J. Appl. Environ. Biol. Sci., 4(11S)92-97, 2015

ISSN: 2090-4274
Journal of Applied Environmental and Biological Sciences
www.textroad.com

The Effect of Soy-Protein Isolate on the Tomato Paste Viscosity by Using Response Surface Methodology

Bita Mohammadalami, Hossein Ghahramani[2*]

[1]Department of Food science Engineering, Ayatollah Amoli Branch, Islamic Azad University, Amol, Iran.
[2]Department of Chemical Engineering, Quchan Branch, Islamic Azad University, Quchan, Iran.

Received: October 29, 2014
Accepted: December 31, 2014

ABSTRACT

Viscosity is one of the most important indices in evaluating general quality and customer acceptance tomato paste. This study was conducted to evaluate the effect of soy-protein isolation on the tomato paste viscosity by using response surface methodology. Treatments were soy-protein concentration (0, 1.5 and 3 percent), temperature (45, 60 and 75℃) and viscometer rotation (50,100 and 200 rpm).The graphic contours show that the most appearance viscosity at the range of (45-50 and70-75℃) temperature and (1.25-1.75%) soy-protein isolate concentration when the rotation was 50 rpm ($P<0.05$).Also quadratic equation was suitable model for viscosity response to estimate the viscosity equation versus variable research .As the base of results of this study adding 1.5 percent soy-protein significantly increased appearance viscosity.

KEYWORDS: response surface method, soy-protein isolated, tomato paste, viscometer, viscosity.

INTRODUCTION

Tomato is the most important agricultural products, and it is the second world importance vegetables with respect of dollar value and its main product is tomato paste. Due to increasing demand for this product in Iran and the world, studying effective parameter in improving tomato paste features is necessary (4). Tomato paste is one of the food conversion products which is obtained clarified extract viscosity of tomato. Recently using different compound and adding in order to increase quality and nutritional properties of food is considered. Since FDA confirmed soybean is having health advantages, using soy-protein as one of the compound components in many foods is searched. Because tomato has 8 percent protein that has low protein in comparison of other vegetables (6) adding soybean that has high percent protein can increase dried matter and improve features of anti-oxidant and anti-cancer and rheological and quality features. Viscosity is one of the important physical indexes in evaluating general quality and customer acceptance, so having an acceptable viscosity and according to standard, which are either demanded –customer or having a suitable condition for designing production different units are important. Adding soy-protein isolate to tomato paste in a water environment can change product rheological behavior. Viscosity of tomato paste products depends on many parameters including organic parameter (such as variety and investigation degree) compositional parameter (such as solution solid, acidity, content of pectin) processing parameters (such as final stage crust and heat process) (1). Pure tomato paste is a concentrated system by deformed articles such as separated cells. In these systems most of viscosity is determined by the concentration and articles deformation. Thakada also studied the effect of protein- pectin reaction on the tomato juice viscosity, they reported that the most viscosity of tomato juice obtained when pH was between 4 and 4.5(3). This showed that protein–pectin reaction is depending on to revocable electrostatic complex. Also Tiziani compared tomato juice rheology behavior containing 1 percent soy-protein with standard tomato juice. Dynamic experiments indicated a physical gel behavior for both samples. It seems that an enhanced aggregation between pectin and soy-protein, leading to increased stability of the suspension, without major qualitative effects of the gel-like behavior(7). Mesbahi added gain and peel of tomato in order to improve food value and rheological properties. In that research, they were added dry and sift peel and gain produced from tomato paste and after determining chemical primary specification of powder and sauce, in the next stage, powder in extent of 1, 2, 5, 7 and 10 percent as firmed compound are added to tomato sauce and their rheological properties (consistency and viscosity) of sauce samples and compare them with witness sample in which viscosity is increased (2). Poul studied effect of hydrocolloid on the tomato paste's consistency in a research, the effect of adding different levels of hydro- colloid such as carboxy methyl cellulose, sodium alginate and Acasia were 0.75percent, 1.5 percent and 2.25 percent respectively, these products have a better acceptance in 0.75 percent of hydrocolloid in comparison to other levels. They had a good viscosity and their coefficient of consistency obtained from logarithm v/s ($shear\ stress/shear\ rate$) That they were decreased by adding hydrocolloids. To consider concentration and viscosity tomato paste is necessary for designing unit operation this product. Therefore, the aim of this research was adding soy-protein isolated in 0, 1.5 and 3 percent to tomato paste and studying viscosity tomato paste and at least suggested the equation related.

***Corresponding Author**: Hossein Ghahramani, Department of Chemical Engineering, Quchan Branch, Islamic Azad University, Quchan, Iran. E-mail: hsin_ghr@yahoo.com

MATERIALS AND METHOD

5 kilogram tomato paste with the same varieties was obtained from the North Khorasan's Khorram paste factory. Sampling was done before pasteurization, by an Italy line operator with primary brix of 26.59 in 76℃ and they transferred to the laboratory. The samples were missing any addition, the materials and salt and, they were kept inrefrigerator at 2℃ for considering tests after preparing. Soy-protein isolate[1] was provided from Wanfeng International Trading Co. by order of Tehran's Ashna Commercial Company.Due to the primary sample of brix was marked, soy-protein isolated powder from different concentration was distributed with the base of wet weight in distilled water 40℃, and was mixed in 15 minutes with the heater in temperature 40℃, then saluted powders were added to 26.59 primary brix tomato paste to extent that samples include 0, 1.5 and 3 percent powder, then diluting in any sample were done with distilled water until all samples brix, reach to 12.5with refractometer (A.B. Model. CHINA). The samples were kept about 5 days in refrigerator in temperature 2℃ in glass vessels of 250 grams. Viscosity test was done on the all samples in sixth day. In rotational Viscometer (VISCOELITE ANTON PAAR model, FANGILAB GROUP, S.A.CHINA) selected rotation range and suitable spindles in considering Brix, due to the high moment percent for measuring viscosity in different rotation at each variable then spindle in vessel include 60 gram tomato paste by brix 12.5 were considered. All set was put in a glass vessel by a height of 12 cm. On keeping temperature, the temperature of glass vessel was kept in the range 47 to 78℃, and then all treatments were tested. The test was done in an environment temperature (20℃) in search laboratory of Azad university Quechan branches. By using test design the response surface didn’t need repeating. In this part, for determining effective factors on the viscosity, response surface methodology was used in laboratory condition, the effect of independence factors on the viscosity, response surface methodology are used in laboratory condition the effect of independence factors, including soy- protein isolates powder in three levels 0, 1.5 and 3 percent, the temperature in levels of 45, 60 and 75℃ and viscosity rotation in levels of 50, 100 and 200 were analyzed.RSM method is a central composite design (CCD). This method is used for determining static model and devaluing. Between effective factors to aim as well as identifying the most effective factor in the process function. The first design of tests was formed by using Minitab software which shows twenty tests in any repetition. Viscometer unable to drawing kinematic viscosity graphs on the base of rotation in minutes. So after the results were obtained on the base of centipoises in different courses. Viscosity average due to the highest moment percent in any rotation were calculated. For this, viscosity data were added in any rotation and concentration, then soy-protein isolated enter excel software. Twenty different treatments were determined on the base of considered level variables by using design of response surface of Minitab software 16.

RESULTS AND DISCUSSION

The average amount of test data is shown in table (1) on the base of centipoises.

Table1. Average amount of test data

StdOrder	Run Order	PtType	Blocks	Soya%	temperature	N(rpm)	viscosity
1	1	1	1	0	45	50	1030.80
2	2	1	1	3	45	50	759.00
3	3	1	1	0	75	50	1285.60
4	4	1	1	3	75	50	688.33
5	5	1	1	0	45	200	405.00
6	6	1	1	3	45	200	482.25
7	7	1	1	0	75	200	433.25
8	8	1	1	3	75	200	454.50
9	9	-1	1	0	60	100	522.80
10	10	-1	1	3	60	100	545.83
11	11	-1	1	1.5	45	100	1535.66
12	12	-1	1	1.5	75	100	1419.75
13	13	-1	1	1.5	60	50	1918.60
14	14	-1	1	1.5	60	200	700.60
15	15	0	1	1.5	60	100	1041.50
16	16	0	1	1.5	60	100	1042.25
17	17	0	1	1.5	60	100	1043.75
18	18	0	1	1.5	60	100	1044.25
19	19	0	1	1.5	60	100	1041.75
20	20	0	1	1.5	60	100	1043.25

[1]- SPI

According to the data's table were graphing response surface charts and interaction contours (p<0.05).

Table 2. Analysis of Variance for viscosity

source	DF	Seq ss	Adj ss	Adj ms	F	P
Regression	9	2805722	2805722	311747	7.94	**0.002**
Linear	3	1257375	1073733	357911	9.12	**0.003**
soya%	1	55882	45095	45095	1.15	**0.309**
temprature	1	472	326	326	0.01	**0.929**
N(rpm)	1	1201021	1028312	1028312	26.19	**0.000**
Square	3	1426471	1426471	475490	12.11	**0.001**
soya%*soya%	1	1054825	1371414	1371414	34.93	**0.000**
temprature*temprature	1	288995	154733	154733	3.94	**0.075**
N(rpm)*N(rpm)	1	82651	82651	82651	2.11	**0.177**
Interaction	3	121876	121876	40625	1.03	**0.418**
soya%*temprature	1	18190	18190	18190	0.46	**0.512**
soya%*N(rpm)	1	101275	101275	101275	2.58	**0.139**
temprature*N(rpm)	1	2411	2411	2411	0.06	**0.809**
Residual Error	10	392571	392571	39257		
Lack-of-Fit	5	392564	392564	78513	62291.20	**0.000**
Pure Error	5	6	6	1		
Total	19	3198293				

The table 2 shows the results of the statistical analysis. Regarding the table (2) quadratic model was significant for viscosity factor. Other significant model phrases, also included: Viscometer rotation and soy-protein isolate percent second degree phrase. Also, none of the phrases related to interaction effects were significant. The high amount of R^2 and R^2 adjustment, also showed the high ability of the quadratic model in estimitated.

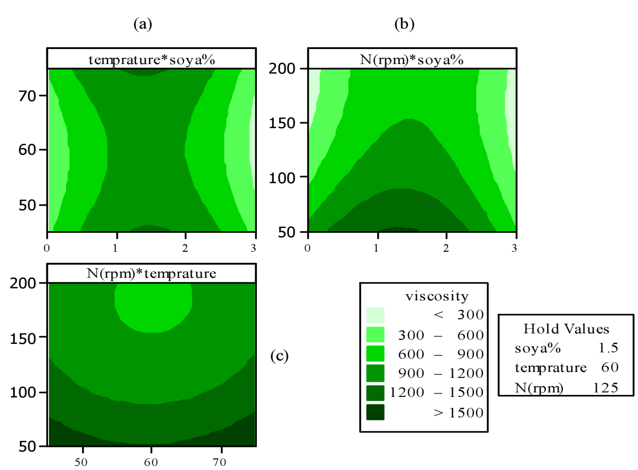

Figure1. Contour plots of viscosity interaction between (a) temperature and soya %, (b) rotation Viscometer and soya%, (c) rotation Viscometer and temperature at hold values

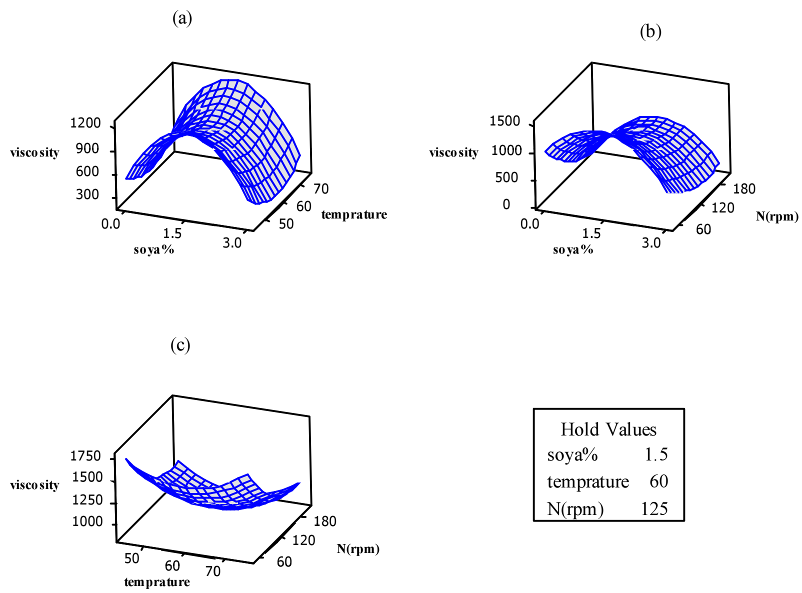

Figure2. Surface plots of viscosity on the relation between (a) temperature and soya %, (b) rotation Viscometer and soya%, (c) rotation Viscometer and temperature at hold values

The concurrent effects of two variables on viscosity were showed in figure 2. The concurrent effect of soy-protein isolates percent and temperature at hold Viscometer rotation (125rpm) is shown in figure 2-a. SPI percent from 0 to 1.5 percent, significantly increased the viscosity, then increase up to 3 percent decreased the viscosity. Regarding the significance of the square SPI percent ($p<0.005$) the presence of the curves in contours can be expected. The increase of viscosity with the increase of SPI is probable because of the increase in the total amount of solid materials in tomato paste. The concurrent effect ofsoy-protein isolate concentration percent and Viscometer rotation at hold temperature (60) was shown in figure 2-b. When the rotation increased, viscosity decreased. The concurrent effect oftemperature and Viscometer rotation on hold soy-protein isolate concentration (1.5%) was shown in figure 2-c. The viscosity decreased by increased temperature up to 60 then viscosity increased as a result of Viscometer rotation decreased when the temperature increased up to 75.none of the interaction effects, did not have a significant effect on the viscosity ($p>0.005$). Therefore, Viscometer rotation and square soy-protein isolates concentration were probably the most effective variables in our study ($p<0.005$). The graphic contours show that the most appearance viscosity in the range of (45-50 and70-75°C) temperature and (1.25-1.75%) soy-protein isolates concentration when the rotation was 50 RPM ($P<0.05$).

Suggested model viscosity

Viscosity response was used for modeling and selecting the best formula. The coefficients were shown in table (3). High amounts of R^2 and adjusted R^2 indicated that quadratic equation

Table 3. Quadratic coefficients related to suggested model viscosity

Term	symbol	Coefficient
Constant	X_0	5091.22
Soya%	X_1	900.196
Temperature	X_2	-121.041
N (rpm)	X_3	-13.6433
Soya%*soya%	X_1^2	-313.860
Temperature*temperature	X_2^2	1.05425
N (rpm)*N (rpm)	X_3^2	0.0351984
Soya%*temperature	X_1X_2	-2.11928
Soya%*N (rpm)	$X_1 X_3$	0.989193
Temperature*N (rpm)	$X_2 X_3$	-.0152622

Was a suitable model for viscosity response to estimate the viscosity equation versus soy-protein isolate percent, temperature and Viscometer rotation variables. P index was identified the importance of any coefficients. In this suggested equation, square viscosity rotation (X_3^2) and the coefficient interaction temperature and viscosity rotation effect ($X_2.X_3$) were not significant. Using the recent response surface equation which indicates the experimental relation between the testing variables and viscosity is reported as follows:

$Y= 5091.22\ X_0-13.6433\ X_3-313.860\ X_1^2$

Viscosity optimization with added SPI

The optimistic operational condition was searched by using the optimization techniques. First, optimization goals were determined, and then the response surfaces as well as independent variables were regulated. Then, using mini-tab the best results were achieved. The imposed adjustments on optimization process included: the minimum SPI concentration and the maximum viscosity. The determination of the optimal operation was done by response surface and contour chart (figure 3). The results of the optimization process showed that the optimistic condition with viscosity of 1789.828 centipoises figure (3) is observable in the optimum temperature of 75°C, a rotation of 50 RPM and SPI concentration of 1.2727 percent.

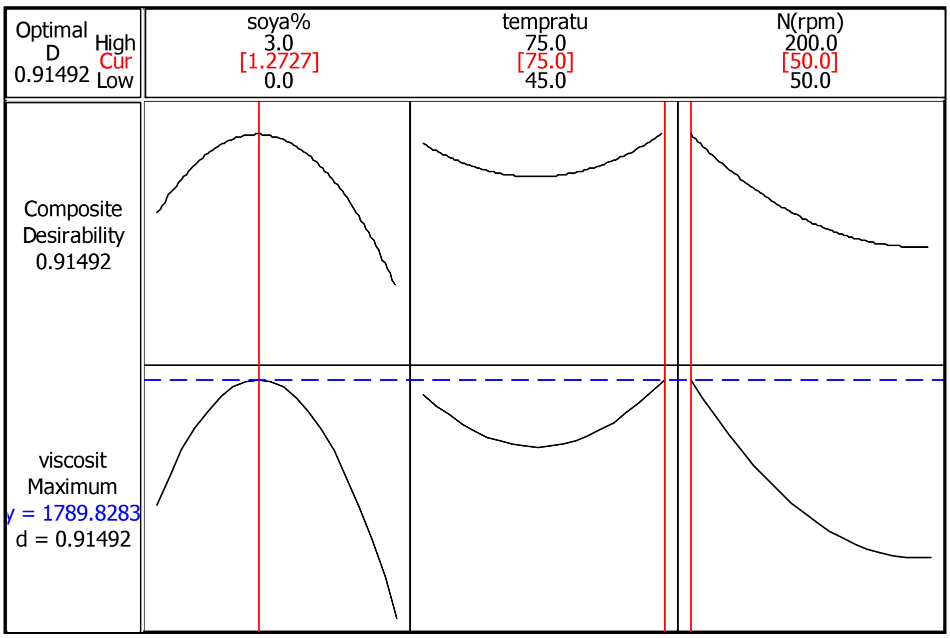

Figure3. The optimization viscosity diagram

Conclusion

The study showed that the most appearance viscosity in the range of (45-50 and70-75°C) temperature and (1.25-1.75%) soy-protein isolate concentration when the rotation was 50 RPM (P<0.05). The most suitable model for viscosity response was a second degree equation. We realized that viscosity was improved by adding soy-protein isolate 1.5 percent provided that the temperature was 45,75°C and viscosity rotation was 50 (rpm).probably soy-protein isolate could be replaced with concentrated materials which consuming in tomato paste because of saving in cost, used 1.5 percent was better.

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