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Optimizations Of Ingredients For Sensory Evaluation Of Aloe Vera Jam Preparation Using Response Surface Methodology (RSM)

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Abstract

The present work is focused on the sensory quality of jam produced by aloe vera. Response surface methodology (RSM) was used to optimize the ingredients like: aloe vera juice (800-1200 ml), sugar (800-1200 g kg^{-1}), pectin (35-60 g kg^{-1}) and citric acid (20-40 ml). Results showed that the model fit was significant ($p < 0.05$) and there was satisfactory correlation between actual and fitted values. The statistical model was used to optimise the factors levels for highest acceptability, to produce aloe vera jam. Data obtained from RSM on aloe vera jam production were subjected to the analysis of variance (ANOVA) and analyzed using a second order polynomial equation. Sensory analysis for color, taste, aroma and texture in the aloe vera jam produced at the optimized ingredients composition were performed. The optimum condition for the best sensory score is aloe vera juice 990 ml, sugar 1022 g kg^{-1}, pectin 50.3 g kg^{-1} and citric acid 28.2 ml. Jam produced under the optimum conditions for sensory score was again subjected to evaluation of sensory values and the results were compared with the RSM predictions.

Keywords: Jam, pectin, sugar, optimization, citric acid.

1. INTRODUCTION

Jam is an intermediate food prepared by boiling fruit pulp with sugar, acid, pectin and other ingredients for colouring and flavouring with preservatives to a thick consistency and firmness to the hold the fruit tissues [1-2] .

The standards for the quality of jam are given by different agencies. The Bureau of Indian Standards (BIS) and Prevention of Food Adulteration (PFA) specify that jam should contain more than 68.5% total soluble solids (TSS) and at least 45% fruit [3] .According to the specification of the Codex Alimentarius Commission the finished jam should contain more than 65% TSS. Sugar constitutes more than 40% of total weight and 80% of total solids in jam [4].

Higher sugar content of jam increases its calorific value. Since the dietary awareness of consumers is more it has become very important to see for alternative sweeteners with less calorific value. This can be accomplished by partial or full replacement of sucrose with other carbohydrate or non-carbohydrate sweeteners like xylitol, sorbitol, aspartame, acesulfame-K, cyclamate, stevioside, sucralose, or combinations of these [5]. Fruit jams are commonly used with breads, cookies, cake fillings and others [6].

Aloe vera products have long been used in health foods for medical and preservative purposes. This is probably a result of the aloe vera gel's ability to fine-tune our immunity therefore enhancing the body's abilities to fight off challenges. The gel also has antioxidant properties that are mainly due to its overall effect on the body and it contains vitamins A, C and E. Aloe vera induces an improvement in blood flow to the skin through capillary dilation. It acts as a natural anti-inflammatory agent without the side-effects of steroids [7-10].

The objective of the present work is to produce jam using aloe vera. This is the first study which focuses on the production of jam using aloe vera. The quality of the jam depends on the proportion of the mixture which can be tested by sensory analysis. In product development and optimisation, Response surface methodology (RSM) is used to model and optimise the response affected by levels of one or more quantitative factors [11]. This method has been successfully applied by several authors to determine the optimum formulation for a food product [12-14]. The RSM is an innovative approach to model a system with the collection of statistical techniques where in interactions between multiple processes variables can be identified with a fewer experimental trials [15]. The RSM experimental design is an efficient approach to deal with a large number of variables and there are several reports on application of RSM for the evaluation of sensory analysis [16].

2. MATERIALS AND METHOD

2.1Jam masses

The jam ingredients like aloe vera juice, sugar, pectin and citric acid were obtained from market.

2.2 Sample preparation

Sugar was dissolved in water till complete saturation in a boiling pan and the mixture was heated with occasional stirring. Aloe Vera juice and pectin was then added to the mixture, once the mixture attains 60^0C citric acid was added. This mixture is then stirred for a while, cooled and then packed as jam [17].

2.3 Optimization of aloe vera jam production for sensory analysis

The Response surface methodology (RSM) consists of a group of empirical techniques used for the evaluation of relationship between clusters of controlled experimental factors and measured response. The RSM was employed to optimize the process ingredients like aloe vera juice, sugar, pectin and citric acid in the aloe vera jam preparation. The ranges of these four ingredients are given in Table 1.

The statistical software package "Minitab 16" was used to analyze the experimental data. All variables were taken at a central coded value of zero. The minimum and maximum ranges of variables investigated are listed in (Table 1). Experiments were performed according to the central composite design (CCD) in the RSM. The design of experiment was given in Table 2. Upon the completion of experiments, the average maximum sensory evaluation of aloe vera jam for color, taste, aroma and texture was taken as the response (Y). A multiple regression analysis of the data was carried out for obtaining an empirical model that relates the response measured to the independent variables.

A second-order polynomial equation is

$$Y = \beta_0 + \sum_{i=1}^{k} \beta_i X_i + \sum_{i=1}^{k} \beta_{ii} X_i^2 + \sum_{i=1, i<j}^{k=1} \sum_{j=2}^{k} \beta_{ij} X_i X_j, \quad (1)$$

Where Y is the measured response, $\beta 0$ is the intercept term, βi are linear coefficients, βii are quadratic coefficient, $\beta i\ j$ is interaction coefficient, and Xi and Xj are coded independent variables. The optimal concentrations of the critical variables were obtained by analyzing response surface methodology. The statistical analysis of the model was represented in the form of analysis of variance (ANOVA).

2.4 Sensory evaluation

The sensory evaluation was carried out by an untrained panel of 45 members (20 males and 25 females) in the age 20 – 30 years consisting of faculty and graduate students of the laboratory of Food process and technology at the Department of Technology, Annamalai University. The sensory evaluation was carried out for the aloe vera jam samples for the factors Colour, taste, aroma and texture. Overall acceptability of aloe vera jam samples were evaluated following nine point hedonic scale (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike,4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely).

3 RESULTS AND DISCUSSION

3.1Optimization of aloe vera jams production for sensory analysis

The results obtained were given in Table 3. A polynomial model was proposed for sensory analysis of foods in the production of aloe vera jam. The four outputs, namely color, taste, aroma and texture of the product were given as polynomials in equations (2), (3), (4) and (5) respectively,

$$Y= 8.88971-0.27496A+0.16388B+0.10804C-0.59512D-0.69086A^2-0.24248B^2-0.52773C^2-0.70348\ D^2 +0.60944AB +0.15294\ AC+0.10994AD +0.17906BC -0.06619BD +0.20581CD \quad (2)$$

$$Y= 8.87500-0.28863A+0.15221B+0.16954C-0.60812D-0.74322\ A^2 -0.23997\ B^2 -0.52222\ C^2-0.70247D^2+0.63669AB+0.05094AC+0.14969AD+0.13294BC-0.07356BD+0.28844CD \quad (3)$$

$$Y= 9.0000-0.1229A+0.1354B+0.1271C-0.6646D-0.6828A^2 0.3578B^2 0.4953C^2 0.7578D^2+0.6656AB+0.1281AC+0.2906AD+0.1906BC+0.1031BD+0.1031BD+0.2031CD \quad (4)$$

$$Y=8.8850-0.2285A+0.1660B+0.1361C-0.5453D-0.6874A^2-0.1768\ B^2 -0.5242\ C^2 -0.7006\ D^2 +0.5624AB +0.2182AC +0.1789AD +0.1168BC -0.1247BD +0.2473CD \quad (5)$$

ANOVA for the response surface methodology is given in Table 4 to 7 for color, taste, aroma and texture respectively. The F value of 130.51 for color, 99.30 for taste, 53.58 for aroma and 47.02 for texture implies the model is significant. Generally values of "prob > F "less than 0.05 indicate that model term is significant. Values greater than 0.1 indicate that the model terms are not significant.

In the present work, all the linear, square and interactive effects viz. AB, AC, AD, BC and CD were significant for sensory values of color. For sensory values of taste, all the linear, square and interactive effects AB, AD, BC and CD were significant. For sensory values of aroma, all the linear, square, interactive effects AB, AD, BC and

CD were significant. For sensory values of texture all the linear, all the square, interactive effects of AB, AC, AD and CD were significant.

The coefficients of determination (R^2) for sensory values were found to be 0.9913 for color, 0.9886 for taste 0.9791 for aroma and for texture 0.9763. The predicted R^2 value 0.9507 for color, 0.9362 for taste, 0.8797 for aroma and texture 0.8642 is in reasonable agreement with the adjusted R^2 value of 0.9837 for color, 0.9787 for taste, 0.9608 for aroma and texture 0.9555.

The above model can be used to predict the sensory analysis of aloe vera jam production within the limits of the experimental factors. Figure 1 - 4, shows that the experimental response values agree well with the predicted response values. The interactive effects of variables on sensory analysis of aloe vera jam production in the form of contour plots were shown in Figures 5 – 11. The experimental conditions for different sensorial score obtained and their response for the sensorial color, taste, aroma and texture were given in Table 4 to 7.

Figure 5, shows the significant interaction between aloe vera juice and sugar for color. The sensory value of color increases with increase in aloe vera juice and sugar to about 994 ml and 1034 g kg^{-1} respectively and thereafter sensory score decreases with further increase in aloe vera juice and sugar. The same trend was observed in Figure 6, which shows an increase in pectin and citric acid resulted in increase in sensory value of color up to 50.3 g kg^{-1} and 28.1 ml respectively**.**

Figure 7, shows the significant interaction between aloe vera juice and sugar for taste. The sensory value of taste increased with increase in aloe vera juice and sugar to about 986 ml and 1022 g kg^{-1} respectively and thereafter sensory score decreases with further increase in aloe vera juice and sugar.

Figure 8, shows the significant interaction between aloe vera juice and sugar for aroma. The sensory value of aroma increased with increase in aloe vera juice and sugar to about 974 ml and 986 g kg^{-1} respectively and thereafter sensory score decreases with further increase in aloe vera juice and sugar. The same trend was observed in Figure 9, which shows an increase in aloe vera juice and citric acid resulted in increase in sensory value of aroma up to 974 ml and 49.9 ml respectively.

Figure 10, shows the significant interaction between pectin and citric acid for texture. The sensory value of texture increased with increases pectin and citric acid to about 50.3 g kg^{-1} and 28.1 ml respectively and its sensory score decreases with further increase in pectin and citric acid. The same trend was observed in Figure 11, which shows an increase in aloe vera juice and citric acid resulted in increase in sensory value of texture up to 994 ml and 28.1ml respectively.

Response surface methodology (RSM) can be used to model and optimise any response affected by levels of one or more quantitative factors. The optimum conditions for the best sensory score of the four outputs were obtained using Response optimizer in Minitab 16. They are: aloe vera juice- 990 ml, Sugar- 1022 g kg^{-1}, Pectin- 50.3 g kg^{-1}, and citric acid- 28.2 ml. An experimental run was conducted by taking the operating parameters that yielded best sensory value. The jam produced was tested with the panelists and the scores were compared with the predicted value. The overall scores were 8.90 for color and taste, 9.00 for aroma and texture.

4 CONCLUSIONS

The present investigation deals with the production of aloe vera jam using aloe vera juice, sugar, pectin and citric acid. Response Surface Methodology design was used to test the relative importance of sensory outputs the optimum condition for the best sensory score is aloe vera juice – 990 ml, sugar- 1022 g kg^{-1}, pectin- 50.3 g kg^{-1} and citric acid- 28.2 ml. The proportion of the four ingredients for the best sensory value of taste is given higher priority and the experiment run for the optimum conditions obtained from RSM gave a sensory score of 8.90 for color and taste, 9.00 for aroma and texture.

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Table 1. Coded and actual levels of the ingredients for the design of experiment.

Ingredients	Code	Coded levels				
		-2	-1	0	+1	+2
Aloe vera juice, ml	A	800	900	1000	1100	1200
Sugar, g kg^{-1}	B	800	900	1000	1100	1200
Pectin, g kg^{-1}	C	40	45	50	55	60
Citric acid, ml	D	20	25	30	35	40

Table 2. Experimental design matrix for jam production using aloe vera

Run no	A	B	C	D
1	-1	-1	1	1
2	0	0	0	0
3	-1	1	1	1
4	0	0	0	0
5	0	0	0	0
6	1	-1	-1	-1
7	0	0	-2	0
8	0	0	0	0
9	1	1	-1	-1
10	-1	-1	-1	1
11	0	0	0	-2
12	0	-2	0	0
13	0	0	2	0
14	2	0	0	0
15	-1	1	-1	-1
16	0	0	0	0
17	-1	1	1	-1
18	-2	0	0	0
19	0	2	0	0

20	1	1	1	-1
21	0	0	0	0
22	1	-1	1	-1
23	-1	-1	-1	-1
24	-1	-1	1	-1
25	1	-1	-1	1
26	1	1	1	1
27	0	0	0	0
28	0	0	0	2
29	-1	1	-1	1
30	1	-1	1	1
31	1	1	-1	1

Table 3. Central composite design (CCD) of factors in coded levels with sensory analysis of foods in the production of aloe vera jam using RSM.

Run no	Color		Taste		Aroma		Texture	
	Experimental	Predicted	Experimental	Predicted	Experimental	Predicted	Experimental	Predicted
1	7.000	6.709	7.500	7.030	6.65	6.312	6.950	6.870
2	8.890	8.890	8.800	8.875	9.00	9.000	8.850	8.885
3	6.120	6.243	6.100	6.180	5.60	5.840	6.100	6.061
4	8.892	8.890	8.850	8.875	9.00	9.000	8.890	8.885
5	8.821	8.890	8.800	8.875	9.00	9.000	8.820	8.885
6	6.241	6.180	6.250	6.175	6.50	6.398	6.240	6.090
7	6.551	6.683	6.500	6.447	6.55	6.765	6.552	6.516
8	8.900	8.890	8.941	8.875	9.00	9.000	8.915	8.885
9	7.364	7.461	7.300	7.634	7.50	7.412	7.365	7.563
10	7.000	6.945	6.401	6.482	6.55	6.290	7.120	6.773
11	7.377	7.226	7.300	7.281	7.15	7.298	7.375	7.173
12	7.455	7.552	7.400	7.611	7.00	7.298	7.455	7.846
13	6.954	6.955	6.942	7.125	7.20	7.273	6.954	7.060
14	5.850	5.536	5.354	5.325	6.00	6.023	5.850	5.678
15	7.421	7.517	7.415	7.340	7.25	7.165	7.420	7.690
16	8.911	8.890	8.900	8.875	9.00	9.000	8.911	8.885
17	7.369	7.174	7.350	7.266	7.50	7.137	7.369	7.264
18	6.350	6.796	6.320	6.479	6.25	6.515	6.350	6.592
19	8.332	8.368	8.300	8.220	7.85	7.840	8.830	8.510
20	7.852	7.969	7.840	7.764	7.50	7.898	7.852	8.011
21	8.934	8.890	8.920	8.875	9.00	9.000	8.934	8.885
22	5.900	6.212	5.910	5.774	6.50	6.121	5.905	6.071
23	8.547	8.434	8.540	8.427	8.90	8.813	8.547	8.467
24	7.699	7.615	7.690	7.822	7.90	8.023	7.699	7.574
25	4.890	4.890	4.880	4.829	5.10	5.037	4.890	5.113
26	7.320	7.238	7.300	7.277	8.10	7.762	7.325	7.523
27	8.880	8.890	8.914	8.875	9.00	9.000	8.875	8.885
28	4.722	5.006	4.700	4.849	4.50	4.640	4.720	4.992
29	6.510	6.003	5.099	5.100	5.10	5.054	5.545	5.497
30	5.540	5.506	5.500	5.581	5.35	5.573	6.540	6.082
31	6.000	6.146	6.120	5.994	6.45	6.465	6.150	6.086

Table 4. Regression analysis and corresponding *t* and p- value of second order polynomial model for the optimization of sensory analysis of foods in the production of aloe vera jam for color and taste

Source	Color			Taste		
	Regression Coefficient	t-statistic	P-value	Regression Coefficient	t-statistic	P-value
Intercept	8.88971	143.882	0.000	8.87500	121.217	0.000
A	-0.27496	-8.240	0.000	-0.28863	-7.299	0.000
B	0.16388	4.911	0.000	0.15221	3.849	0.001
C	0.10804	3.238	0.005	0.16954	4.288	0.001
D	-0.59512	-17.835	0.000	-0.60812	-15.380	0.000
A*A	-0.69086	-22.600	0.000	-0.74322	-20.517	0.000
B*B	-0.24248	-7.932	0.000	-0.23997	-6.624	0.000
C*C	-0.52773	-17.264	0.000	-0.52222	-14.416	0.000
D*D	-0.70348	-23.013	0.000	-0.70247	-19.392	0.000
A*B	0.60944	14.913	0.000	0.63669	13.147	0.000
A*C	0.15294	3.742	0.002	0.05094	1.052	0.309
A*D	0.10994	2.690	0.016	0.14969	3.091	0.007
B*C	0.17906	4.382	0.000	0.13294	2.745	0.014
B*D	-0.06619	-1.620	0.125	-0.07356	-1.519	0.148
C*D	0.20581	5.036	0.000	0.28844	5.956	0.000

For color S = 0.163467, PRESS = 2.43035, R-Sq = 99.13%, R-Sq (pred) = 95.07%, R-Sq (adj) = 98.37% .

Table 5. Regression analysis and corresponding *t* and p- value of second order polynomial model for the optimization of sensory analysis of foods in the production of aloe vera jam for aroma and texture.

Source	Aroma			Texture		
	Regression Coefficient	t-statistic	P-value	Regression Coefficient	t-statistic	P-value
Intercept	9.0000	89.101	0.000	8.8850	88.321	0.000
A	-0.1229	-2.253	0.039	-0.2285	-4.205	0.001
B	0.1354	2.482	0.025	0.1660	3.056	0.008
C	0.1271	2.330	0.033	0.1361	2.506	0.023
D	-0.6646	-12.183	0.000	-0.5453	-10.037	0.000
A*A	-0.6828	-13.663	0.000	-0.6874	-13.812	0.000
B*B	-0.3578	-7.160	0.000	-0.1768	-3.553	0.003
C*C	-0.4953	-9.911	0.000	-0.5242	-10.532	0.000
D*D	-0.7578	-15.164	0.000	-0.7006	-14.075	0.000
A*B	0.6656	9.963	0.000	0.5624	8.453	0.000
A*C	0.1281	1.918	0.073	0.2182	3.279	0.005
A*D	0.2906	4.350	0.000	0.1789	2.689	0.016
B*C	0.1906	2.853	0.012	0.1168	1.756	0.098
B*D	0.1031	1.544	0.142	-0.1247	-1.874	0.079
C*D	0.2031	3.040	0.008	0.2473	3.717	0.002

For taste S = 0.193710 ,PRESS = 3.36844,R-Sq = 98.86%, R-Sq(pred) = 93.62%, R-Sq(adj) = 97.87%.

Table 6. Analysis of variance (ANOVA) for the quadratic polynomial model for the optimization of sensory analysis of foods in the production of aloe vera jam for color and taste.

Source	Color					Taste				
	SOS	DF	MS	F	P	SOS	DF	MS	F	P
Regression	48.8222	14	3.4873	130.51	<0.000	52.1636	14	3.7260	99.30	0.000
Linear	11.2393	4	2.8098	105.15	<0.000	12.1208	4	3.0302	80.75	0.000
Square	29.8118	4	7.4530	278.91	<0.000	31.4564	4	7.8641	209.58	0.000
Interaction	7.7711	6	1.2952	48.47	<0.000	8.5864	6	1.4311	38.14	0.000
Residual Error	0.4275	16	0.0267		-	0.6004	16	0.0375	-	-
Lack-of-Fit	0.4202	10	0.0420	34.34	<0.000	0.5800	10	0.0580	17.06	0.001
Pure Error	0.0073	6	0.0012	-	-	0.0204	6	0.0034	-	-
Total	49.2497	30	-	-	-	52.7640	30	-	-	-

For aroma S = 0.267244, PRESS = 6.582, R-Sq = 97.91%, R-Sq (pred) = 87.97%, R-Sq(adj) = 96.08%.

Table 7. Analysis of variance (ANOVA) for the quadratic polynomial model for the optimization of sensory analysis of foods in the production of aloe vera jam for aroma and texture.

Source	Aroma					Texture				
	SOS	DF	MS	F	P	SOS	DF	MS	F	P
Regression	53.5716	14	3.8265	53.58	<0.000	46.6361	14	3.3312	47.02	0.000
Linear	11.7904	4	2.9476	41.27	<0.000	9.4953	4	2.3738	33.51	0.000
Square	31.6665	4	7.9166	110.85	<0.000	29.3598	4	7.3399	103.61	0.000
Interaction	10.1147	6	1.6858	23.60	<0.000	7.7811	6	1.2968	18.31	0.000
Residual Error	1.1427	16	0.0714	-	-	1.1335	16	0.0708	-	-
Lack-of-Fit	1.1427	10	0.1143	25.95	-	1.1239	10	0.1124	70.60	0.000
Pure Error	0.0000	6	0.0000	-	-	0.0096	6	0.0016	-	-
Total	54.7144	30	-	-	-	47.7696	30	-	-	-

For texture S = 0.266161, PRESS = 6.48674, R-Sq = 97.63%, R-Sq (pred) = 86.42%.R-Sq (adj) = 95.55%.

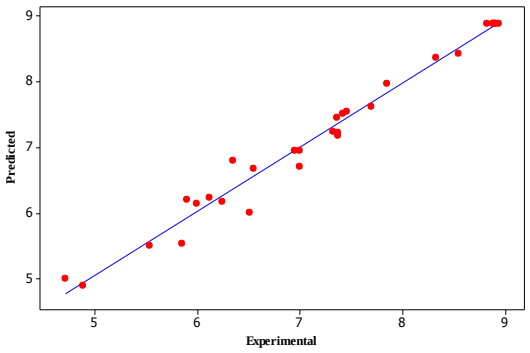

Figure 1. Predicted response versus experimental value (color)

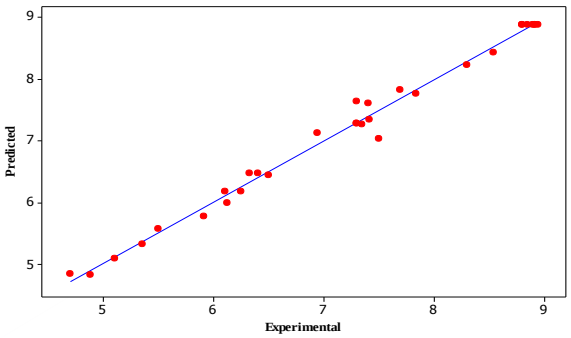

Figure 2. Predicted response versus experimental value (Taste)

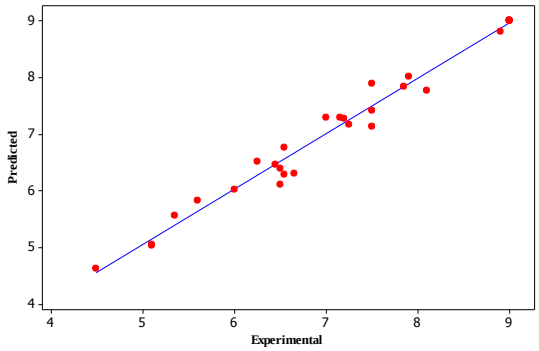

Figure 3. Predicted response versus experimental value (Aroma)

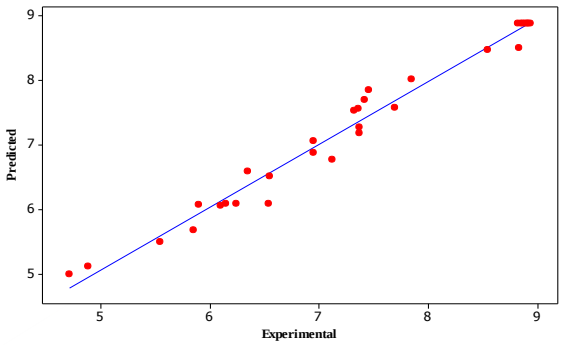

Figure 4. Predicted response versus experimental value (Texture)

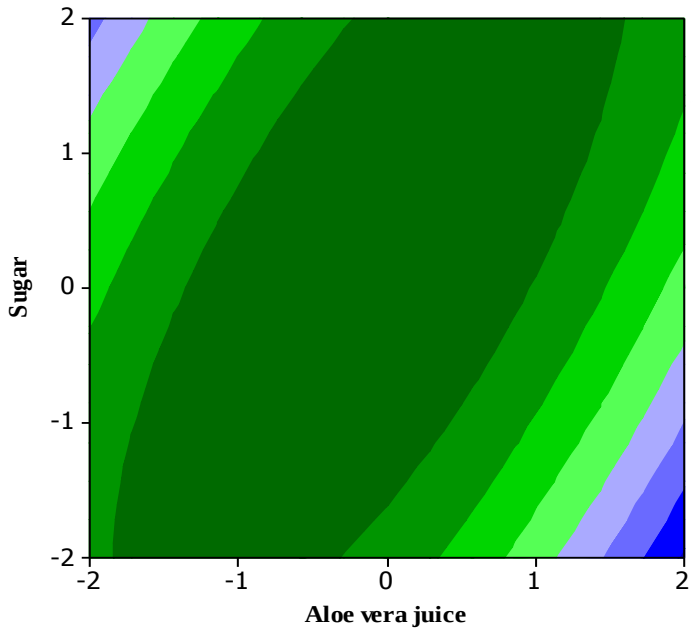

Figure 5. Contour plot showing the interactive effects of aloe vera juice and sugar on sensory analysis of aloe vera jam for color.

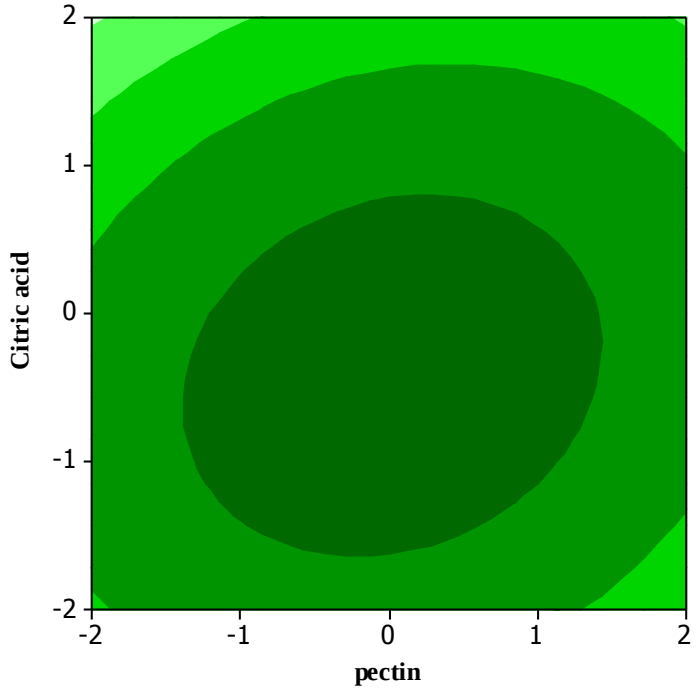

Figure. 6. Contour plot showing the interactive effects of pectin and citric acid on sensory analysis of aloe vera jam for color.

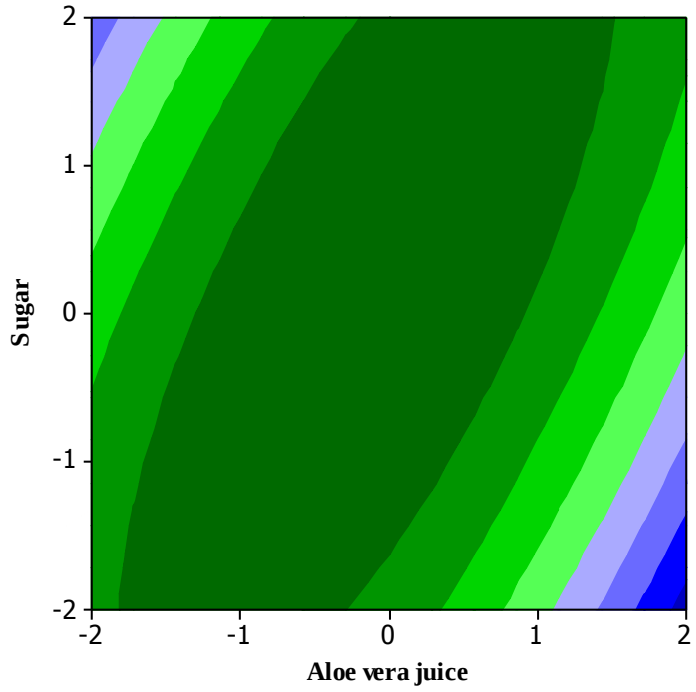

Figure.7. Contour plot showing the interactive effects of aloe vera juice and sugar on sensory analysis of aloe vera jam for taste.

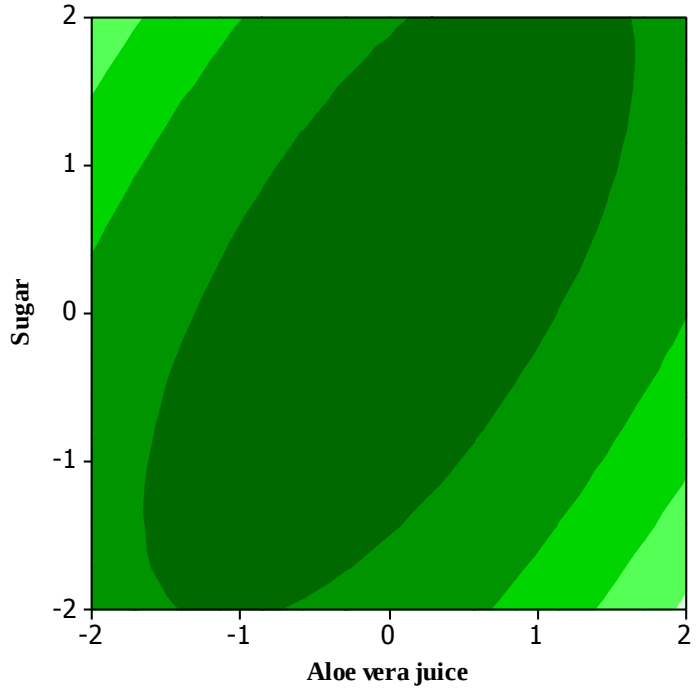

Figure. 8. Contour plot showing the interactive effects of aloe vera juice and sugar on sensory analysis of aloe vera jam for aroma.

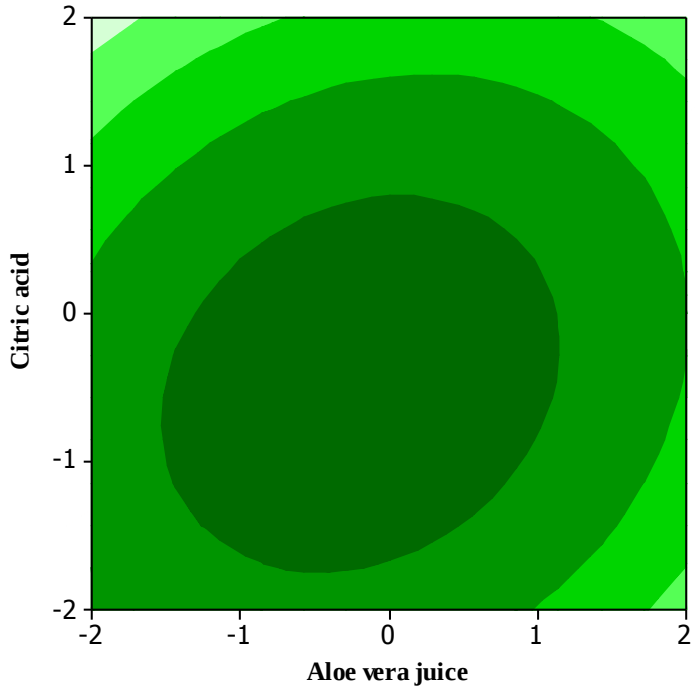

Figure. 9. Contour plot showing the interactive effects of aloe vera juice and citric acid on sensory analysis of aloe vera jam for aroma.

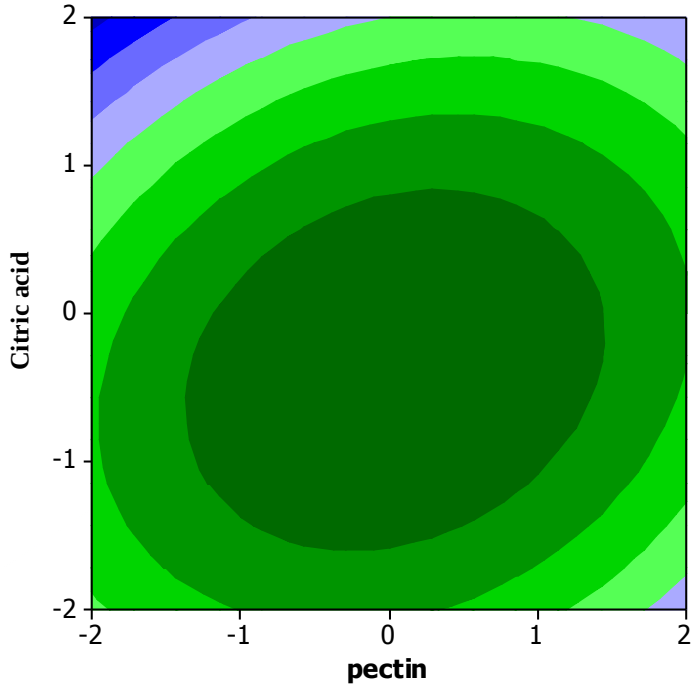

Figure. 10. Contour plot showing the interactive effects of pectin and citric acid on sensory analysis of aloe vera jam for texture.

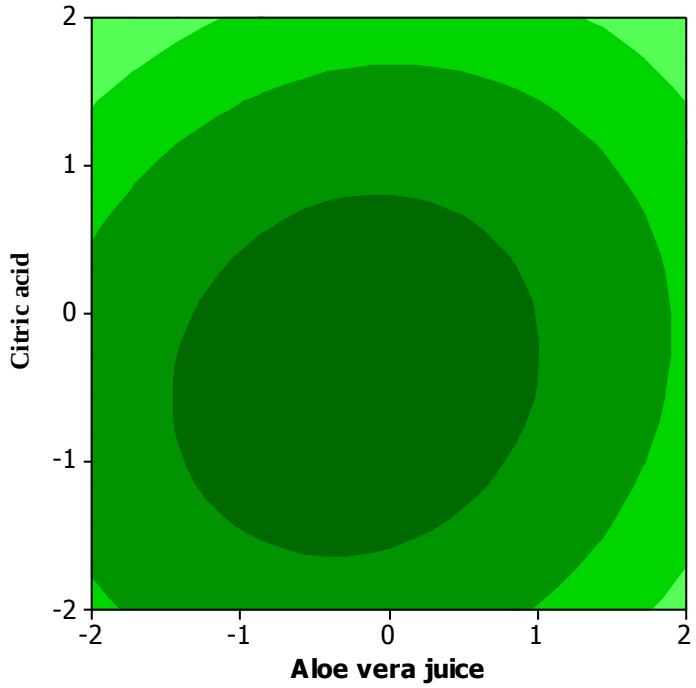

Figure. 11. Contour plot showing the interactive effects of aloe vera juice and citric acid on sensory analysis of aloe vera jam for texture.