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Effects of *Prunus mume* Extract and Red Pepper Powder on the Sensory Taste of *Kochujang*

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Abstract

Response surface methodology (RSM) was used for analyzing the sensory properties of *kochujang* made with *Prunus mume* (*maesil*) extract. Experiments were carried out according to a central composite design, selecting amount of *Prunus mume* extract and red pepper powder in the formulation as independent variables and sensory attributes such as sensory flavor, taste, and color as response variables. The polynomial model developed by RSM for sensory taste was highly effective to describe the relationships between the studied factors and the responses. The estimated response surface and contour plots confirm that the amount of *maesil* extract has a significant positive effect on sensory taste ($p<0.01$). Increase in the amount of *maesil* extract leads to a sharp increase of sensory taste value at all red pepper powder levels.

Keywords: *kochujang, Prunus mume, maesil*, sensory, taste, RSM

Introduction

Kochujang is a traditional Korean hot pepper seasoning that has sweet taste from a starch hydrolyzate, hot taste of red pepper, and savory taste from the soybean protein hydrolyzates and nucleic acids (Oh *et al.*, 2006). These various tastes of fermented food are affected by many factors such as raw materials, microorganisms, fermentation process (Park *et al.*, 2003), blend ratios, and enzymic hydrolysis of raw materials during fermentation (Shon *et al.*, 2003).

In order to improve the functionality and meet consumers' growing demands on diverse types of *kochujang*, several studies were conducted to investigate the quality properties of those *kochujang*. Some of them are: *kochujang* made with pumpkin (Choo and Shin, 2000), horseradish and mustard (Shin *et al.*, 2000), apple and persimmon (Jeong *et al.*, 2000), different condiments (Kim and Lee, 2001), sea tangle and chitosan (Kwon and Kim, 2002), kiwifruit (Kim and Song, 2002), *Lycium chinense* fruit (Kim *et al.*, 2003), *Paecilomyces japonica* (Bang *et al.*, 2004), medicinal herbs (Park *et al.*, 2005), and red-rice and barley (Hyun *et al.*, 2007). Most of the *kochujang* studied; however, were home-made style using *meju* (traditional *kochujang*) which is different from commercial one. Generally, *meju kochujang* is made of glutinous rice, *meju*, red pepper powder, and others, which are fermented by enzymic reactions of microorganisms. On the other hand, in commercial type *(koji kochujang)*, *koji* and glutinous rice already inoculated with *Aspergillus oryzae* are added and fermented for one to three months.

In this research, commercial-type *kochujang* was produced with *Prunus mume* (*maesil*) extract which has been known to have several functional properties (Bae *et al.*, 2000; Lee and Shin, 2001; Lee *et al.*, 2002; Park and Hong, 2003). In developing new type of processed food, it is of great importance to identify and characterize the sensory properties as influenced by major processing conditions in the formulation. Therefore, the objective of the present study was to investigate the effects of *maesil* extract and red pepper powder on the sensory attributes such as taste, flavor, and color properties using response

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surface methodology (RSM).

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) in uniform sizes and salt added, then stored in a fermentation tank for 2 days, after that fermented in a pot at 23.6°C for 10 days prior to manufacturing the *kochujang*. *Maesil* extract was purchased from Weon Food Co., Korea and 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. The soluble solids content and pH of *maesil* extract were 68.3°Brix and 2.8, respectively.

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 80 g of mixed condiments, 60-100 g of red pepper powder, and 0-80 g of *maesil* extract. The mixture was then cooled down to 40°C and blended with 30 g of spirits and placed in a pot at room temperature (23-24°C) before use. Formulations of *kochujang* used in the experiments are given in Table 1.

Experimental design

Response surface methodology (RSM) was employed to design this experiment. A two-variable, five-level central composite design (CCD) was employed where the independent variables were the amount of *maesil* extract and red pepper powder. The amount of *maesil* extract and red pepper powder varied, respectively, from 0 to 80 g and from 60 to 100 g. A total of nine combinations were chosen in random order according to CCD configuration for two factors. The experimental design in the coded and actual levels of variables is shown in Table 2. The response functions (y) were sensory flavor, taste, and color. These variables were related to the coded variables (x_i, i=1, 2) by a quadratic polynomial regression model below using the method of least squares:

$$y = b_0 + b_1x_1 + b_2x_2 + b_{12}x_1x_2 + b_{11}x_1^2 + b_{22}x_2^2$$

The coefficients of the polynomial were represented by b_0 (constant term), b_1 and b_2 (linear effects), b_{11} and b_{22} (quadratic effects), and b_{12} (interaction effect).

Sensory evaluation

Sensory evaluation of the *maesil kochujang* was carried out by 10 trained panelists comprising of students of the Department of Food Science and Engineering at Daegu University. All the samples, randomly coded using a three-digit number, were

Table 1. Formulations of *kochujang* with different amount of *maesil* extract and red pepper powder

Materials	*Kochujang* sample (g)								
	x_1 x_2	x_1 x_2	x_1 x_2	x_1 x_2	x_1 x_2	x_1 x_2	x_1 x_2	x_1 x_2	x_1 x_2
	-1 -1	-1 1	1 -1	1 1	-2 0	2 0	0 -2	0 0	0 2
Kochujang pre-mixture	520	520	520	520	520	520	520	520	520
Maesil extract	20	20	60	60	0	80	40	40	40
Corn syrup	300	300	300	300	300	300	300	300	300
Red pepper powder	70	90	70	90	80	80	60	80	100
Mixed seasoning	80	80	80	80	80	80	80	80	80
Spirits	30	30	30	30	30	30	30	30	30

Table 2. The RSM experimental design (in coded level of two variables) employed for preparing *Prunus mume* extract-added *kochujang*

Serial number	*Maesil* extract (g)	Red pepper powder (g)
	X_1 (x_1)	X_2 (x_2)
1	20 (-1)	70 (-1)
2	20 (-1)	90 (1)
3	60 (1)	70 (-1)
4	60 (1)	90 (1)
5	0 (-2)	80 (0)
6	80 (2)	80 (0)
7	40 (0)	60 (-2)
8	40 (0)	80 (0)
9	40 (0)	100 (2)

evaluated randomly in each session. Panelists received a tray containing the samples, a glass of water, and a evaluation sheet. The panelists were instructed to cleanse their mouth between the samples using water. Sensory attributes evaluated were flavor, taste, and color. Panelists expressed judgements about samples using a structured numeric scale of nine points, wherein 9= extremely strong, 8=very much strong, 7=moderately strong, 6=slightly strong, 5=neither strong or weak, 4=slightly weak, 3=moderately weak, 2=very much weak, and 1=extremely weak, for each attribute evaluated. The evaluation was done in duplicate.

Statistical analysis

The results were analyzed using the analysis of variance (ANOVA) and the effect and regression coefficients of individual linear, quadratic, and interaction term were determined. Statistical judgments were made based on the F-value at a probability (p) of 0.05, 0.01, and 0.001. Contour plots and response surfaces were then generated based on the regression coefficients of the model. All the statistical analyses were done using Statistical Analysis System programs (SAS, 2001).

Results and Discussion

The experimental results on the effect of the independent variables namely amount of *maesil* extract and red pepper powder on the three response functions

Table 3. Effect of red pepper powder and *Prunus mume* extract on three dependent variables with the observed responses and predicted values

Serial number	Sensory attributes					
	Experimental			Predicted		
	Flavor	Taste	Color	Flavor	Taste	Color
1	5.10±1.94	4.80±2.12	5.75±1.37	4.70	4.99	4.89
2	5.45±1.79	5.35±1.95	7.20±1.54	4.89	5.16	5.80
3	4.63±1.46	7.10±1.37	4.85±1.31	4.68	7.41	4.33
4	4.65±2.41	6.70±1.98	6.70±1.38	4.55	6.63	5.63
5	4.25±1.94	3.65±1.84	5.75±1.02	4.61	3.68	6.40
6	4.35±2.21	7.65±1.42	5.35±1.39	4.25	7.56	5.67
7	4.30±1.26	6.95±1.23	3.45±1.32	4.35	6.73	3.66
8	4.50±1.54	6.20±1.91	3.00±1.03	5.01	6.08	4.93
9	4.20±1.91	5.95±1.88	5.10±1.59	4.41	6.11	5.86

(sensory flavor, taste, and color) are shown in Table 3. Average sensory scores ranged from 4.20-5.45 and 3.00-7.20, respectively for flavor and color. Minimum sensory taste score of 3.65 was found when *kochujang* was made with 80 g of red pepper powder without *maesil* extract while maximum score of 7.10 was recorded with 60 g of *maesil* extract and 70 g of red pepper powder.

The independent and dependent variables were fitted to the second-order model equation and examined for the goodness of fit. The analysis of variance were performed to determine the significance of the linear, quadratic and interaction effects of the independent

Table 4. Coefficients of determination, R^2, and probability values for three response functions

Coefficients	Sensory attributes		
	Flavor	Taste	Color
b_0 (intercept)	5.0067**	6.0778***	4.9278*
b_1	-0.0892	0.9708**	-0.1833
b_2	0.0142	-0.1542	0.5500
b_{12}	-0.0825	-0.2375	0.1000
b_1^2	-0.1450	-0.1146	0.2760
b_2^2	-0.1575	0.0854	-0.0427
R^2	0.3474	0.9785	0.3971
p or probability	0.8745^{ns}	0.0105*	0.8289^{ns}

*Significant at $p \leq 0.05$, **Significant at $p \leq 0.01$, ***Significant at $p \leq 0.001$, ^{ns}non-significant.
Subscripts: 1 = *maesil* extract, 2 = red pepper powder.

variables on the dependent variables. Table 4 summarizes the coefficients of the variables in the models and corresponding R^2. Each equation is an empirical relationship between sensory attributes and the test variables in coded units. R^2 values explain the proportion of variation in the response attributed to the model rather than to random error and have been suggested that the value should be at least 80% for good fit model (Joglekar and May, 1987). The statistical analysis indicated that the proposed model for sensory taste was highly adequate and with satisfactory value of R^2 (=0.9785). Unfortunately however, the R^2 values for sensory flavor and color were 0.3474 and 0.3971, respectively indicating that a high proportion of variability was not explained by the data. For this reason, these results were not discussed further.

Table 3 also presents predicted values for each sensory attributes. Each of the observed values is compared with the predicted values that was calculated from the model, as depicted in Fig. 1. As expected, observed values for sensory taste but not for flavor and color are in good accordance with the predicted values.

The significance of each coefficient was also compared in Table 4. It can be seen that the variable with the largest effect on sensory taste was the linear term of *maesil* extract ($p<0.01$). The relationship between the processing parameters and each response variable can be best understood by examining the response surfaces generated. Fig. 2 shows the effect of the amount (*i.e.*, concentration) of *maesil* extract and of that of red pepper powder on sensory taste. It was observed that the sensory taste of *maesil kochujang* depended more on the amount of the *maesil* extract added than that of red pepper powder, as its linear effect was positive and

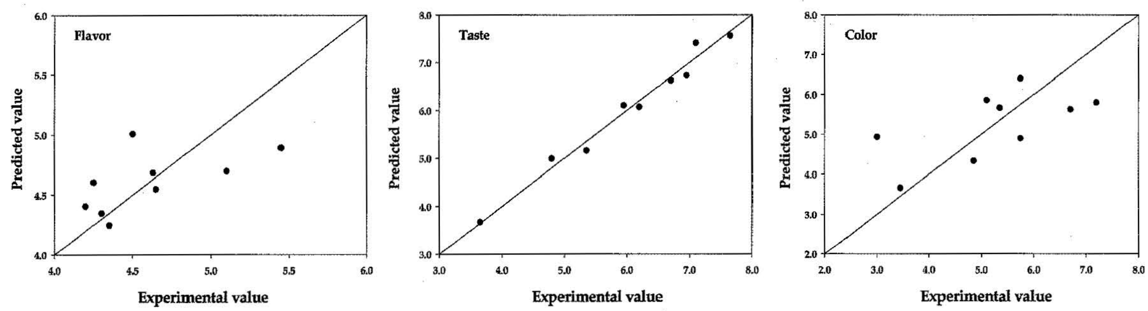

Fig. 1. Comparison between predicted and observed sensory scores.

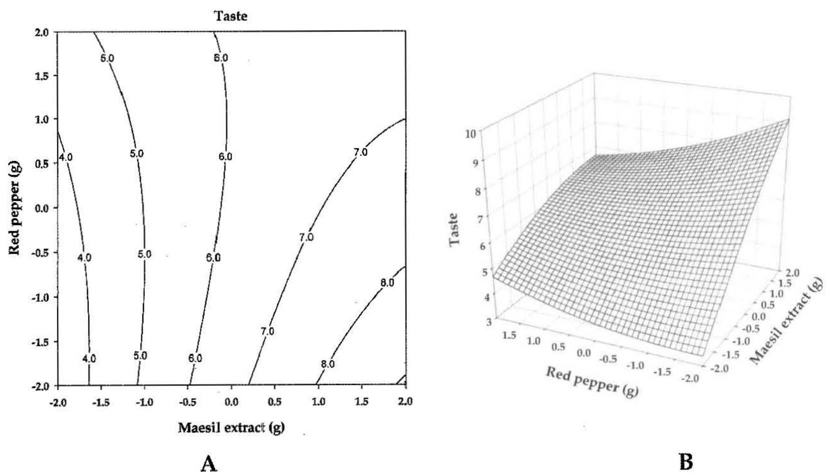

Fig. 2. Contour plots (A) and response surface (B) for the effect of red pepper powder and *Prunus mume* extract on sensory taste of *kochujang*.

significant at 1% level of significance. Increase in the amount of *maesil* extract leads to a sharp increase of sensory taste value at all red pepper powder levels.

References

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

Bang HY, Park MH and Kim GH. 2004. Quality characteristics of *kochujang* prepared with *Paecilomyces japonica* from silkworm. *Korean J. Food Sci. Technol.* **36**: 44-49

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

Hyun KU, No JD, Lim SI, Cha SK and Choi SY. 2007. Characteristics of HMG-Co A reductase inhibitory activity of fermented red pepper soybean paste (*kochujang*) prepared from red-rice and barley. *Korean J. Microbiol. Biotechnol.* **35**: 173-176

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

Joglekar AM and May AT. 1987. Product excellence through design of experiments. *Cereal Foods World* **32**: 857-868

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 physicochemical characteristics of traditional *kochujang* during fermentation. *Korean J. Food Sci. Technol.* **33**: 353-360

Kim YS and Song GS. 2002. Characteristics of kiwifruit-added traditional *kochujang. Korean J. Food Sci. Technol.* **34**: 1091-1097

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 SH, Chio JS, Park KN, Im YS and Choi WJ. 2002. Effects of *Prunus mume* Sieb. extract on growth of lactic acid bacteria isolated from *kimchi* and preservation of kimchi. *Korean J. Food Preserv.* **9**: 292-297

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

Oh JY, Kim YS and Shin DH. 2006. Changes in micro-organisms, enzyme activities and gas formation by the addition of mustard powder on *kochujang* with different salt concentration. *Food Sci. Biotechnol.* **15**: 298-302

Park CS, Jeon GH and Park CJ. 2005. Quality characteristics of *kochujang* added medicinal herbs. *Korean J. Food Preserv.* **12**: 565-571

Park HK, Gil B, Kim JK. 2003. Characteristics of taste components of commercial *kochujang. Food Sci. Biotechnol.* **12**: 119-121

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

SAS Institute. 2001. Statistical analysis system. Version 8.0 for Windows. The SAS Institute, Cary, N.C.

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

Shon S, Kim J, Oh H and Ha J. 2003. Volatile flavor components of *kochujang* prepared with *Aspergillus oryzae, Bacillus licheniformis* and *Saccharomyces rouxii. Food Sci. Biotechnol.* **12**: 18-22

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