KOREAN J. FOOD COOKERY SCI.
Vol. 28, No. 2 April, 2012

Proportion Optimization for Manufacture *Kochujang* Sauce Supplemented with Tonic Herbal Extract and Beef Using Response Surface Methodology

Ji Won Yang[1] · Sung Soo Kim[1] · Sang Yoon Choi[1] · Il Sook Choi[2] and Young-Sun Lee[2]

[1]*Korea Food Research Institute, Sungnam 463-746, Republic of Korea*
[2]*Department of Food and Nutrition, Kyung Hee University, Seoul 130-701, Republic of Korea*

Abstract

Kochujang is a fermented paste originated from in and *Kochujang* sauce is a nutritionally and functionally improved version of *Kochujang* with additions of beef and tonic herbal extracts. The optimization of the ingredient ratios in the manufacturing of *Kochujang* sauce was investigated using central composite design and response surface methodology. The amount of beef (X_1) and the amount of tonic herbal extract (X_2) were chosen as the independent variables. The dependent variables consisted of the properties and sensory evaluation scores The examined physicochemical properties included water activity, pH, color, viscosity, and soluble solids. The sensory evaluation attributes were color, flavor, taste, texture, and overall acceptability. Among them, the selected dependent variables were the sauce viscosity (Y_1) and the overall acceptability (Y_2) of the sauce. The optimal conditions for the independent variables were X_1= 9.7% and X_2= 14.1%. In addition, the predicted values of the multiple response optimal conditions were Y_1= 331000 (cP) and Y_2= 7.1 (points), and the actual experimental values were Y_1= 3316667 (cP) and Y_2= 7 (points).

Key words : *Kochujang,* herbal extracts, response surface methodology

I. Introduction

Recently, food consumption has been changing toward a direction that considers taste, convenience, and health as being equally important (Shin DH 2008). Furthermore, the need for high quality food that addresses wellbeing, the importance of health, and food safety has increased (Lee YH 2007). Accordingly, as peoples' interests in health have continued to increase, food development research has been actively under way to incorporate the physiological effects and vitality that various medicinal plants can offer (Sohn ES et al. 2004).

† Corresponding author : Young-Sun Lee, Department of Food and Nutrition, Kyung Hee University
Tel: +82-31-780-9069
Fax: +82-31-709-9876
E-mail: caroline.yangjiwon@gmail.com

There have been many phytochemicals investigations pertaining to *Astragalus membranaceus* Bunge, *Acanthopanacis cortex*, and an *Angelica gigas* Nakai, which are herbaceous plants whose dried roots are used in tonics in oriental medicine (Park JC and Yee ST 2000). All three have been declared as raw food materials in Korea and are important "tonifying" adaptogenic herb. *Astragalus membranaceus* Bunge is known to possess antioxidant (Kim EY et al. 2004), immune-stimulating (Shin SW et al. 2004), memory-improving (Liu ZY et al. 1993), anti-ageing (Chen K and Li C 1993), anti-tumor (Zheng H et al. 1997), and anti-viral effects (Huang ZQ et al. 1995). *Acanthopanacis cortex* possesses immunity-promoting (Jeong HW et al. 2005), anti-oxidant (Im KR et al. 2008a), anti-viral (Kwon DH et al. 2003), skin-whitening (Im KR et al. 2008b), anti-cancer (Lee JH et al. 1999), bone-growth activity (Yang DS et al. 2003), and anti-diabetic effects (Choung ES et al. 2008). *Angelica gigas* Nakai is recognized for its anti-bacterial (Yun KW and Choi

SK 2004), skin-whitening (Kim CH et al. 2008), hyperlipemia restraining (Chung MH et al. 1998), immune-promoting (Lee GH et al. 2006), anti-inflammatory (Jang SI et al. 2002), and anti-cancer effects (Park KW et al. 2007), and is also known to protect liver function (Oh SH et al. 1999).

Kochujang, a fermented red pepper soybean paste, is a well-known traditional food in Korea, and has played an important role in providing characteristic tastes and flavors of Korean foods. *Kochujang* provides hot, sweet, salty, and savory tastes, as well as color and flavor. It is rich in protein, fatty acids, vitamin B_1, vitamin B_2, vitamin C, folic acid, and carotene (Bang HY et al. 2004). *Kochujang* promotes digestion and the excretion of body wastes (Choi SM et al. 2002). In addition, it has anti-cancer (Park KY et al. 2001) and anti-bacterial effects (Lee JM et al. 1996). *Kochujang* also recently showed an anti-obesity effect (Choo JJ 2000). The *Kochujang* sauce used in this research was made by roasting after mixing the *kochujang* with beef and tonic herbal extracts.

This *Kochujang* sauce is not salty and has a different hot taste relative to the salty and hot taste of general *Kochujang*. In addition, it may be considered to have a functional effect due to the addition of the tonic herbal extracts. There have been various studies examining value-added enhancements of *Kochujang* by additions of functional food materials. These examinations of both function and taste have included the following: *Kochujang* with added orange extract (Chae IS et al. 2008), sea tangle powder (Cui CB et al. 2002), Japanese apricot (Lee MJ and Lee JH 2007), medical herbs (Park CS et al. 2005), vegetable worms (Bang HY 2004), mushrooms (Ahn MR et al. 2003), kiwi (Kim YS and Song GS 2002), apple (Lee GD et al. 2000), onion powder (Seo KI et al. 2000), fermented ginseng (Shin HJ et al. 1999), garlic porridge (Song HS et al. 2008), fucoidan (Ahn IS et al. 2006), pine needle, and *Artemisia princeps* (Kim EL and Kang SC 2007), which have shown quality-improvement, anti-obesity, anti-oxidant, anti-bacterial, and anti-cancer effects. However, until now, no research has investigated *Kochujang* containing additions of beef and tonic herbal extracts. The objectives of this study were to optimize the proportion of herbal extracts to beef in the manufacturing of *Kochujang* sauce using response surface methodology (RSM; 1951). RSM is effective for the optimization and monitoring of food manufacturing processes. The basic principle of RSM is to determine model equations that describe the interrelations between independent and dependent variables (Edwards IM and Jutan A 1997).

II. Materials and Methods

1. Materials and sample preparation

The root of *Astragalus membranaceus* Bunge, *Acanthopanacis cortex*, and *Angelica gigas* Nakai were provided by the Jecheon City Agricultural Technology Center in Jecheon City (Chungbuk, Korea). These herbs were extracted with distilled water at 100℃ for 8 hr, and the extracts were filtered by filter cloth. Before use as a tonic herbal extract, the extracts of *Astragalus membranaceus* Bunge Root, *Acanthopanacis cortex*, and *Angelica gigas* Nakai were diluted to 5° Brix and used in a ratio of 6:3:1. This was obtained from a preliminary study on sensory evaluation. The beef, garlic, and ginger were domestic products purchased from Nonghyup Hanaro Mart (Sungnam, Gyeonggi, Korea). The *kochujang* (Daesang Co., Ltd., Jeonbuk, Korea) as well as black pepper (Otttogi Co., Ltd., Chungbuk, Korea), sesame oil (Otttogi Co., Ltd., Chungbuk, Korea), roasted sesame seed (Haepyo Co., Ltd., Ansan, Gyeonggi, Korea), and corn syrup (Haepyo Co., Ltd., Ansan, Gyeonggi, Korea) were also purchased from Nonghyup Hanaro Mart (Sungnam, Gyeonggi, Korea). Table 1 shows the amounts of materials used in the *Kochujang* sauce. The manufacturing process was as follows. The minced beef was marinated in the tonic herbal extracts for 2 hr at 4℃. Next, garlic, ginger juice, and the marinated beef were roasted for 5 minutes. Then, the black pepper and *Kochujang* were added and roasted for 5 additional minutes. Finally, the *Kochujang* sauce was finished by adding the sesame oil, corn syrup, and sesame seed.

Table 1. The amount of material of *Kochujang* sauce

	control	1	2	3	4	5	6	7	8	9
Kochujang	56	53	59	51	59	56	56	56	56	50
Beef	12	15	9	17	9	12	12	12	12	18
5° Bx *Astragalus membranaceus* Bunge extract	9	10.2	10.2	7.8	7.8	9	9	11.4	6.6	9
5° Bx *Acanthopanacis* cortex extract	4.5	5.1	5.1	3.9	3.9	4.5	4.5	5.7	3.3	4.5
5° Bx *Angelica gigas* Nakai extract	1.5	1.7	1.7	1.3	1.3	1.5	1.5	1.9	1.1	1.5
Corn syrup	6	6	6	6	6	6	6	6	6	6
Garlic	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Sesame seed	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Sesame oil	1	1	1	1	1	1	1	1	1	1
Ginger juice	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Black pepper	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

2. Determination of pH and color

The pH was determined using a pH-meter (Orion410A, Allometrics Inc., LA, USA) at 20℃. The pH meter was calibrated with buffer standards of pH 4.01 and 7.00. The color of the *Kochujang* sauce was determined with a Color Meter (Model CR-300, Minolta Co. Ltd., Osaka, Japan). L, a, and b values were obtained.

3. Determination of water activity and viscosity

Water activity (Aw) was determined using a water activity meter (ms1 Set AMS, Novasina, Switzerland) at 20℃ upon equilibration of the Aw value. Viscosity was measured at a spindle (No. 4) rotational speed of 0.3 rpm using a digital viscometer (LVDV-II+ PRO, Brookfield Engineering Labs Inc., MA, USA) at 40℃. The viscometer output parameters were determined after 5 min.

4. Sensory evaluation

The samples were cooked in an industrial kitchen in the laboratory. Thirty minutes after cooking, the samples were served in porcelain dishes with three-digit random numbers and covered with lids. The sensory evaluations were performed by 20 trained panels who were staff members of the Korea Food Research Institute. The panelists were asked to give scores using a structured hedonic scale ranging from 1 to 9 (Meilgaard MM et al. 1999), with 1 being disliked extremely and 9 being liked extremely. The evaluations consisted of color, taste, flavor, texture, and overall acceptability.

5. Experimental design

The central composite design (CCD) with two variables and five levels for each variable was based on the performed experiments and was used to optimize the manufacturing process of *Kochujang* sauce. The independent variables were beef (6%~18%) and the tonic herbal extracts (11%~19%), coded as X_1 and X_2, respectively. The dependent variables were viscosity and the sensory panel score. The range and center point values of the two independent variables were based on the results of the preliminary experiments, and are shown in Table 2. The viscosity measurements (cP, Y_1) and sensory panel scores (points, Y_2) were selected as dependent variables for the combination of the independent variables, which are given in Table 3. Eleven experimental runs were randomized in order to minimize the effects of unexpected variability in the observed responses.

Table 2. Experimental range and values of the independent variables in the central composite design for manufacture of *Kochuhjang* sauce

Independent variable	Unit	Symbol	Coded levels				
			−1.414	−1	0	1	1.414
Beef	%	X_1	6	9	12	15	18
Herbs extract	%	X_2	11	13	15	17	19

Table 3. Central composite design and response of dependent variables to independent variables for the manufacture of *Kochuhjang*

Run No.	Coded levels of variable		Response	
	X_1	X_2	Y_1	Y_2
1	-1	-1	420000	7
2	1	-1	982667	6.3
4	-1	1	755000	5.3
5	1	1	939333	5.7
6	-1.41421	0	491333	6
7	1.41421	0	868000	6.5
8	0	-1.41421	873333	6.4
9	0	1.41421	1205000	5.4
10	0	0	404667	7.1
11	0	0	391333	7.3
12	0	0	401502	7.4

X_1 (beef, %)
X_2 (herbal extract, %)
Y_1 (viscosity, cP)
Y_2 (overall acceptability, points)

6. Analysis of data

The response surface regression (RSREG) procedure of the Statistical Analysis System software (Version 8.01, SAS Institute Inc., USA) was used to fit a following quadratic polynomial equation where Y is the dependent variable (viscosity and sensory panel score); β_0 is a constant; β_i, β_{ii}, β_{ij} are regression coefficients; and X_i and X_j are levels of the independent variables. The Ridge Max option of the RSREG procedure was used to compute the estimated ridge of the optimum response for increasing radii from the center of the origin design. Multiple response optimizations were heuristically calculated by the desirability function of MINTAB statistical software (Version 13, Minitab Inc., PA, USA) in order to search for the condition that simultaneously satisfies the two dependent variables (Y_1 and Y_2). The response surface plots were developed using Maple software (Maple 7, Waterloo Maple Inc., Canada) and represented as a function of a set of two independent variables while keeping the other two independent variables at the optimal values.

Ⅲ. Result and Discussion

1. Diagnostic checking of the fitted models

The RSREG procedure of the SAS software was employed to fit the quadratic polynomial equation to the experimental data. All the coefficients of linear (X_1, X_2), quadratic (X_1^2, X_2^2), and interaction terms were calculated for significance with the *t*-statistic, and the estimated coefficients of each model are presented in Table 4. All the interaction coefficients were highly significant ($p<0.01$) in all models. Also, all the linear coefficients, except for the X_1 term of Y_2, were significant ($p<0.05$), and all the quadratic coefficients, except for the X_2^2 term of Y_2, were significant ($p<0.05$). In order to develop the fitted response surface model equations, all insignificant terms ($p>0.05$) were eliminated, and the fitted models are shown in Table 5. The coefficients of determination (R^2) for Y_1 and Y_2 were 0.971 and 0.951, respectively, which indicate that the model is suitable to represent the real relationships among the selected reaction parameters. The values of R^2 for all models were high for the response surface and were significant at p=0.0001. These R^2 values were high because the experimental design was based on the adequately performed preliminary tests.

Table 4. Estimated coefficients of the fitted quadratic polynomial equation for different responses based on the *t*-statistic

	Y_1		Y_2	
	coefficient	*P*-value	coefficient	*P*-value
constant	399168	0.000	7.26667	0.000
X_1	113110	0.001	0.03598	0.564
X_2	67238	0.012	-0.32829	0.002
X_1^2	59479	0.010	-0.25417	0.004
X_1X_2	149355	0.000	-0.34167	0.001
X_2^2	-47292	0.042	0.13750	0.065

X_1 (beef, %)
X_2 (herbal extract, %)
Y_1 (viscosity, cP)
Y_2 (overall acceptability, points)

Table 5. Response surface model for the manufacture of *Kochuhjang*

Responses	Quadratic polynomial model	R^2	*p*-value
Y_1	Y_1=399168+113110X_1+67238X_2+59479X_1^2+149355X_2^2-47292 X_1X_2	0.971	0.0001
Y_2	Y_2=7.2667-0.32829X_2-0.25417 X_1^2-0.34167X_1X_2	0.951	0.0001

Y_1 (viscosity, cP)
Y_2 (overall acceptability, points)

2. Analysis of variance

The statistical significance of the quadratic polynomial model equation was evaluated by analysis of variance (ANOVA). Table 6 shows the ANOVA results for the models explaining the response of the two dependent variables, Y_1 and Y_2. The cross-product terms for Y_2 were not significant at the 95% probability level, whereas the cross-product terms for Y_1 were. In addition, the linear terms, quadratic terms, and total regression model were significant ($p<0.05$) at the 95% probability level. For the results of the lack-of-fit test, which indicates the fitness of the model, the dependent variable Y_1 was significant at the 95% probability level. However, the lack-of-fit test of Y_2 did not show a significant *p*-value at the 95% probability level. A check of model adequacy was performed by the normality test (Anderson-Darling normality test) for error terms using residuals of the dependent variables, Y_1 and Y_2. The error terms of the two dependent variables had normal distributions according to the Anderson-Darling normality test. Therefore, the response surface model represented as a quadratic polynomial equation was statistically significant.

3. Conditions for optimum responses

The two independent variables, X_1 and X_2, were chosen as the central condition of the CCD for optimization of the *Kochujang* sauce processing. The uncoded values of the independent variables were determined by a preliminary study (Table 2). The coded and uncoded values in the optimum condition obtained from the results of the RSM are shown in Table 7. According to the canonical analysis of the RSREG procedure, all four values of Y_1 and Y_2 were negative. Y_1 and Y_2 are shown in the stationary point of Fig. 1. The predicted values of Y_1 and Y_2 were 322,900 (cP) and 7.3464 (points), respectively. The viscosity is an important physical property of a sauce in a wide range of applications. In general, a low viscosity value means a good quality *Kochujang* sauce. Also, overall acceptability is the most important constituent in the sensory evaluation. A high overall

Table 6. Analysis of variance (ANOVA) for the response of dependent variables

Response	Sources	DF	SS	MS	*F*-value	*P*-value
Y_1	Model	5	8.23	1.65	33.88	0.001
	Linear	2	2.77	1.39	28.53	0.002
	Quadratic	2	5.10	2.60	52.50	0.000
	Cross-product	1	35784153889.00	35784153889.00	7.37	0.042
	Residual	5	24278684260.00	4855736852.00	-	-
	Lack of fit	3	24181610479.00	8060536826.00	166.07	0.006
	Pure error	2	97073781.00	48536890.00	-	-
	Total	10	24278684568.23	4855736853.65	-	-
Y_2	Model	5	5.27	1.05	19.40	0.003
	Linear	2	1.75	0.87	16.07	0.007
	Quadratic	2	3.22	1.61	29.65	0.002
	Cross-product	1	0.30	0.30	5.57	0.065
	Residual	5	0.27	0.05	-	-
	Lack of fit	3	0.22	0.07	3.21	0.246
	Pure error	2	0.05	0.02	-	-
	Total	10	5.54	1.10	-	-

Y_1 (viscosity, cP)
Y_2 (overall acceptability, points)

acceptability value subjectively indicates good acceptability for a *Kochujang* sauce. Therefore, Y_1 and Y_2 were chosen as the dependent variables. In order to optimize the two dependent variables (Y_1 and Y_2) simultaneously, the desirability function of MINITAB statistical software was defined by the follow conditions: goal (Y_1: minimize, Y_2: maximize) and target (Y_1 = 322900 and Y_2 = 7.3464). The coded values of the independent variables were the amount of beef (X_1 = -0.7571) and the amount of tonic herbal extracts (X_2 = -0.4428). The critical values of the multiple response optimizations by the desirability function of MINITAB and the average of Y_1 and Y_2 were similar. The actual values of the independent variables against the coded values were X_1 = 9.7287% and X_2 = 14.1144%, respectively. The predicted values of the multi response optimal conditions were Y_1 = 331000 (cP) and Y_2 = 7.1006 (points), with 1 as the value of the desirability function.

4. Response surface plots and the effects of factors

Fig. 1 shows the estimated response function and the effects of the independent variables (X_1 and X_2) on the dependent variables (Y_1 and Y_2). The two independent variables of X_1 and X_2 were major factors in the processing of the *Kochujang* sauce. As such, the response surface plot shows interactions between the two independent variables and one dependent variable while keeping the other two independent variables at optimal values. Fig. 1A depicts the effects of the independent variables on Y_1 (viscosity). As the

Table 7. Optimal conditions for the manufacture of *kochuhjang*

Dependent variables	Independent variables	Critical value		Predicted value	Stationary point
		Coded	Uncoded		
Y_1 (Viscosity, cP)	X_1	-0.7857	9.6429	322900	Minimum
	X_2	-0.2714	14.4572		
Y_2 (Overall acceptability, points)	X_1	-0.0429	11.8713	7.3464	Maximum
	X_2	-0.3571	14.2858		
Average of Y_1 and Y_2	X_1	-0.4143	10.7571	-	-
	X_2	-0.31425	14.3715		
Multiple response optimization	X_1	-0.7571	9.7287	-	-

X_1 (beef, %)
X_2 (herbal extract, %)

Table 8. Response surface model for the manufacture of *Kochujang*

Responses		Quadratic polynomial model
Water activity (Y_3)		Y_3=4.81257+0.08028X_2
pH (Y_4)		Y_4=0.825533-0.004671X_1+0.008525X_2+0.001538X_1X_2
Color	L (Y_5)	Y_5=22.6130-0.2164X_1+0.3041X_2-0.1410 X_1X_2
	a (Y_6)	Y_6=5.74600-0.38999X_2-0.14863 X_1^2
	b (Y_7)	Y_7=4.09700-0.19665X_1+0.33308X_2-0.13350X_1X_2
Sensory evaluation	Color (Y_8)	Y_8=6.9333+0.2280X_1-0.4371 X_2-0.2396X_1^2-0.3146X_2^2+0.2750X_1X_2
	Flavor (Y_9)	Y_9=7.26667-0.32463X_2-0.24792X_1^2-0.34792X_2^2
	Taste (Y_{10})	Y_{10}=7.4333-0.1311X_1-0.2487 X_2-0.3771X_1^2-0.4271X_2^2+0.2000X_1X_2
	Texture (Y_{11})	Y_{11}=7.46667-0.24446 X_2-0.29792X_1^2-0.54792X_2^2

Y_3 (Water activity, %)
Y_4 (pH)
Y_5 (Color L)
Y_6 (Color a)
Y_7 (Color b)
Y_8 (Color, points)
Y_9 (Flavor, points)
Y_{10} (Taste, points)
Y_{11} (Texture, points)

coded values of the two independent variables were close to zero, viscosity decreased. The effects of the two factors were statistically significant with the factor X_2 having a stronger effect. X_1 also greatly affected viscosity, but the viscosity was less affected within a range of the coded values of 0 to -1.414. Y_2, as the dependent variable, increased as the coded values neared 0. Also, X_2 showed some effect for overall acceptability. Furthermore, when X_1 increased from 0 to -1.414, Y_2 greatly decreased and was less affected within a range of the coded values of 0 to 1.414. When considering the two response surface plots, all the independent variables affected the dependent variables, with X_2 being the most important factor. Therefore, the setting of the tonic herbal extract volume was suggested as a key factor in *Kochujang* sauce processing. Fig. 2 and Fig. 3 show the estimated response functions and the effects of the independent variables (X_1, X_2) on the dependent variables (Y_3, Y_4, Y_5, Y_6, Y_7, Y_8, Y_9, Y_{10} and Y_{11}). Fig. 2 A, B, C, and E show that Y increased when the tonic herbal extract amount was increased and the beef amount was decreased. Y_3 (Water activity) significantly increased with the amount of tonic herbal extract and was not influenced by the amount of beef. Y_4 (pH), Y_5 (color L), and Y_7 (color b) were significantly influenced by both the tonic herbal extract and beef amounts, respectively. The curvatures shown in Fig. 2 D confirm that the relationship found between the independent interaction effects and the Y_6 (color a) value appear to be nonlinear. Y_6 (color a) was significantly influenced by the amount of tonic herbal extract. Fig. 3 shows that Y, as the dependent variable, increased as the coded values neared 0. The response first increased with the increase in herb extract and beef, and then declined with further increase in herb extract and beef. Y_8, Y_9, Y_{10}, Y_{11} were depicted, and the herb extract and the beef were increased to 7-13% and 9-12%. Y_8 and Y_{10} (color and taste) were significantly influenced by both factors whereas Y_9 and Y_{11} show flavor and texture were significantly influenced by the tonic herbal extract amount

Table 9. Experimental and predicted results for verification under the optimized conditions

Dependent variables	Predicted value	Experimental value
Y_1	331000	316666.7±23628
Y_2	7.1006	7±0.894

Y_1 (viscosity, cP)
Y_2 (overall acceptability, points)

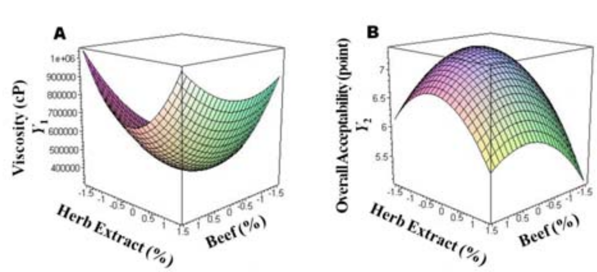

Fig. 1. Response surface plots for proportion optimization in the manufacture of *Kochujang*

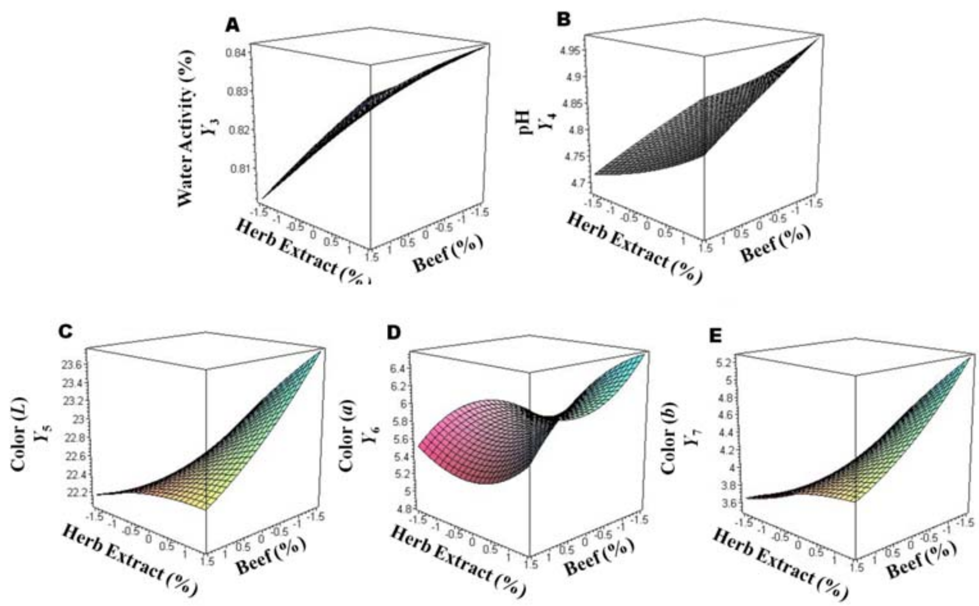

Fig. 2. Response surface plots of physicochemical properties of *Kochujang* sauce

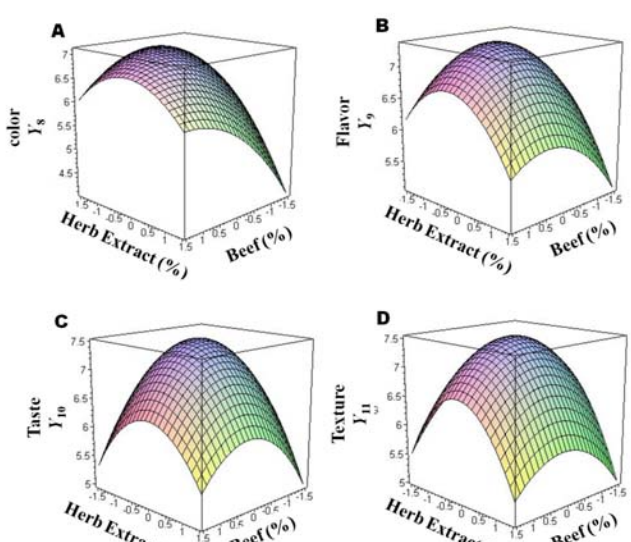

Fig. 3. Response surface plots of sensory evaluations of *Kochujang* sauce

5. Verification of predicted values

Verification experiments were conducted under the optimal conditions (tonic herbal extract amount = 9.7% and beef amount = 14.1%) to compare the predicted values and actual values of the dependent variables (Table 8). The actual values, repeated five times, were viscosity = 316667 and overall acceptability = 7. Both the actual values and predicted values almost coincided with each other. Therefore, the estimated response surface model was adapted for optimization of *Kochujang* sauce processing.

Ⅳ. Conclusion

This study investigated the optimum main ingredient ratios in the manufacturing of *Kochujang* sauce using RSM. The main ingredients in the *kochujang* sauce were herbal extracts and beef, and the employed preliminary experiments examined both physicochemical properties and sensory evaluation scores to determine their optimal mixing ratios. The results presented in this study indicate that the ratios of the herbal extract amount and beef amount had effects on viscosity and overall acceptability. In general, the studied *kochujang* sauce was significantly ($p<0.05$) influenced by the proportion of the herbal extract. It was also indicated that the instability of the sauce emulsion may be controlled by an appropriate proportion of herbal extract to beef. The two optimized ratios for the viscosity and overall acceptability of the *Kochujang* sauce were a beef amount of 9.6% and an herbal extract amount of 14.5%; and a beef amount of 11.9% and an herbal extract amount of 14.3%. The final optimized multi-response ratio of the *Kochujang* sauce was a beef amount of 9.7% and an herbal extract amount of 14.1%. Under the corresponding optimum condition, there was no significant ($p<0.05$) difference between the experimental and predicted values, verifying the accuracy of the employed response surface models in predicting the variation of the *Kochujang* sauce properties as a function of the amounts of herbal extract and beef.

V. References

Ahn IS, Do MS, Choi BH, Kong CS, Kim SO, Han MS, Park KY. 2006. Reduced leptin secretion by fucoidan-added *Kochujang* and anti-adipogenic effect of fucoidan in mouse 3T3-L1 adipocytes. Food Sci Nutri11: 31-35

Ahn MR, Jung DY, Hong SP, Song KS, Kim YS. 2003. Quality characteristic of tradition *Kochujang* that add mushrooms. J Kor Soc Agr Chem Biotech 46(3): 229-234

Bang HY, Park MH, Kim GH. 2004. Quality Characteristics of *Kochujang* prepared with Paecilomyces japonica from silkworm. Korean J Food Sci Technol 36(1): 44-49

Box GEP, Wilson KB. 1951. On the experimental attainment of optimum conditions. J Royal Statistical Soc (Series B) 13: 1-45

Chae IS, Kim HS, Ko YS, Kang MH, Hong SP, Shin DB. 2008. Effect of citrus concentrate on the physicochemical properties of *Kochujang*. Korean J Food Sci Technol 40(6): 626-632

Chen K, Li C. 1993. Recent advances in studies on traditional Chinese anti-aging materia medica. J Trad Chin Med 13:303–

Choi SM, Jeon YS, Rhee SH, Park KY. 2002. Red pepper powder and Kimchi reduce body weight and blood and tissue lipids in rats fed a high fat diet. Nutraceuticals Food 7: 162-167

Choo JJ. 2000. Anti-obesity effects of *Kochujang* in rats fed on a high-fat diet. Korean J Nutr 33: 787-793

Choung ES, Bak JP, Choi H, Jang GS, Kang SH, Kang SC, Zee OP. 2008. Effects of antidiabetic and GLUT4 gene expression of Acanthopanax senticosusextracts. Korean J Pharm 39(3): 228-232

Chung MH, Lim JH, Oh HS. 1998. Effect of Angelicae gigantisradix extract on experimentally induced hyperlipemia in rats. Korean J Pharm 29(4): 300-311

Cui CB, Oh SW, Lee DS, Ham SS. 2002. Effects of the biological activities of ethanol extract from Korean traditional *Kochujang* added with sea tangle (Laminaria longissima Korean J Food Preserv 9(1): 1-7

Edwads IM, Jutan A. 1997. Optimization and control using response surface methods. Com Chem Eng 21: 441-453

Meilgaard MM, Civille GV, Carr BT. 1999. Sensory evaluation techniques. CRC Press, 3rd Editionpp.174-176

Huang ZQ, Qin NP, Ye W. 1995. Effect of Astragalus membranaceuson T-lymphocyte subsets in patients with viral myocarditis. Chin J Integr Trad West Med 15(6): 328-330

Im KR, Kim MJ, Jung TK, Yoon KS. 2008a. Antioxidant activity of partially purified extracts isolated from Acanthopanax sessiliflorum seeman. Korean J Biotech Bioeng 23(4): 329-334

Im KR, Kim MJ, Jung TK, Yoon KS. 2008b. The inhibitory effects of Acanthopanax sessiliflorum seeman on melanogenesis. J Soc Cos Sci Kor 34(2): 149-156

Jang SI, Kim HJ, Hwang KM, Pae HO, Yun YG, Ching H T, Kim YC. 2002. Anti-inflammatory effect of ethanol extract of Angelica uchiyamanain activated murine raw264.7 macrophages. Kor J Oriental Med Pre 10(2): 189-197

Jeong HW, Rho YH, Lee GS, Kim CJ, Jeon BG. 2005. Experimental effects of Acanthopanacis cortex extract on the immunity, anti-cancer and obesity in mice. Kor J Oriental Physiol Pathol 19(2): 389-397

Kim CH, Kwon MC, Han JG, Na CS, Kwak HG, Choi GP, Park UY, Lee HY. 2008. Skin-whitening and UV-protective effects of Angelica gigas Nakai extracts on ultra high pressure extraction process. Kor J Med Crop Sci 16(4): 255-160

Kim EL, Kang SC. 2007. Quality evaluation by the addition of pine needle and *Artemisia princeps* in vinegared *Kochujang*. J Kor Soc Appl Bio Chem 50(3): 167-177

Kim EY, Baik IH, Kim JH, Kim SR, Rhyu MR. 2004. Screening of the antioxidant activity of some medicinal plants. Korean J Food Sci Technol 4636(2): 333-338

Kim YS, Song GS. 2002. Characteristics of kiwifruit-added traditional *Kochujang*. Korean J Food Sci Technol 34(6): 1091-1097

Kwon DH, Kim MB, Yoon DY, Lee YH, Kim JW, Lee HG, Choi IS, Lim JS, Choe YK. 2003. Screening of plant resources of anti-viral activity. Kor J Med Crop Sci 11(1): 24-30

Lee GD, Lee JM, Jeong EJ, Jeong YJ. 2000. Monitoring on organoleptic properties and rheology with recipe of apple *Kochujang*. J Korean Soc Food Sci Nutr 29(6): 1068-1074

Lee GH, Kang SS, An WG, Lee YS, Kwon YK, Shin SW. 2006. Comparison of immune promotion effects of water-extracted Angelicae gigantis Rehmanniae radix Paeoniae japonica and Polygoni multiflori radix. Korean J Oriental Physiol Pathol 20(6): 1507-1515

Lee JH, Kim YC, Woo HJ. 1999. Study on the anti-cancer effect of Acanthopanax sessiliflorus J Korean Oriental Med 20(3): 54-65

Lee JM, Jang JH, Oh NS, Han MS. 1996. Bacterial distribution of *Kochujang*. Korean J Food Sci Technol 28: 260-266

Lee MJ, Lee JH. 2007. Analysis of processing conditions on Maesil-*Kochujang* production using response surface methodology. J Food Sci Nutr 36(5): 629-35

Lee YH. 2007. Current state of Korean traditional foods. Food Industry Nutr 12(1): 51-62

Liu ZY, Yang YG, Zheng B. 1993. Effect of improving memory and inhibiting acetylcholine esterase activity by Invigorating-qi and Warming-yang recipe. Chin J Integr Trad West Med 646(13): 675-

Oh SH, Cha YS, Choi DS. 1999. Effects on the lipid metabolism and liver function and alcohol metabolism in rats fed diet of addition Angelicae gigantis radix. J Korean Soc Agr Chem Biotechnol 42(1): 29-33

Park CS, Jeon GH, Park CJ. 2005. Quality characteristics of *Kochujang* added medicinal herbs. Korean J Food Preserv 12(6): 565-571

Park JC, Yee ST. 2000. Functional food and bioactive constituents from oriental medicine resources. Food Industry Nutr 5(3): 27-37

Park KW, Choi SR, Shon MY, Jeong IY, Kang KS, Lee ST, Shim KH, Seo KI. 2007. Cytotoxic effects of decursin from Angelica gigas Nakai in human cancer cells. J Korean Soc Food Sci Nutr 36(11): 1385-1390

Park KY, Kong KR, Jung KO, Rhee SH. 2001. Inhibitory effects of *Kochujang* extracts in the tumor formation and lung metastasis in mice. J Food Sci Nutr 6: 187-191

Seo KI, Kim YT, Cho YS, Shion MY, Lee SW. 2000. Changes in physicochemical properties of *Kochujang* added with onion powder. J East Asian Soc Dietary Life 10: 425-430

Shin DH. 2008. Current status and globalization strategy of Korean traditional ethnic food. Food Sci Industry 41(3): 2-22

Shin HJ, Shin DH, Kwak YS, Choo JJ, Kim SY. 1999. Changes in physiochemical properties of *Kochujang* by red ginseng addition. J Korean Soc Food Sci Nutr 28(4): 760-765

Shin SW, Lee YS, Park J H, Kwon TK, Suh SI, Kwon YK. 2004. Comparison of immunomodualtory effects of water-extracted ginseng radix, Pilose asia-bell, Astragali radix, Astractylodes rhizoma alba and Dioscoreae rhizoma. Korean J Oriental Physiol Pathol 18(4): 1140-1146

Sohn ES, Kim SW, Kang JS, Lee SP. 2004. Domestic R&D trend analysis of functional food using medical plants. Appl Chem 8(2): 470-473

Song HS, Kim YM, Lee KT. 2008. Antioxidant and anticancer activities of traditional *Kochujang* added with garlic porridge. J Life Sci 18(8): 1140-1146

Yang DS, Cha MH, Kang BJ, Oh SW, Kim YE, Yoon YS. 2003. A study on the longitudinal bone growth of growth-stimulating material with Eleutherococcus senticosus Korean J Food Sci Technol 35(4): 702-707

Yun KW, Choi SK. 2004. Antimicrobial activity in 2 Angelica species extracts. Kor J Plant Res 17(3): 278-282

Zheng H, Dong Z, She J. 1997. Modern study of traditional Chinese medicine. Xue Yuan Press, Beijing