ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Statistical Optimization of Ingredients for Sensory Evaluation of Idly Preparation Using Response Surface Methodology (Rsm)

E Krishnaprabakaran and T Viruthagiri

Department of Chemical Engineering, Annamalai University, Annamalainagar, Tamilnadu 608002, India

ABSTRACT

The study aims to make idly batter using xanthan. The ingredients like, pH (4-6), temperature (0-300C), fermentation time (0-12 hrs) and xanthan (0-0.1%) were optimized using response surface methodology (RSM). The design contains a total of 31 experimental runs involving replications of the central points in a randomized factorial design and organized. Data obtained from RSM on idly batter preparation were subjected to the analysis of variance (ANOVA) and were analyzed using a second order polynomial equation. Sensory analysis for color, taste, aroma and texture in the idly batter preparation were performed. The optimum ingredient compositions for the best sensory score of the four outputs were: pH- 4.48, temperature 30.40C, Fermentation time12.02hrs and xanthan0.072% idly batter preparation under the optimum conditions was subjected to evaluation of sensory values and the results were compared with the RSM predictions.

Keywords: Xanthan, optimization, salt, Rice and Black gram

Corresponding author

INTRODUCTION

Idli is a very popular fermented breakfast food staple consumed in the Indian subcontinent, especially in southern parts. The major ingredients are rice (Oryza sativum) and black gram (Phaseolus mungo). Traditionally, Idli preparation is as follows: [1] Soaking the rice and black gram separately [2]. After draining the water, grinding rice and black gram separately with occasional addition of water during the grinding process [3] Mixing rice and black gram batters together with addition of a little salt [4]. Allowing to ferment overnight at room temperature [5]. Depositing the fermented batter in special Idli pans and steaming for 5±8 min [1-2].

Rheology and particle size studies are helpful in design and development of such equipment for complete automation of Idli making. Several aspects such as methods of Idli preparation, effect of raw materials, effect of temperature, effect of pH, micro-organisms involved, biochemical and nutritive changes have been reviewed by many authors [3-9]. In a direction towards reducing the fermentation time of idli batter and increasing the shelf life of fermented batter, an improved process for the preparation of shelf-stable idli batter was made available [10]. Similary there are number of works for adding the stabilizers in increase or decrease the fermentation time [11-14]. So in our work we use xanthan gum as stabilizers for decrease the fermentation time

Xanthan is a food additive used to thicken, emulsify, and stabilize water-based foods. It is used in many different types of food, including salad dressings, sauces, condiments, ice creams, and other frozen foods. Many gluten-free baking products also contain it. This additive helps food with oil, like salad dressings, stay mixed, it helps give some foods a smooth texture, and it can help the ingredients in other products bind together [15-16].

A polysaccharide gum, or three-chain sugar compound, xanthan gum is created through the fermentation of the bacteria *Xanthomonas campestris* with glucose and/or sucrose. It is also sometimes called corn sugar. This additive is very stable at a wide variety of temperatures and pH levels.

The purpose and scope of the present study was to decrease the fermentation time of idli and to evaluate the quality of the idlis for color, taste, aroma and textural quality using RSM.

MATERIALS AND METHODS

Raw Materials

Xanthan was purchased from Agro gums, Ahmedabad (india). Rice from local market was used to see the quality traits. Whereas the dehulled black gram and edible grade salt were purchased from the local market were also used for idli making.

Preparation of idli batter

Rice and black gram in the ratio of 4:1 by weight were taken. Then the weighed rice and blackgram was washed and soaked separately for 4 hours. After soaking, the water was drained. The soaked rice and black gram were separately ground in a wet grinder. Water was added as when required.

Fermentation

After idly batter was ready, table salt was added and allowed to ferment at room temperature for 12 hours naturally. The volume of batter was recorded in a measuring cylinder before and after fermentation.

Preparation of idli

Equal volume of batter samples were taken for suitable shapes, placed in plates stacked one above the other and steamed for 15-20 minutes in an idli steamer.

Optimization of idly preparation for sensory analysis

The quality of the idly is greatly influenced by the proportion of pH, temperature, fermentation time and xanthan. The Response surface methodology (RSM) consists of a group of empirical techniques used for evaluation of relationship between clusters of controlled experimental factors and measured response. The RSM was employed to optimize the components like pH, temperature, fermentation time and xanthan which enhance the idly preparation. The ranges of these four variables are given in Table 1.

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

Ingredients	Code	Coded levels				
		-2	-1	0	1	2
pH	A	3.5	4	4.5	5	5.5
Temperature ^{0}C	B	10	20	30	40	50
Fermentation time hrs	C	4	8	12	16	20
Xanthan %	D	0	0.05	0.1	0.15	0.2

Experiments were performed according to the central composite design (CCD) in the RSM. The design of experiment is given in Table 2. The statistical software package "Minitab 16**"** was used to analyze the experimental data. All variables were taken at a central coded value of zero. Upon the completion of experiments, the average maximum sensory evaluation of idly 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

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

Where *Y* is the measured response, β_0 is the intercept term, β_i are linear coefficients, β_{ii} are quadratic coefficient, $\beta_{i\,j}$ is interaction coefficient, and X_i and X_j are coded independent variables. The optimal concentrations of the critical variables were obtained by analyzing response surface methodology. The statistical analysis of the model is represented in the form of analysis of variance (ANOVA).

Table 2: Experimental design matrix for idly preparation using xanthan.

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

Sensory evaluation

Sensory evaluation was carried out by a 30 member panel (20 males and 10 females) consisting of faculty and graduate students of the laboratory of Food process and technology at the Department of Technology, Annamalai university in the age of 22-36 years. The samples were evaluated based on color, taste , aroma and texture using a 9 point hedonic scale [14] where: 9=Excellent, 8 = very good, 7 = good, 6 = Just a little good, 5=May be good or may be bad, 4=Just a little bad, 3=Bad, 2=very bad and 1=worst.

RESULTS AND DISCUSSION

Optimization of ingredients in sensory analysis idly preparation by RSM:

The results obtained are given in Table 3. A polynomial model is proposed for sensory analysis of foods in the preparation of idly. The four outputs, namely colour, taste, aroma and texture of the product are given as polynomials in equations (2), (3) (4) and (5) respectively,

$$Y= 8.88414-0.28054A +0.15438B + 0.14963C -0.55896D -0.62169 A^2-0.17519 B^2-0.51582 C^2-0.64082 D^2 + 0.58769 AB + 0.07419AC + 0.14356 AD + 0.16006 BC-0.06106BD + 0.30794 CD \quad (2)$$

$$Y = 8.78857-0.26521A + 0.12313B +0.18646C -0.58104D-0.68219 A^2-0.18532 B^2-0.55969 C^2-0.67719 D^2 + 0.52719AB + 0.05406AC + 0.10531AD + 0.15969BC- 0.06656BD + 0.28531CD \quad (3)$$

$$Y=8.8850-0.2285A+0.1660B+0.1361C-0.5453D-0.6874A^2-0.1768 B^2 -0.5242 C^2 -0.7006 D^2 +0.5624AB +0.2182AC +0.1789AD +0.1168BC -0.1247BD +0.2473CD \quad (4)$$

$$Y= 8.87500-0.28863A+0.15221B+0.16954C-0.60812D-0.74322A^2-0.23997 B^2-0.52222C^2-0.70247 D^2 +0.63669AB +0.05094AC+0.14969AD+0.13294BC-0.07356BD+0.28844CD \quad (5)$$

ANOVA for the response surface methodology are shown in Table 4 to 7 for color, taste, aroma and texture respectively. The F value of 67.32 for color, 67.04 for taste, aroma for 47.02 and texture for 99.30 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.

Table 3: Central composite design (CCD) of factors in coded levels with sensory analysis of foods in the preparation of idly using RSM.

Run no	Color		Taste		Aroma		Texture	
	Experimental	Predicted	Experimental	Predicted	Experimental	Predicted	Experimental	Predicted
1	7.120	7.120	7.400	6.992	6.950	6.870	7.500	7.030
2	8.650	8.650	8.700	8.789	8.850	8.885	8.800	8.875
3	6.450	6.450	6.300	6.370	6.100	6.061	6.100	6.180
4	9.000	9.000	8.750	8.789	8.890	8.885	8.850	8.875
5	8.950	8.950	8.750	8.789	8.820	8.885	8.800	8.875
6	6.345	6.345	6.500	6.382	6.240	6.090	6.250	6.175
7	6.680	6.680	6.000	6.177	6.552	6.516	6.500	6.447
8	8.940	8.940	8.875	8.789	8.915	8.885	8.941	8.875
9	7.880	7.880	7.250	7.497	7.365	7.563	7.300	7.634
10	6.501	6.501	6.510	6.476	7.120	6.773	6.401	6.482
11	7.480	7.480	7.150	7.242	7.375	7.173	7.300	7.281
12	8.220	8.220	7.435	7.801	7.455	7.846	7.400	7.611
13	7.250	7.250	6.890	6.923	6.954	7.060	6.942	7.125
14	5.758	5.758	5.460	5.529	5.850	5.678	5.354	5.325
15	7.520	7.520	7.515	7.291	7.420	7.690	7.415	7.340
16	8.910	8.910	8.780	8.789	8.911	8.885	8.900	8.875
17	7.482	7.482	7.250	7.305	7.369	7.264	7.350	7.266
18	7.325	7.325	6.450	6.590	6.350	6.592	6.320	6.479
19	8.435	8.435	8.450	8.294	8.830	8.510	8.300	8.220
20	7.954	7.954	7.740	7.726	7.852	8.011	7.840	7.764
21	8.925	8.925	8.820	8.789	8.934	8.885	8.920	8.875
22	6.120	6.120	6.250	5.973	5.905	6.071	5.910	5.774
23	8.647	8.647	8.460	8.286	8.547	8.467	8.540	8.427
24	7.598	7.598	7.550	7.661	7.699	7.574	7.690	7.822
25	5.150	5.150	5.210	4.993	4.890	5.113	4.880	4.829
26	7.620	7.620	7.200	7.213	7.325	7.523	7.300	7.277
27	8.814	8.814	8.845	8.789	8.875	8.885	8.914	8.875
28	5.450	5.450	4.800	4.918	4.720	4.992	4.700	4.849
29	5.350	5.350	5.100	5.215	5.545	5.497	5.099	5.100
30	5.750	5.750	5.550	5.726	6.540	6.082	5.500	5.581

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 idly for colour and taste.

Source	Color			Taste		
	Regression Coefficient	t-statistic	P-value	Regression Coefficient	t-statistic	P-value
Intercept	8.88414	109.306	0.000	8.78857	104.235	0.000
A	-0.28054	-6.391	0.000	-0.26521	-5.824	0.000
B	0.15438	3.517	0.003	0.12313	2.704	0.016
C	0.14963	3.409	0.004	0.18646	4.095	0.001
D	-0.55896	-12.734	0.000	-0.58104	-12.760	0.000
A*A	-0.62169	-15.460	0.000	-0.68219	-16.353	0.000
B*B	-0.17519	-4.357	0.000	-0.18532	-4.442	0.000
C*C	-0.51582	-12.827	0.000	-0.55969	-13.417	0.000
D*D	-0.64082	-15.935	0.000	-0.67719	-16.233	0.000
A*B	0.58769	10.932	0.000	0.52719	9.453	0.000
A*C	0.07419	1.380	0.187	0.05406	0.969	0.347
A*D	0.14356	2.670	0.017	0.10531	1.888	0.077
B*C	0.16006	2.977	0.009	0.15969	2.863	0.011
B*D	-0.06106	-1.136	0.273	-0.06656	-1.194	0.250
C*D	0.30794	5.728	0.000	0.28531	5.116	0.000

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 idly for aroma and texture.

Source	Aroma			Texture		
	Regression Coefficient	t-statistic	P-value	Regression Coefficient	t-statistic	P-value
Intercept	8.8850	88.321	0.000	8.87500	121.217	0.000
A	-0.2285	-4.205	0.001	-0.28863	-7.299	0.000
B	0.1660	3.056	0.008	0.15221	3.849	0.001
C	0.1361	2.506	0.023	0.16954	4.288	0.001
D	-0.5453	-10.037	0.000	-0.60812	-15.380	0.000
A*A	-0.6874	-13.812	0.000	-0.74322	-20.517	0.000
B*B	-0.1768	-3.553	0.003	-0.23997	-6.624	0.000
C*C	-0.5242	-10.532	0.000	-0.52222	-14.416	0.000
D*D	-0.7006	-14.075	0.000	-0.70247	-19.392	0.000
A*B	0.5624	8.453	0.000	0.63669	13.147	0.000
A*C	0.2182	3.279	0.005	0.05094	1.052	0.309
A*D	0.1789	2.689	0.016	0.14969	3.091	0.007
B*C	0.1168	1.756	0.098	0.13294	2.745	0.014
B*D	-0.1247	-1.874	0.079	-0.07356	-1.519	0.148
C*D	0.2473	3.717	0.002	0.28844	5.956	0.000

Table 6.Analysis of variance (ANOVA) for the quadratic polynomial model for the optimization of sensory analysis of foods in the preparation of idly for color and taste

Source	Color					Taste				
	SOS	DF	MS	F	P	SOS	DF	MS	F	P
Regression	43.5839	14	3.1131	67.32	0	46.7036	14	3.336	67.04	0
Linear	10.4966	4	2.6241	56.75	0	10.9889	4	2.7472	55.21	0
Square	25.1567	4	6.2892	136	0	29.2623	4	7.3156	147.01	0
Interaction	7.9306	6	1.3218	28.58	0	6.4524	6	1.0754	21.61	0
Residual Error	0.7399	16	0.0462	-	-	0.7962	16	0.0498	-	-
Lack-of-Fit	0.6569	10	0.0657	4.75	0.035	0.7737	10	0.0774	20.6	0.001
Pure Error	0.083	6	0.0138	-	-	0.0225	6	0.0038		
Total	44.3238	30	-	-	-	47.4998	30			

For color S = 0.215040, PRESS = 3.89675, R-Sq = 98.33%, R-Sq (pred) = 91.21%, R-Sq (adj) = 96.87%
For taste S = 0.223077, PRESS = 4.48705, R-Sq = 98.32%, R-Sq (pred) = 90.55%, R-Sq(adj) = 96.86%

Table 7. Analysis of variance (ANOVA) for the quadratic polynomial model for the optimization of sensory analysis of foods in the preparation of idly for aroma and texture

Source	Aroma					Texture				
	SOS	DF	MS	F	P	SOS	DF	MS	F	P
Regression	46.6361	14	3.3312	47.02	0	52.1636	14	3.726	99.3	0
Linear	9.4953	4	2.3738	33.51	0	12.1208	4	3.0302	80.75	0
Square	29.3598	4	7.3399	103.61	0	31.4564	4	7.8641	209.58	0
Interaction	7.7811	6	1.2968	18.31	0	8.5864	6	1.4311	38.14	0
Residual	1.1335	16	0.0708	-	-	0.6004	16	0.0375	-	-
Error										
Lack-of-Fit	1.1239	10	0.1124	70.6	0	0.58	10	0.058	17.06	0.001
Pure Error	0.0096	6	0.0016	-		0.0204	6	0.0034	-	-
Total	47.7696	30	-	-		52.764	30			

For aroma S = 0.266161, PRESS = 6.48674, R-Sq = 97.63%, R-Sq (pred) = 86.42%.R-Sq (adj) = 95.55%.
For texture S = 0.193710 ,PRESS = 3.36844,R-Sq = 98.86%, R-Sq(pred) = 93.62%, R-Sq(adj) = 97.87%.

It was observed that all the linear, square and interactive effects of A*B, A*D, B*C and C*D are significant for sensory values of color. For sensory values of taste, all the linear, square and interactive effects of A*B, B*C and C*D are significant. For sensory values of aroma, all the linear, square and interactive effects of A*B, A*C, A*D and C*D are significant. For sensory values of texture, all the linear, square and interactive effects of A*B, A*D, B*C, and C*D are significant.

The coefficients of determination (R^2) for sensory values were found to be 0.9833 for color, 0.9832 for taste, 0.9763 for aroma and texture for 0.9886. The predicted R^2 value 0.9121for color, 0.9055 for taste, 0.8642 for aroma and texture for 0.9362 was in reasonable agreement with the adjusted R^2 value of 0.9687 for color, 0.9686 for taste, 0.9555 for aroma and texture for 0.9787.

The interactive effects of variables on sensory analysis of idly preparation in the form of surface plots are shown in Figures 1 – 7. The experimental conditions for different sensorial score obtained and their response for the sensorial color, taste, aroma and texture are given in Table 4 to 7.

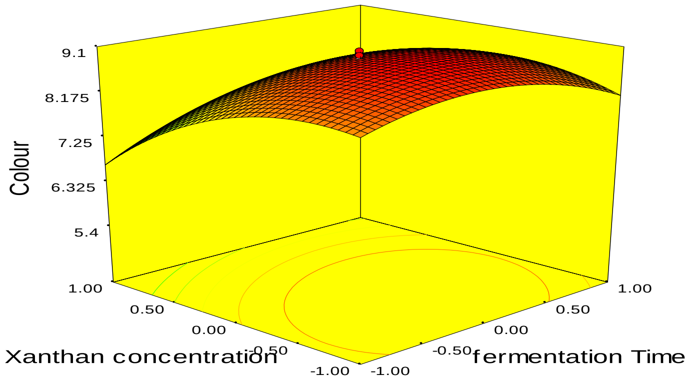


Figure. 1. Surface plot showing the interactive effects of fermentation time and xanthan on sensory analysis of idly for color

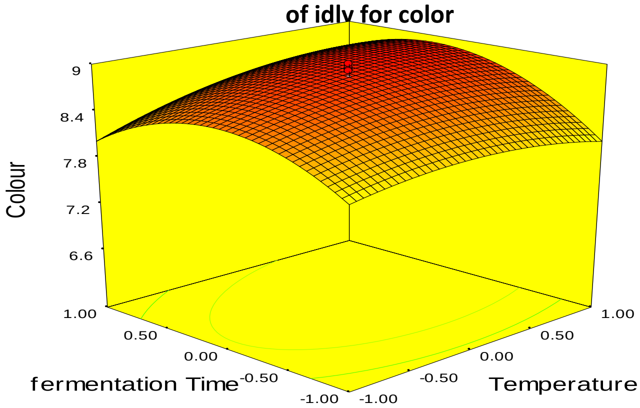


Figure. 2. Surface plot showing the interactive effects of temperature and fermentation time on sensory analysis of idly for color.

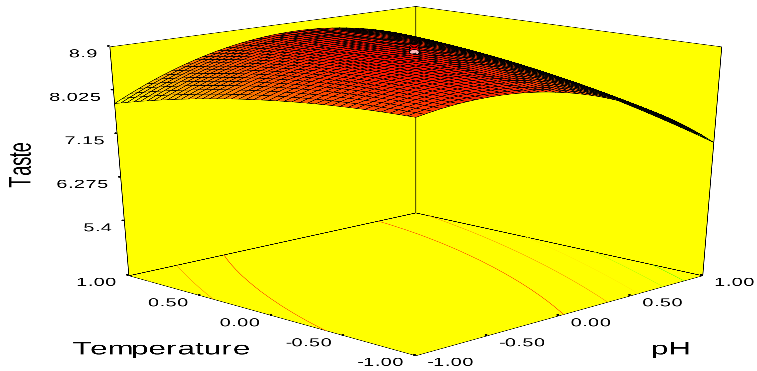


Figure. 3. Surface plot showing the interactive effects of pH and temperature on sensory analysis of idly for taste

ISSN: 0975-8585

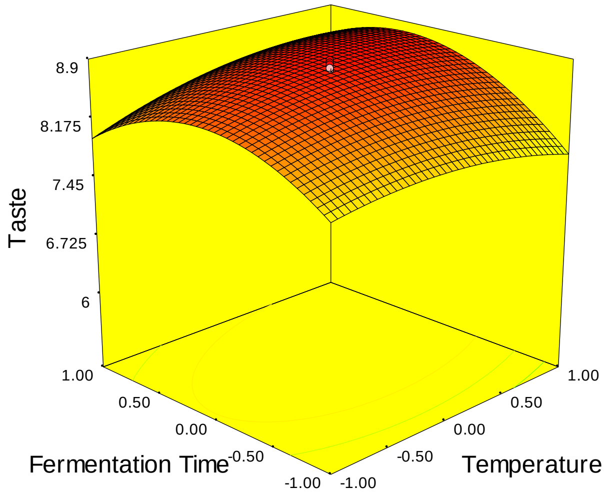


Figure. 4. Surface plot showing the interactive effects of temperature and fermentation time on sensory analysis of idly for taste

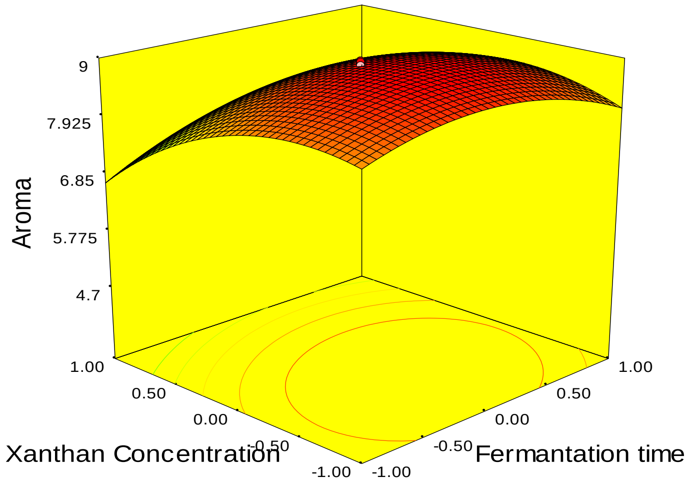
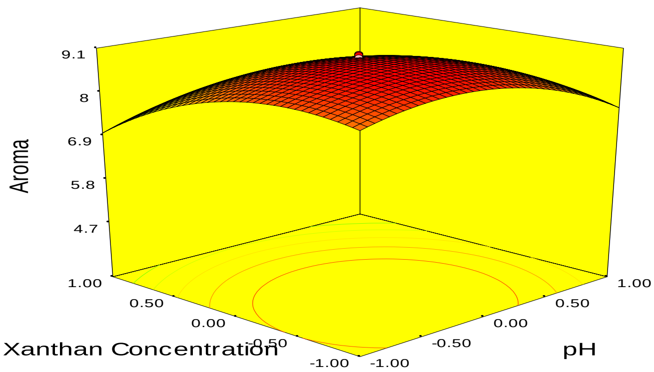


Figure. 5. Surface plot showing the interactive effects of fermentation time and xanthan on sensory analysis of idly for aroma.



F igure. 6. Surface plot showing the interactive effects of PH and xanthan on sensory analysis of idly for aroma.

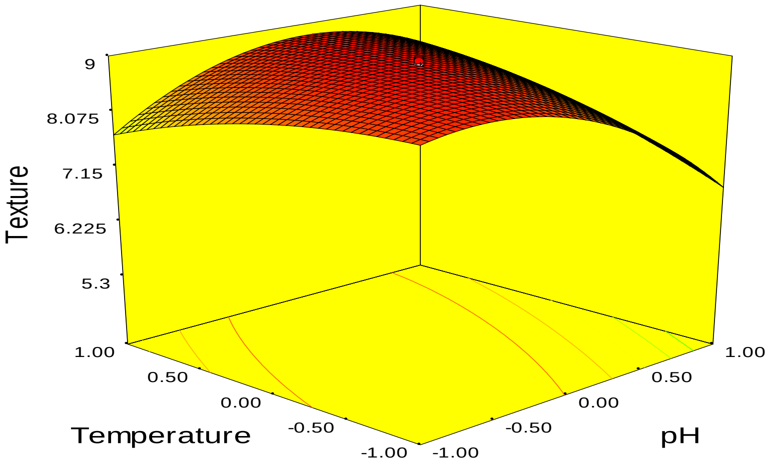


Figure.7. Surface plot showing the interactive effects of PH and temperature on sensory analysis of idly for texture.

Figure 1shows the significant interaction between fermentation time and xanthan for color. The sensory value of color increases with increase in fermentation time and xanthan to about 12.04 hrs and0.075% respectively and sensory score decreases with further increase in fermentation time and xanthan. The same trend is observed in Figure 2, which shows an increase in temperature and fermentation time resulted in increase in sensory value of color up to 31.4^{0}C and 12.04 hrs respectively.

Figure 3 shows the significant interaction between pH and temperature for taste. The sensory value of taste increased with increase in pH and temperature to about 4.46 and 32.6^{0}C respectively and sensory score decreases with further increase in pH and temperature. The same trend was observed in Figure 4, which shows an increase in temperature and fermentation time resulted in increase in sensory value of taste up to 32.6^{0}C and12.02 hrs respectively.

Figure 5 shows the significant interaction between fermentation time and xanthan for aroma. The sensory value of aroma increased with increases in fermentation time and xanthan to about 12.06 hrs and 0.072 % respectively and its sensory score decreases with further increase in fermentation time and xanthan. The same trend was observed in Figure 6, which shows an increase in pH and xanthan resulted in increase in aroma up to 4.48 and 0.072% respectively.

Figure 7 shows the significant interaction between pH and temperature for texture. The sensory value of texture increased with increases in pH and temperature to about 4.46 and 32.2^{0}C respectively and its sensory score decreases with further increase in pH and temperature. The optimum conditions for the best sensory score of the four outputs are: pH- 4.48 temperature 30.4^{0}C Fermentation time12.02hrs and xanthan0.072%.

An experimental run was conducted by taking optimum ingredients that yielded best sensory score value. The idly preparation was tested with the panelists and the scores were compared with the predicted value. The overall scores were 8.90 for color and taste , 8.95

for aroma and texture which are in good agreement with the predicted values given in Table 4 and 5.

CONCLUSIONS

The ingredients like, pH, temperature, fermentation time and xanthan were optimized for the preparation of idly using Response Surface Methodology. The design was used to test the relative importance of sensory outputs of the idly in terms of color, taste, aroma and texture. The proportion of the four ingredients for the best sensory score value is given highest priority and the experiment run for the optimum conditions obtained from RSM gave a sensory score of 8.90 for color and taste, 8.95 for aroma and texture

REFERENCE

[1] Bean MM. Elliston-Hoops EA. Nishita KD. Cereal Chem 1983; 60(6): 445-449.
[2] Steinkraus KH. Antonic Van Leewenhock 1983; 49(3): 337-348.
[3] Vanveen AG. Steinkraus KH. J Agric Food Chem 1970; 18(4): 576-578.
[4] Krishnamurthy P. Siddappa GS. J Food Sci Tech 1966; 1(3): 132.
[5] Desikachar HSR, Radhakrishnamurthy R, Rao GR, Kadol SB, Srinivasan M, & Subramanyan V. Journal of Scienti®c Industrial Research (India) 1960; 19C:168-172.
[6] Joseph E, Crites SG, and Swanson BG. Food Structure 1993;12: 483-488.
[7] Steinkraus KH. (1983). Handbook of indigenous fermented foods (pp.132-146). New York: Marcel Dekker.
[8] Steinkraus KH, Van Veen AG, and Thiebeau DB. Food Technol 1967; 21:916-919.
[9] Thyagaraja N, Otani H, & Hosono A. Lebensmittel- Wissenschaft und Technologie 1991;24: 504-507
[10] P Nisha, Laxmi Ananthanarayan, Rekha S. 19(2) 179-358 2005
[11] Bharti K. Iyer, Laxmi Ananthanarayan. Sci Technol 2008;41(6): 1053-1059
[12] Palanisamy BD, Rajendran V, Sathyaseelan S, Bhat R, Venkatesan BP. International J Food Sci Nutr 2012;63 (1):5-15
[13] Wu P, Xu X, Xu Y, Chen Q, Pan S. Curr Microbiol 2011;63 (5):458-463
[14] Aachary AA, Gobinath D, Prapulla SG. Int J Food Sci Technol 2011; 46 (7):1346-1355
[15] Kim JN, Shin WS. J Food Sci Tech 2009;41 (1):69-76
[16] Rekha CR, Vijayalakshmi G. J Food Sci Tech 2011;48 (3):329-334