lee*

Department of Food Science and Engineering, Daegu University, Gyeongsan, Gyeongbuk 712-714, Korea

Abstract

In order to improve the functional properties and to satisfy consumers' new demands on new types of commercial *kochujang*, different concentrations (0-8%) of *Prunus mume* (*maesil*) extract were blended with *kochujang* pre-mixture and aged for 10 days at room temperature and their physicochemical properties were evaluated. pH ranged 3.76-5.10 and increased amount of *maesil* extract significantly decreased pH while titratable acidity increased significantly ($p<0.05$). Moisture content and water activity increased as the concentration of *maesil* extract increased while NaCl content and apparent viscosity decreased significantly ($p<0.05$). L^*-, a^*-, and b^*-values ranged 27.06-29.11, 11.80-16.78, and 7.63-12.46, respectively. With the increasing in the concentration of *maesil* extract from 0% to 2-4% and from 2-4% to 6-8% in the samples, all color parameters decreased significantly ($p<0.05$). In addition, simple mathematical models to predict each physicochemical property were proposed. The significant R^2-values indicated that the prediction models fitted well with the experimental data.

Keywords: *kochujang*, *Prunus mume*, *maesil*, physicochemical, mathematical model

Introduction

Kochujang, a fermented hot pepper-soybean paste, is a popular traditional condiment in Korea and has hot, sweet, savory tastes. This distinctive flavor and taste originate from raw materials, free sugars and free amino acids produced by microorganisms and enzyme hydrolysis of raw materials during fermentation (Lee et al., 2007). Quality, taste, flavor, and color of *kochujang* is strongly influenced by raw materials used, blend ratio, fermentation conditions, and so on (Shin et al., 1996; Shin et al., 1997).

There have been many researches on quality changes of traditional *kochujang* (Kim et al., 1986; Park, 1993; Kim et al., 1993; Kim et al., 1997) which uses *meju* rather than *koji* or bacterial enzymes as in commercial *kochujang*. Generally, *meju kochujang* is fermented by enzymatic reactions of bacteria and yeasts and requires a long fermentation and aging period while *koji kochujang* fermented for one to three months. With the increased consumption of *kochujang* and growing concerns on health benefits, many researchers have attempted to produce the *kochujang* with pumpkin (Choo & Shin, 2000), fruit juices (Park et al., 1993), apple and persimmon (Jeong et al., 2000), horseradish or mustard (Shin et al., 2000), garlic (Kim & Lee, 2001), and so on.

In this research, we attempted to investigate the effects of *Prunus mume* (*maesil*) extract on the physicochemical properties of commercial *kochujang* and provide simple mathematical models to predict those properties as influenced by the concentration of *maesil* extract. *Maesil* has been used in many types of foods for long time and reported to have many functional properties such as antioxidative and antimicrobial effects against the wide spectrum of putrefactive and food spoilage microorganisms and also an anticancer activity (Ko, 1997; Lee, 1998; Cha et al., 1999; Lim, 1999; Bae et al., 2000).

Materials and Methods

Materials

Kochujang pre-mixture was obtained from Poorun Foods Co., Ltd. (Yeoungcheon, Gyeongbuk, Korea), which was prepared by blending 22% wheat powder (Imported from USA by Dong Ah Flour Mills Co., Ltd., Seoul, Korea), 20% wheat grain (Imported from China), 10.5% salt (Imported from Mexico), and 47.5% purified water. The pre-mixture is often used to prevent darkening of color in the preparation of commercial *kochujang*. Wheat flour was first steamed with pressure after spraying the warm water and blended with

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

ground wheat grain (inoculated with 0.05% spore suspension of *Aspergillus oryzae* starter and incubated at 35-40°C for 48-52 hr) in uniform sizes and salt, then stored in a fermentation tank for 2 days, then fermented in a pot at 23.6 for 10 days prior to manufacturing the *kochujang*. *Maesil* extract was purchased from Saehan Maesil Farm (Miryang, Gyeongnam, Korea) and corn syrup (100% corn starch, TS Co., Ltd., Incheon, Korea), red pepper powder (Imported from China), mixed condiments (contained 38% red pepper powder, 15% salt, 7% garlic, and 4% onion; Korea-China Trade Co., Daejeon, Korea), and spirits (Haitai & Company, Seoul, Korea) were also obtained from Poorun Foods Co., Ltd. (Yeoungcheon, Gyeongbuk, Korea).

Kochujang preparation

Kochujang was prepared following the commercial manufacturing practice by Poorun Foods Co., Ltd. Aged *kochujang* pre-mixture and 30% corn syrup were pasteurized at 72-75°C for 40 min while blending 8% mixed condiments, and 7% red pepper powder. The mixture was then cooled down to 40°C and blended with 3% spirits and placed in a pot at room temperature (23-24°C) before use. Different amount (0-8%) of *maesil* extract was substituted with the *kochujang* pre-mixture according to the formulation given in Table 1.

pH and titratable acidity measurement

Five grams of *kochujang* were homogenized with distilled water (sample:water=1:9, w/w) at 800 rpm for 15 min. The pH of the sample was determined using a pH meter (Model 340, Mettler Delta Co., Halstead, UK) at room temperature. Same sample was used to measure titratable acidity, amount of 0.1 N NaOH solution to titrate the sample beyond pH = 8.3. All measurements were done in triplicate.

Moisture content and water activity measurement

The moisture content was determined using convection oven at 105°C overnight. Water activity of each sample was measured using a water activity meter (TH-500, Novasina, Swiss). All measurements were done in triplicate.

Table 1. Formulation of *kochujang* with *maesil* extract substituted

Materials	*Kochujang* sample				
	0%	2%	4%	6%	8%
Kochujang pre-mixture	52	50	48	46	44
Maesil extract	0	2	4	6	8
Corn syrup	30	30	30	30	30
Red pepper powder	7	7	7	7	7
Mixed seasoning	8	8	8	8	8
Spirits	3	3	3	3	3
Total	100	100	100	100	100

NaCl content and apparent viscosity measurement

NaCl content was determined by Mohr method (Lee, 1990). Five grams of *kochujang* pre-mixture were homogenized with 250 mL distilled water and filtered. Ten mL of filtrate were titrated with 0.1 N silver nitrate after adding 1 mL of 2% K_2CrO_4 solution. The apparent viscosity was determined using a cylindrical viscometer (Model RVDV-II+, Brookfield Co., USA) using a RV spindle (No. 7) at 2.5 rpm at 21°C. All measurements were done in triplicate.

Color measurement

Color was measured using a Chromameter (model CR-200, Minolta Co., Osaka, Japan) calibrated with a calibration plate using Y=94.2, x=0.3131, and y=0.3201. Color was recorded using the *CIE-L*a*b** uniform color space, where L^* indicates lightness, a^* indicates chromaticity on a green (-) to red (+) axis, and b^* chromaticity on a blue (-) to yellow (+) axis. All measurements were done in triplicate and the mean values were reported.

Statistical analysis

The statistical analysis was done using the SAS Statistical Analysis System for Windows v8.1 (2002). The means were compared with Duncan's Multiple Range test at 5% level of significance. The regression analysis was used to develop a simple mathematical model.

Results and Discussion

pH and titratable acidity

Changes in pH and titratable acidity as influenced by *maesil* extract are presented in Fig. 1. Increased amount of *maesil* extract significantly decreased pH while titratable acidity increased significantly (p<0.05). The results are in good agreement from the finding of Lee & Lee (2006). The decrease in pH is probably due to the high amount of organic acids (Choo & Shin, 2000) contained in the *maesil* extract whose pH was 2.67. Lee & Shin (2001) and Park & Hong (2003) also reported the decrease in pH of bread with the addition of *maesil*. Park et al. (1993) also reported that pineapple juice-added *kochujang* showed a higher titratable acidity value as compared with the samples made with orange, grape, or apple juices because of higher amount of organic acids in pineapple juice.

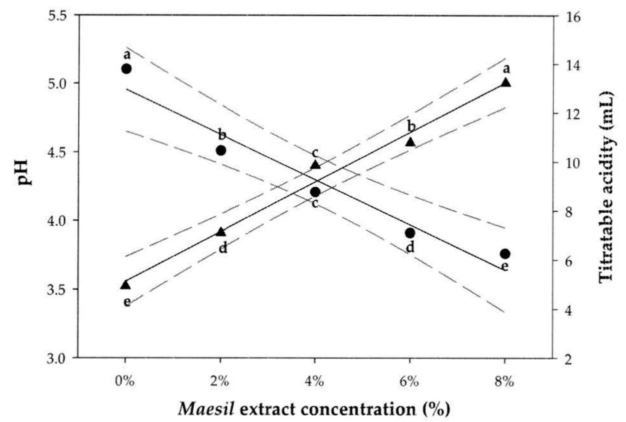

Fig. 1. Changes in pH (●) and titratable acidity (▲) as influenced by *maesil* extract concentration. Data followed by different letters in the same property are significantly different among the treatments ($p<0.05$). —— and – – – lines indicate prediction model and 95% confidence interval, respectively.

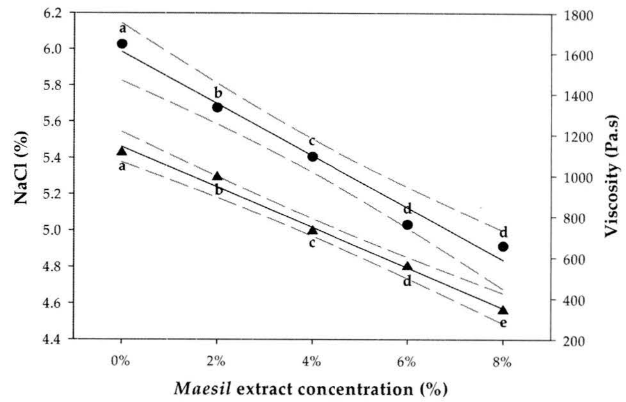

Fig. 3. Changes in NaCl content (●) and apparent viscosity (▲) as influenced by *maesil* extract concentration. Data followed by different letters in the same property are significantly different among the treatments ($p<0.05$). ——and – – – lines indicate prediction model and 95% confidence interval, respectively.

Moisture content and water activity

Changes in moisture content and water activity are presented in Fig. 2. Moisture content and water activity ranged from 36.22-38.37%, 0.61-0.67, respectively. Increased *maesil* extract concentration significantly increased the water activity ($p<0.05$). Increase in the water activity due to *maesil* extract was sharper as compared to that of moisture content, which was rather gradual. Moisture content for all samples was less than 45% which is required by the food regulation of *kochujang*. Kim et al. (2003) reported similar increase in the water activity with high amount of *Lycium chinense* in *kochujang*. The water activity of *kochujang* is influenced by the amount of free sugar, amino acids, organic acids, salt, and water contained in *kochujang*. It has been reported that average water activity values for traditional *kochujang* ranged 0.672-0.701 (Lee & Lee, 2007) and the data obtained here are close to the reported values.

NaCl content and apparent viscosity

Changes in NaCl content and apparent viscosity are presented in Fig. 3. NaCl content and apparent viscosity ranged 4.91-6.02% and 343.47-1112.67 Pa.s, respectively. Both NaCl content and apparent viscosity decreased significantly with higher amount of *maesil* extract in the sample ($p<0.05$). This reduction of NaCl content is desirable since low-sodium *kochujang* is preferred with respect to the consumers' health

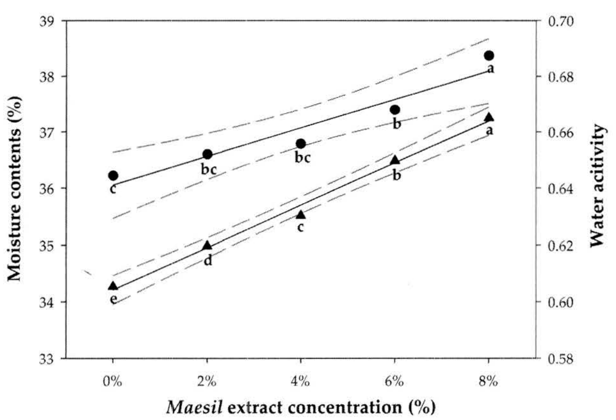

Fig. 2. Changes in moisture content (●) and water activity (▲) as influenced by *maesil* extract concentration. Data followed by different letters in the same property are signifi-cantly different among the treatments ($p<0.05$). —— and – – – lines indicate prediction model and 95% confidence interval, respectively.

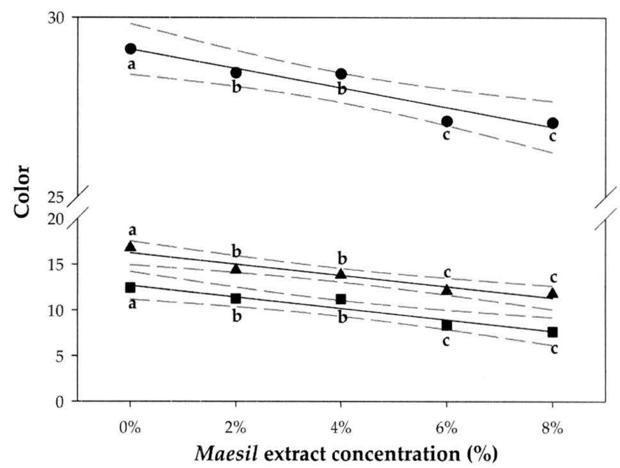

Fig. 4. Changes in CIE color parameters (*L-, ●, *a**-, ▲, and *b**-value, ■) as influenced by *maesil* extract concentration.** Data followed by different letters in the same property are significantly different among the treatments (p<0.05). —— and – – – lines indicate prediction model and 95% confidence interval, respectively.

Table 2. Simple models to predict the physicochemical properties of *maesil kochujang*

Property	Model[1)]	Regression coefficient			R^2
		b_0	b_1	b_2	
pH	Linear	4.9553	-0.1643	-	0.9460^{**}
	Quadratic	5.0829	-0.2919	0.0159	0.9960^{**}
Titratable acidity (mL)	Linear	5.1220	1.0140	-	0.9839^{***}
	Quadratic	4.9420	1.1940	-0.0225	0.9866^{*}
Moisture (%)	Linear	36.0533	0.2549	-	0.9208^{**}
	Quadratic	36.2837	0.0245	0.0288	0.9866^{*}
Water activity	Linear	0.6041	0.0074	-	0.9923^{***}
	Quadratic	0.6056	0.0059	0.0002	0.9959^{**}
NaCl (%)	Linear	5.9834	-0.1433	-	0.9800^{**}
	Quadratic	6.0352	-0.1951	0.0065	0.9912^{**}
Viscosity (Pa·s)	Linear	1141.6533	-98.7267	-	0.9909^{***}
	Quadratic	1128.1676	-85.2410	-1.6857	0.9925^{**}
*L**-value	Linear	29.1107	-0.2715	-	0.8983^{*}
	Quadratic	29.1064	-0.2672	-0.0005	0.8983^{NS}
*a**-value	Linear	16.2240	-0.6101	-	0.9313^{**}
	Quadratic	16.6492	-1.0354	0.0532	0.9709^{*}
*b**-value	Linear	12.6920	-0.6287	-	0.9130^{*}
	Quadratic	12.4292	-0.3658	-0.0329	0.9269^{NS}

[1)]Linear model: $Y=b_0+b_1X$, Quadratic model: $Y=b_0+b_1X+b_2X^2$
where, Y=physicochemical property and X=concentration (%) of *maesil* extract, respectively.
[2)]*Significant at 5% level, ** 1% level, *** 0.1% level, ^{NS} Non-significant.

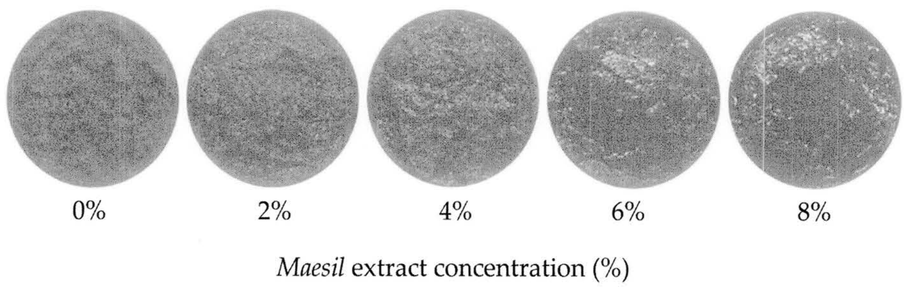

Fig. 5. Photographs taken for *kochujang* appearances as influenced by *maesil* extract concentration.

benefit. The NaCl contents of *maesil kochujang* were considerably lower than those reported for *kochujang* made with sea tangle and chitosan (Kwon & Kim, 2002) and *Lycium chinense* (Kim et al., 2003). Those values ranged 8.66-9.13% and 10.18-10.75%, respectively.

CIE color parameters

*L**-, *a**-, and *b**-values ranged 27.06-29.11, 11.80-16.78, and 7.63-12.46, respectively (Fig. 4). With the increasing in the concentration of *maesil* extract from 0% to 2-4% and from 2-4% to 6-8% in the samples, all color parameters decreased significantly ($p<0.05$). These results are in good agreement with others (Lee & Lee, 2006; Lee & Lee, 2007). Color characteristics of wet noodle with *maesil* juice (Lee et al., 2003) and those of bread (Park & Hong, 2003) with *mume* extract showed similar decrease. Photographs taken for each sample as affected by the substitution of *maesil* extract are also shown apparent and distinctive color differences among samples. The color became darker (blackish red) and shinier with a higher amount of *maesil* extract (Fig. 5).

Prediction modeling

Simple mathematical model to predict the physicochemical properties was done by regression analysis. Regression coefficients and R^2-values of each linear as well as quadratic model for each property are summarized in Table 2. All the linear models developed were significant at least at the 5% level of significance and R^2-values ranged 0.8983-0.9923. These simple models can be readily used to estimate each property when concentration of *maesil* extract is given.

References

Bae JH, Kim KJ, Kim SM, Lee WJ and Lee SJ. 2000. Development of the functional beverage containing the *Prunus mume* extracts. Korean J. Food Sci. Technol. **32**: 713-719.

Cha HS, Hwang JB, Park JS, Park YK and Jo JS. 1999. Changes in chemical composition of mume fruits during maturation. Korean J. Postharv. Sci. Technol. **6**: 481-487.

Choo JJ and Shin HJ. 2000. Sensory evaluation and changes in physicochemical properties, and microflora and enzyme activities of pumpkin-added *Kochujang*. Korean J. Food Sci. Technol. **32**: 851-859.

Jeong YJ, Seo JH, Lee GD, Lee MH and Yoon SR. 2000. Changes in quality characteristics of traditional *kochujang* prepared with apple and persimmon during fermentation. J. Korean Soc. Food Sci. Nutr. **29**: 575-581.

Kim DH, Ahn BY and Park BH. 2003. Effect of *Lycium chinense* fruit on the physicochemical properties of *Kochujang*. Korean J. Food Sci. Technol. **35**: 461-469.

Kim DH and Lee JS. 2001. Effect of condiments on the physico-chemical characteristics of traditional *kochujang* during fermentation. Korean J. Food Sci. Technol. **33**: 353-360.

Kim KH, Bae JS, and Lee TS. 1986. Studies on the quality of *kochujang* prepared with grain and flour of glutinous rice. J. Korean Agric. Chem. Soc. **29**: 227-236.

Kim YS, Jeoung MC, Oh HI and Kang TS. 1993. Changes in quality characteristics of traditional Kochujang during fermentation. Korean J. Food Sci. Technol. **25**: 724-729.

Kim YS, Kwon DJ, Oh HI, and Kang TS. 1997. Comparison of physicochemical characteristics traditional *kochujang* prepared with various raw material. Korean J. Food Sci. Technol. **29**: 907-912.

Ko YT. 1997. The preparation of yogurt from egg white powder and milk products. Korean J. Food Sci. Technol. **29**: 546-554.

Kwon YM and Kim DH. 2002. Effects of sea tangle and chitosan on the physicochemical properties of traditional *Kochujang*. J. Korean Soc. Food Sci. Nutr. **31**: 977-985.

Lee HA, Nam ES and Park SI. 2003. Quality characteristics of wet noodle with *Maesil* juice. Korean J. Food Cult. **18**: 527-535.

Lee MJ. 1990. Food analysis. Dong Myung Sa, Seoul, Korea, pp. 152-155.

Lee MJ and Lee JH. 2006. Quality characteristics of *Kochujang* prepared with *Maesil* (*Prunus mume*) extract during aging. J. Korean Soc. Food Sci. Nutr. **35**: 622-628.

Lee MJ and Lee JH. 2007. Analysis of processing conditions on *maesil kochujang* production using response surface methodology. J. Korean Soc. Food Sci. Nutr. **36**: 629-635.

Lee MJ, Seog EJ and Lee JH. 2007. Changes in microorganisms, enzyme activities and taste components of *kochujang* added with *maesil* extract during fermentation. J. Food Sci. Nutr. **12**: 51-57.

Lee TH. 1998. Effect of *Prunus mume* extract on the growth rate of animal leuckemic cells (L1210, P388) and human colon cancer cells (HRT-18, HCT-48, HT-29). PhD Dissertation, Korea University, Korea.

Lee YW and Shin DH. 2001. Bread properties utilizing extracts of mume. Korean J. Food Nutr. **14**: 305-310.

Lim JW. 1999. Studies on the antibacterial and physiological activities of *Prunus mume*. MS Thesis, Kyung Hee University, Korea.

Park JS, Lee TS, Kye HW, Ahn SM and Noh BS. 1993. Study on the preparation of Kochujang with addition of fruit juices. Korean J. Food Sci. Technol. **25**: 98-140.

Park SI and Hong KH. 2003. Effect of Japanese apricot flesh on baking properties of white breads. Korean J. Food Cult. **18**: 506-514.

Park WP. 1993. Quality changes of *kochujang* with different mixing ratio of raw starch material during aging. J. Korean Soc. Food Nutr. **22**: 433-436.

SAS Institute, Inc. 2002. SAS User's Guide. Statistical Analysis Systems Institute, Cary, NC, USA.

Shin DH, Ahn EY, Kim YS and Oh JA. 2000. Fermentation characteristics of *kochujang* containing horseradish or mustard. Korean J. Food Sci. Technol. **32**: 1350-1357.

Shin DH, Kim DH, Choi U, Lim MS and An EY. 1997. Effect of red pepper varieties on the microflora, enzyme activities and taste components of traditional *kochujang* during fermentation. J. Korean Soc. Food Sci. Nutr. **26**: 1050-1057.

Shin DH, Kim DH, Choi U, Lim DK and Lim MS. 1996. Studies on the physicochemical characteristics of traditional *kochujang*. Korean J. Food Sci. Technol. **28**: 157-161.

(접수 2008년 2월 15일, 채택 2008년 5월 2일)