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Sensory Evaluation of *Prunus mume* Extract-Added Vinegared Red Pepper Paste Using Response Surface Methodology

– Research Note –

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Abstract

Response surface methodology (RSM) was used for analyzing the manufacturing process of *Prunus mume* extract-added vinegared red pepper paste (*maesil chokochujang*) with respect to sensory quality properties. Experiments were carried out according to a central composite design, selecting the amount of *kochujang*, amount of *maesil* extract, and type of sugar in the mixture as independent variables; sensory attributes such as flavor, taste, color, and mouthfeel viscosity as response variables. The polynomial models developed by RSM for sensory color and mouthfeel viscosity were highly effective to describe the relationships between the factors studied and the responses. The estimated response surfaces confirmed that the amount of *kochujang* had a positive effect on color ($p<0.001$) whereas the amount of *maesil* extract had a positive effect on mouthfeel viscosity ($p<0.001$). Increase in the amount of *kochujang* led to a sharp increase of the sensory score on color at all the *maesil* extract and sugar type levels. On the other hand, increase in the amount of *maesil* extract caused a sharp increase in the mouthfeel viscosity value regardless of *kochujang* concentration and type of sugar. The differences among samples made with different types of sugar were not significant ($p>0.05$).

Key words: vinegared red pepper paste, *chokochujang*, *Prunus mume*, *maesil,* sensory, RSM

INTRODUCTION

Vinegared red pepper paste (*chokochujang*) is usually made with *kochujang*, sugar, garlic, and vinegar to produce a mixed flavor of hot, sweetness as well as sourness. Its taste and flavor are mostly influenced by the ratio of each ingredient in the blend. Methods for preparation for such mixtures may vary from one to another and *kochujang* is always the major component. It has been usually made by traditional methods learned from experience, but to produce a uniformly high quality product with consistent taste, flavor, color, texture, etc., it is important to analyze the manufacturing process with respect to sensory properties.

Prunus mume (*maesil*) is a species of Asian plum in the family of Rasaceae. The tree originates from China, but it has also been grown in Korea, Taiwan, and Japan since ancient times (1). The fruits are believed to be effective against parasites and ulcers and for promoting a strong digestive system and heart (2-4). *Prunus mume* extracts showed remarkable antimicrobial effects against a wide spectrum of putrefactive and food spoilage microorganisms and also exhibited anticancer activity (5-7).

The objective of this study was to investigate the influence of *maesil* extract, *kochujang*, and types of sugar on the sensory attributes such as flavor, taste, color, and mouthfeel viscosity of *maesil chokochujang* using response 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 under 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, then stored in a fermentation tank for 1 month. Concentrated *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, 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 the *maesil* extract were 68.3°Brix and 2.5, respectively. Brewed vinegar (Ottogi Ltd., Anyang, Gyeonggi, Korea) was procured from a local market. The vinegar contained 80% malt extract, 0.4% hulled barley,

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and tapioca spirits, and total acidity ranged from 6～7%.

Chokochujang preparation

Kochujang was first prepared using the commercial manufacturing methods of 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, and 3% spirits. The mixtures were then cooled down to 40～45°C, placed in a pot, and aged for 100 days at room temperature (23～24°C) before use. *Chokochujang* was prepared by mixing *kochujang* (210～390 g), *maesil* extract (0～60 g), sugar (black, brown, and white), garlic (15 g), and vinegar (60 g).

Experimental design

Response surface methodology (RSM) was employed to investigate the *chokochujang* manufacturing process. A three-variable, three-level central composite design was employed where the independent variables were the amount of *kochujang* (210～390 g), *maesil* extract (0～60 g), and type of sugar used (black, brown, and white). The experimental design in the coded and actual levels of variables is shown in Table 1. The response functions (*Y*) were sensory flavor, taste, color, and mouthfeel viscosity.

The complete designs consisted of 16 combinations (including two replicates of the center point) and were carried out in random order (Table 2). A quadratic polynomial regression model was assumed for prediction purpose of the responses (*Y*). The model proposed was:

$$Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_{11}x_1^2 + b_{22}x_2^2 + b_{33}x_3^2 + b_{12}x_1x_2 + b_{13}x_1x_3 + b_{23}x_2x_3$$

where *Y* is the response variable, b_0 the intercept, b_i the coefficients for the linear, b_{ii} the coefficients for the quadratic effect, b_{ij} the coefficients for the interaction effect. The above equation was solved using SAS package (8) to estimate the responses of the dependent variables, and the contour plots were generated.

Sensory evaluation

Maesil chokochujang was submitted to sensory assessment by a panel consisting of 10 trained panelists, students majoring in Food Science and Engineering. Attributes evaluated were: flavor, taste, color, and mouthfeel viscosity. Panelists expressed judgments about samples using a structured numeric scale of nine points for each attribute evaluated. All the samples, randomly coded using a three-digit number, were evaluated in each session. Panelists received a tray containing the samples, boiled cuttlefish, a glass of water, and an evaluation sheet. The evaluation was done in duplicate. Results were analyzed using a SAS program.

Table 1. Independent variables and their levels in central composite design

Independent variables	Unit	Symbol	Coded levels		
			-1	0	1
Kochujang	(g)	x_1	210	300	390
Maesil extract	(g)	x_2	0	30	60
Sugar	-	x_3	1 (White)	2 (Brown)	3 (Black)

Table 2. The central composite experimental design with the observed responses and predicted values for sensory attributes

Independent variables			Sensory attributes							
			Experimental				Predicted			
Kochujang (g)	*Maesil* extract (g)	Sugar	Flavor	Taste	Color	Mouthfeel viscosity	Flavor	Taste	Color	Mouthfeel viscosity
1	1	1	6.25	6.50	7.20	6.00	5.72	6.36	7.01	6.20
-1	1	1	4.80	5.40	4.70	6.50	5.20	5.03	5.24	6.72
1	1	-1	4.40	6.00	6.50	5.70	4.79	5.85	6.61	5.87
1	-1	1	4.40	6.65	5.90	2.70	4.69	6.60	6.47	2.79
-1	-1	1	5.95	5.00	3.15	3.05	5.50	5.22	3.13	2.96
1	-1	-1	5.70	5.90	6.70	2.65	5.23	6.34	6.24	2.51
-1	1	-1	4.05	4.60	5.25	6.90	3.70	4.73	4.77	6.88
-1	-1	-1	5.00	4.95	2.55	3.30	5.47	5.17	2.83	3.17
0	0	0	4.55	5.00	4.95	5.05	4.54	5.33	5.25	5.47
0	0	0	5.10	5.10	4.90	5.30	4.54	5.33	5.25	5.47
1	0	0	4.40	6.05	7.20	5.40	4.74	5.96	7.18	5.08
0	0	1	4.35	5.45	5.55	5.50	4.66	5.80	4.66	5.08
0	1	0	4.75	4.60	6.00	7.50	4.86	5.14	6.03	6.93
-1	0	0	4.65	4.90	3.75	5.65	4.60	4.71	4.59	5.67
0	0	-1	4.20	6.15	5.15	4.90	4.18	5.52	4.31	5.02
0	-1	0	5.05	6.30	4.60	3.10	5.23	5.48	4.79	3.37

Table 3. Coefficients of determination, R^2, and probability values for four dependent variables for *chokochujang*

Coefficients	Sensory attributes			
	Flavor	Taste	Color	Mouthfeel viscosity
b_0	4.5440***	5.3259***	5.2509***	5.4716***
b_1	0.0700	0.6250*	1.2950***	-0.2950
b_2	-0.1850	-0.1700	0.6200*	1.7800***
b_3	0.2400	0.1400	0.1750	0.0300
b_{11}	0.1216	-0.0125	-0.3938	-0.0875
b_{12}	0.3313	0.0500	-0.0188	0.1250
b_{22}	0.4966	0.0625	0.0438	0.0125
b_{13}	-0.1438	0.0112	0.6362	-0.0948
b_{23}	0.3688	-0.0138	0.1612	-0.3198
b_{33}	-0.1285	0.3362	-0.7638	-0.4198
R^2	0.6700	0.6917	0.8988	0.9701
p or probability	0.3679	0.3215	0.0211	0.0007

*Significant at $p \leq 0.05$, ***Significant at $p \leq 0.001$.

RESULTS AND DISCUSSION

The effects of varied amounts of *kochujang*, *maesil* extract, and types of sugar used in *chokochujang* production on sensory attributes such as flavor, taste, color, and mouthfeel viscosity are shown in Table 2. Minimum sensory flavor score of 4.05 was found when *chokochujang* was made with 210 g of *kochujang*, 60 g of *maesil* extract, and white sugar whereas the maximum sensory flavor score of 6.25 was recorded with 390 g of *kochujang*, 60 g of *maesil* extract with black sugar. The observations for sensory taste were varied between 4.60 and 6.65 within the combination of variables studied. Sensory color and mouthfeel viscosity scores varied 2.55～7.20 and 2.65～7.50, respectively. Minimum color sensory score was found at *kochujang*＝210 g, *maesil* extract＝0 g, and sugar＝white while minimum mouthfeel viscosity score was recorded at *kochujang*＝390 g, *maesil* extract＝0 g, and sugar＝white. Maximum color sensory score was obtained at *kochujang*＝390 g, *maesil* extract＝30 g, and sugar＝brown as well as at *kochujang* ＝390 g, *maesil* extract＝60 g, and sugar＝black. In addition, maximum mouthfeel viscosity score was obtained at *kochujang*＝300 g, *maesil* extract＝60 g, and sugar＝brown.

The independent and dependent variables were fitted to the second-order model equation and examined for the goodness of fit. The analyses of variance were performed to determine the significance of the linear, quadratic and interaction effects of the independent variables on the dependent variables. Table 3 presents the coefficient of determination, R^2, and probability values for four dependent variables (sensory attributes) for *chokochujang.* 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 it has been suggested that the value should be at least 80% for a good fit model (9,10). The results showed that the models for sensory color and mouthfeel viscosity were highly adequate because they have satisfactory levels of R^2 or more than 80%. Unfortunately however, the R^2 values for sensory flavor and taste were 0.67 and 0.69, respectively indicating that a high proportion of variability was not explained by the data. For this reason, these results were not discussed further.

Table 2 also presents predicted values for each sensory attributes. Each of the observed values is compared with the predicted values that were calculated from the model, as depicted in Fig. 1. As expected, observed values for sensory color and mouthfeel viscosity are in good accordance with the predicted values.

The significance of each coefficient was also compared in Table 3. It can be seen that the variable with the largest effect on sensory color was the linear term of *kochujang* ($p<0.001$), followed by the linear term of *maesil* extract ($p<0.05$). On the other hand, the variable with the largest effect on mouthfeel viscosity was the linear term of *maesil* extract ($p<0.001$). 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 *kochujang* and of the amount of *maesil* extract on sensory color. It was observed that the sensory color of *maesil chokochujang* depended more on the amount of the *kochujang* added than that of *maesil* extract, as its linear effect was positive and significant at the 0.1% level of significance. Increasing in the amount of *kochujang* leads to a sharp increase of color sensory value at all *maesil* extract levels and different sugar types.

Mouthfeel viscosity values, on the other hand, were

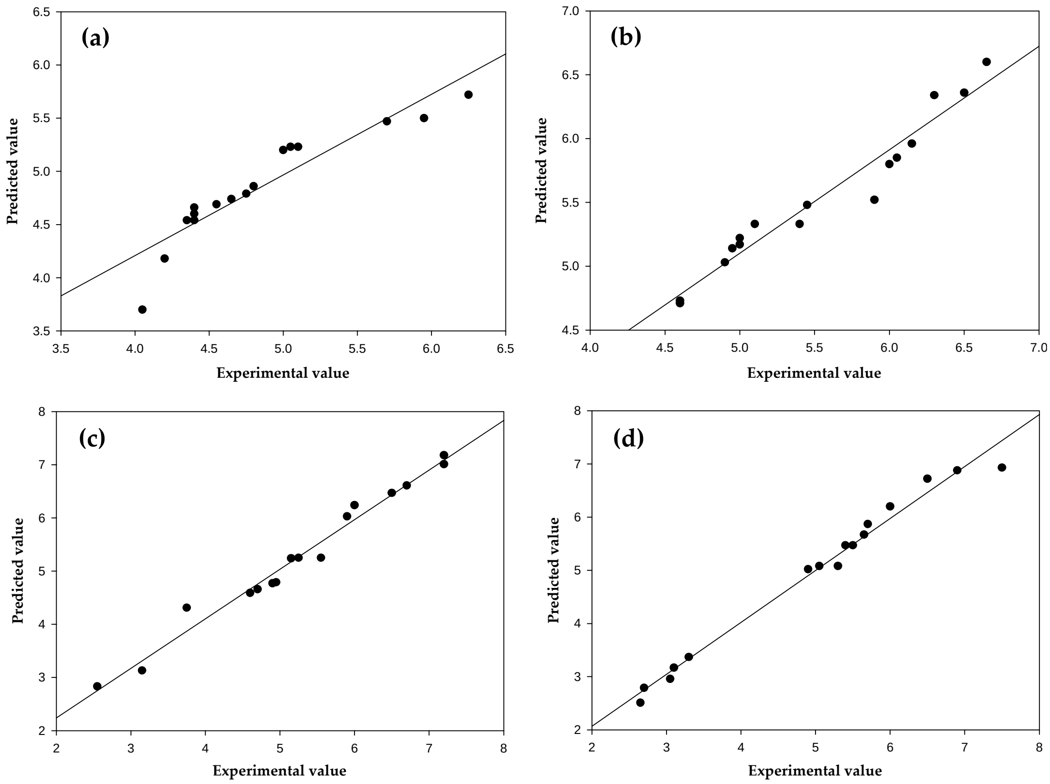

Fig. 1. Comparisons between predicted and observed sensory scores for (a) flavor, (b) taste, (c) color, and (d) mouthfeel viscosity.

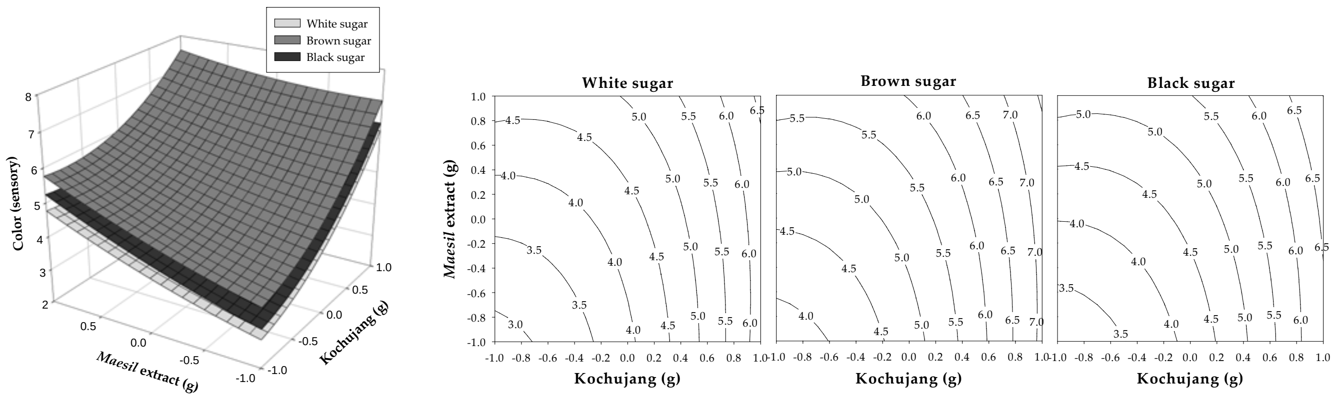

Fig. 2. Response surface and contour plots for sensory color as a function of *kochujang* and *maesil* extract content.

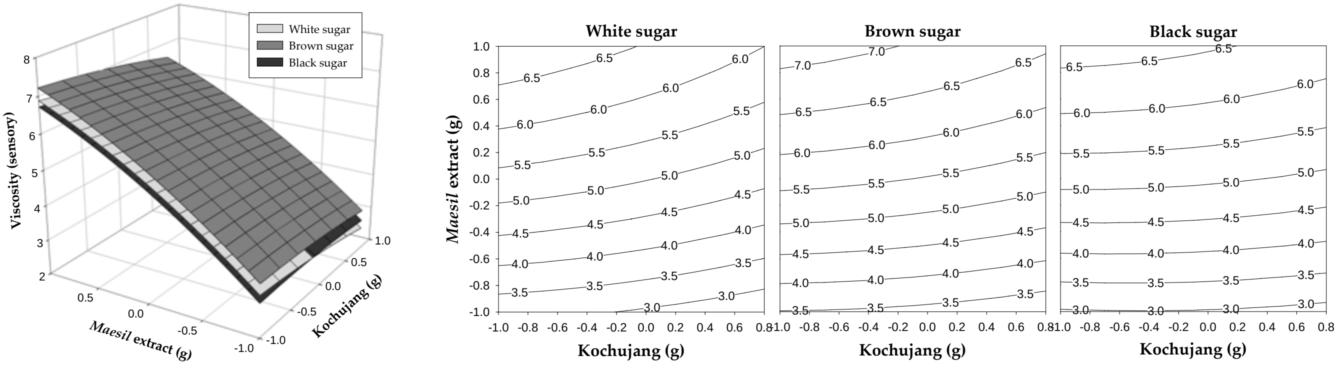

Fig. 3. Response surface and contour plots for mouthfeel viscosity as a function of *kochujang* and *maesil* extract content.

significantly affected by the amount of *maesil* extract added, as its linear effect was positive and significant at the 0.1% level of significance (Fig. 3). Increase in the amount of *maesil* extract caused a sharp increase in the mouthfeel viscosity value at all the *kochujang* levels and different sugar types. The differences among samples made with different types of sugar were not significant.

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