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FORMULATION AND QUALITY EVALUATION OF AMARANTH GAIN FLOUR INCORPORATED IDLI USING RESPONSE SURFACE METHODOLOGY

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ABSTRACT

Idli is a very popular fermented breakfast food staple consumed in the Indian subcontinent, especially in southern parts. Amaranth grain has significant nutritional value. Its protein, mineral, fat and cellulose percentage are higher compared to cereals. Processing techniques causes important changes in the nutritional and sensory characteristics of grains. The study was designed to determine the nutrition profile of the processed Amaranth Grain Flour incorporated idli products using Response Surface Methodology. The processing technique such as roasting, boiling, popping and raw was used to assess the effect of processing on amaranth grain flour incorporated idli. The nutritional and health status point idly appears to be an ideal human food for all ages and at all times. All the food products incorporated with RaAGF mixture were found to be organoleptically acceptable. It has been found that when the level of incorporation of RaAGF increased beyond the accepted levels in any food preparation, the mean scores for all organoleptic characteristics decreased. The most acceptable level of AGF incorporation was 15 to 20% and the mean scores for overall acceptability were 8.60 ± 0.51 to 7.60 ± 0.84 in developed 30 verities of idli. The optimum conditions were PRF (62.78g), RaAGF (18.56g), fenugreek (5.7g) and yeast (0.30g) respectively. Corresponding to these values of process variables, the value of weight (332g), No. of. Pores in a square inch (22), carbohydrate (81g), fat (1.4), protein (14), fiber (2.4) and overall acceptability (8).

Keywords: Amaranth Grain flour, Popping, organoleptic, food preparation.

INTRODUCTION

Idli is a very popular fermented breakfast food staple consumed in the Indian subcontinent, especially in southern parts. The major ingredients are rice (Oryzasativum) and black gram (Phaseolusmungo). Traditionally, Idli preparation is as follows: (Desikachar *et al*, 1960) Soaking the rice and black gram separately. (Holdsworth, S. D., 1971) After draining the water, grinding rice and black gram separately with occasional addition of water during the grinding process. (Joseph, E *et al*, 1993) Mixing rice and black gram batters together with addition of a little salt. (Mitschka, P. 1982) Allowing to ferment overnight at room temperature. Depositing the fermented batter in special Idli pans and steaming for 5±8 min.With the growing demand forbreakfast foods, Idlis are being consumed on a largescale in the institutions such as army, railways and industrialcanteens, etc (Murthy, Nagaraju,Rao and Subba Rao, 1994).

MATERIALS AND METHODS

Amaranth grain (*Amaranthus Cruentus*) used for this investigation were procured from the Sree Krishna agro foods Store, rest of the ingredients such as parboiled rice flour (PRF), urad dhal, fenugreek, yeast, and salt were purchased from Kannan departmental store in Salem,All the ingredients were selected by considering its availability, nutritional and health benefits.

RAW AMARANTH GRAINS INTO FLOUR (RAAGF)

Raw grains were cleaned and washed with distilled water and dried under sunlight. Afterdrying the grains were made into flour. Flour was stored in air tight zip lock covers at ambient temperature for further use.

BASIC FORMULATION OF IDLIS

Thirty different types of idlis with varying proposition of ingredients were optimized (Rice flour (RF), RAGF, Fenugreek and Yeast were mixed at ratios of 55:10:5:0.3, 60:15:6:0.4 and 65:20:7:0.7) and the urad dhal (15g) kept consent for the entire proposition. The fresh mixture was kept for two hours for fermentation; standard and RaAGF incorporated products were prepared. Thecomposition is given in the Table 1.

OPTIMIZATION OF THE PRF, RAAGF, FENUGREEK AND YEAST IDLY-EXPERIMENTAL DESIGN FOR THE PROCESS OF OPTIMIZATION

The Central Composite Rotatable Design (CCRD) was used for selecting the level of parameters in the experiments. RSM was performed using the Design-Expert software program version 7.0. The coded and uncoded independent variables used in the RSM design are listed in Table 1. The levels of the independent parameters were based on preliminary experimental results. The experimental design was based on the CCD as shown below.

Table1- Coded and uncoded independent variables used in RSM design

Symbol	Independent Variables	Range and Levels				
		-2	-1	0	+1	+2
X_1	Rice Flour(RF)	50	55	60	65	70
X_2	Raw Amaranth Grains Flour (RaAGF)	5	10	15	20	25
X_3	Fenugreek(F)	4	5	6	7	8
X_4	Yeast(Y)	0.2	0.3	0.4	0.5	0.6

Table 2 -Different runs of optimization experiments for IDLIES

Uncoded					Coded			
Design	X_1	X_2	X_3	X_4	RF	RaAGF	F	Y
1	55	10	5	0.30	1	-1	1	1
2	65	10	5	0.30	-1	1	-1	-1
3	55	20	5	0.30	0	0	0	-2
4	65	20	5	0.30	0	0	0	0
5	55	10	7	0.30	0	0	2	0
6	65	10	7	0.30	0	2	0	0
7	55	20	7	0.30	0	-2	0	0
8	65	20	7	0.30	-2	0	0	0
9	55	10	5	0.50	0	0	0	2
10	65	10	5	0.50	-1	-1	1	-1
11	55	20	5	0.50	-1	-1	-1	-1
12	65	20	5	0.50	0	0	0	0
13	55	10	7	0.50	1	-1	1	-1
14	65	10	7	0.50	1	1	-1	-1
15	55	20	7	0.50	-1	1	1	1
16	65	20	7	0.50	0	0	0	0
17	50	15	6	0.40	1	1	1	-1
18	70	15	6	0.40	1	1	-1	1
19	60	5	6	0.40	0	0	-2	0
20	60	25	6	0.40	0	0	0	0
21	60	15	4	0.40	0	0	0	0
22	60	15	8	0.40	1	-1	-1	1
23	60	15	6	0.20	0	0	0	0
24	60	15	6	0.60	1	-1	-1	-1
25	60	15	6	0.40	-1	1	-1	1
26	60	15	6	0.40	1	1	1	1
27	60	15	6	0.40	2	0	0	0
28	60	15	6	0.40	-1	-1	1	1
29	60	15	6	0.40	-1	-1	-1	1
30	60	15	6	0.40	-1	1	1	-1

X_1-Rice Flour, X_2-RAGF, X_3- Fenugreek, X_4-Yeast, RF- Rice Flour, RaAGF – Raw Amaranth Grains Flour, F - Fenugreek, Y- Yeast

Each design point consists of the replicates. For the statistical analysis the numerical levels are standardized to -2, -1, 0 and +1, +2. The experiments were carried out in randomized order (Gacula& Singh, 1984). The relationship between standardized variables values is given as follows

$$X_1 = \frac{RF-60}{5}$$

$$X_2 = \frac{RaAGF-15}{5}$$

$$X_3 = \frac{Fenugreek-6}{1}$$

$$X_4 = \frac{Yeast-0.4}{0.1}$$

RESPONSE SURFACE METHODOLOGY

Response surface methodology (RSM) was applied to optimize the levels of four variables RW(X_1), RaAGF(X_2), F(X_3), Y(X_4). Central Composite Rotatable Design (CCRD) was used in selecting the levels of the four variables. The variables were standardized on the basis of their effect of responses i.e., product weight, no of pores in a square inch in idly, carbohydrate, protein, fat, fiber and overall acceptability. The standardized variables (X_i) were obtained using the following second order polynomial equation. The model proposed of each response of Y was

$$Y = \beta_0 + \sum_{i=1}^{3} \beta_i X_i + \sum_{i=1}^{3} \beta_{ii} X_i^2 + \sum_{i<j=1} \beta_{ij} X_i X_j$$

Where:
β_0– constant, β_i– linear coefficient, β_{ii}– quadratic coefficient, β_{ij}– cross product coefficient, X_i, X_j– levels of the independent variables, ***3***– Number of the factors tested

The model permitted evaluation of quadratic terms of the independent variables on the dependent variable. The response surface and contour plot were generated for different interactions of any two independent variables, where holding the value of third variables as constant at central level. The optimization of the process was aimed at finding the optimum values of independent variables. The effect of variables at linear, quadratic and interactive levels on the response was described using significant at 1, 5 level. The counter plot was used to select the range of different ingredients required to get the desired level of response. All the responses under investigation for optimized using Design Expert Software to determined the individual optima of above responses and level of different variables.

PROPOSITION STANDARD IDLI

Rice (Parboiled) -75g, Urad dhal -15g, Fenugreek seeds – 5g, Yeast – 0.5, Water and salt- required consistency

PROCESSING OF INGREDIENTS INTO BATTER

The above said ingredients of different variables in specified proportions were ground coarse and soaked for two hour with yeast to allow fermentation**.** Mixing of salt and addition of water according to the required consistency.The fermented batter offers effervescence with the carbon dioxide produced during fermentation and the fermented batter was used to prepare various idlies.

PHYSICAL PROPERTIES OF DEVELOPED BATTERS BEFORE AND AFTER FERMENTATION

Various physical properties of the developed batters suchas height, weight, pH, spread ability and specific gravity of the batter are analyzed using standard techniques.

PHYSICAL PARAMETERS OF DEVELOPED IDLIS

Various parameters such as diameter, width, weight of the cooked idlis, were assessed using standard procedures. A special test called 'INK print test' was done to record the appearance of idlis permanently by means of photography on Ink prints. These prints furnish a record of number of pores per square inch in the graph sheets which indicates the softness of the developed idlis.

PROXIMATE COMPOSITION OF DEVELOPED IDLIS

The carbohydrate, protein, fat and fiber were determined according to the AOAC (1990) methods on triplicate samples of the cookies. Energy was calculated by the Atwater method (protein x 4; fat x 9; carbohydrate x 4) (Osborne DR and P Voogt, 1978).

ORGANOLEPTIC EVALUATION

The developed idlis were served to a group of 30 semitrained panelists for the evaluation of appearance, colour, flavor, taste, texture and overall acceptability on a 9 point hedonic scale with a scores ranging from 9 to1 where scores 9 to1 represented like extremely and dislike extremely respectively. The quality parameters were quantified and the mean scores of the three evaluations were calculated.

STATISTICAL ANALYSIS

The collected data was compiled and analyzed by using statistical methods. Descriptive statistics, ANOVA and Correlation is computed using s statistical software SPSS version 15.0. Duncan's multiple range tests were applied to determine the significant differences between the idlis.

Table 1- Mean Physical Properties of the Sample batter

Variations	Parameters								
	Height (ml)		Weight (g)		pH		Spreadability		Specific gravity
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	
V_1	5	10	10	14	7.43	6.34	4.4	4.65	1.5
V_2	9	14	10	18	7.14	6.52	4.2	4.5	2.3
V_3	10	15	10	14	7	6.82	4.8	5	2.3
V_4	9.5	17	10	12	7.18	7	4.4	4.6	2.5
V_5	9	14	10	10	7.08	6.77	4.6	4.9	1.8

V_6	8.5	11	10	14	7.08	6,92	4.5	4.8	2.1
V_7	10	16.5	10	12	7.18	7.17	4	5.1	2.3
V_8	8	14	10	4	7.21	7.15	4.8	5	2.3
V_9	8	13	10	8	7.13	6.51	4.3	4.9	2.4
V_{10}	10	17	10	6	7.22	6.59	4.8	5.2	2.3
V_{11}	12	20	10	12	7.18	7.24	4.3	4.6	2.1
V_{12}	11	15	10	12	7.16	7.27	4.1	4.4	2.3
V_{13}	6	15	10	12	7.42	7.17	4	4.4	2.2
V_{14}	9	17	10	10	7.17	7.21	4.5	4.7	2.4
V_{15}	13	17	10	8	7.57	7.22	4.6	4.9	2.1
V_{16}	8.5	15.5	10	8	7.11	7.26	3.7	4.2	2.5
V_{17}	12	14	10	10	7.24	7.18	4.4	4.6	2.1
V_{18}	9	12	10	10	7.30	7.20	4.5	4.7	2.3
V_{19}	8	14	10	10	7.09	7.19	6.8	5	2.6
V_{20}	7.5	10	10	8	7.19	7.21	4.5	4.8	1.5
V_{21}	9.5	15.5	10	10	7.20	7.12	4.6	4.9	1.8
V_{22}	18	17	10	6	7.18	7	4.7	4.9	2.3
V_{23}	11.5	12	10	14	7.19	7.17	4.6	4.8	2.5
V_{24}	10	15	10	8	7.12	7	5	5.2	2.5
V_{25}	7	12	10	6	7.23	7.21	4.1	4.4	2.3
V_{26}	12	20	10	10	7.22	7.20	3.5	3.9	1.8
V_{27}	10	13.5	10	8	7.21	7.20	3.4	3.8	1.7
V_{28}	9.5	10	10	12	7.23	7.11	4.5	4.9	1.8
V_{29}	12	18	10	6	7.22	7.13	4.3	4.5	2
V_{30}	12.5	17.5	10	12	7.25	7.14	4.1	4.4	1.6

Table 2 - Physical parameters of the developed idlis

Variations	**Parameters**			
	Diameter (cms)	**Width (cms)**	**Cooked Weight (g)**	**Number of pores in a square inch**
V_1	7.5	2.5	232	20
V_2	8	3	272	22
V_3	8	3	272	24
V_4	7.5	3.2	280	10
V_5	7.9	2.8	281	18
V_6	8.3	3	286	14
V_7	7.8	3.3	312	14
V_8	8	2.9	304	11
V_9	7.5	3.1	304	20
V_{10}	8	3.2	288	10
V_{11}	7.8	3	280	10
V_{12}	8	2.5	220	10
V_{13}	7.1	3.1	256	18
V_{14}	8	3.3	280	11
V_{15}	7.4	3.3	248	22
V_{16}	7.8	3.5	288	14
V_{17}	8	3.1	316	20
V_{18}	7.7	3.4	255	22
V_{19}	7.5	3.3	295	12
V_{20}	7.6	3.4	319	16
V_{21}	7	3.2	281	19
V_{22}	7	3.3	295	10
V_{23}	7.6	3.7	344	9
V_{24}	8	3.2	283	22
V_{25}	8	3.6	327	20

V_{26}	7.5	3.1	287	19
V_{27}	8	3.4	295	12
V_{28}	8	3.1	271	10
V_{29}	8	3.4	319	12
V_{30}	7.5	3.5	335	12

Table 3 - Proximate Composition of the products

Variations	**Parameters**				
	Carbohydrate (g)	**Protein (g)**	**Fat (g)**	**Fiber (g)**	**Energy (K.cals)**
V_1	68	12.24	1.5	1.4	311.7
V_2	75.9	13.3	1.6	1.4	363
V_3	75.58	13.6	2.1	2.1	346.2
V_4	83.48	14.29	2.2	2.2	398.1
V_5	68.9	12.88	1.6	1.6	318.4
V_6	76.8	13.52	1.7	1.6	370.3
V_7	76.3	14.1	2.3	2.3	352.8
V_8	84.36	14.8	2.3	2.3	323.8
V_9	87.9	12.45	1.5	1.4	312.4
V_{10}	76.05	13.09	1.6	1.4	362.81
V_{11}	75.64	13.8	2.2	2.1	346.8
V_{12}	83.54	14.5	2.2	2.2	398.7
V_{13}	69.03	12.9	1.6	1.6	319.1
V_{14}	76.9	13.6	1.7	2.3	371
V_{15}	76.52	14.38	2.3	2.3	353.5
V_{16}	84.4	15.02	2.3	1.6	405
V_{17}	68.3	12.9	2	1.8	332.6
V_{18}	84.17	14.33	1.3	1.1	401
V_{19}	68.7	12.3	2.5	2.5	332.7
V_{20}	83.8	15.1	1.8	1.7	400.9
V_{21}	75.43	13.16	2	1.9	359.9
V_{22}	77.19	14.2	1.9	1.8	373.24
V_{23}	76.2	13.6	1.9	1.8	365.3
V_{24}	76.3	13.8	2	1.7	401.6
V_{25}	76.27	13.69	1.9	1.8	401.5
V_{26}	76.2	13.63	2.2	1.6	400
V_{27}	76.25	13.67	2.1	1.8	401
V_{28}	76.24	13.65	2.3	1.7	400.5
V_{29}	76.26	13.63	2	1.8	401.5
V_{30}	76.3	13.64	2	1.8	401

RESULTS AND DISCUSSION

DIAGNOSTIC CHECKING OF FITTED MODEL AND SURFACE PLOT FOR ALL Y RESPONSES

Physical as well as chemical properties were analyzed for the effect analysis of dependent variables. Regression analysis indicated that the fitted quadratic model accounts that about 74% (R_2>0.74) of weight of the product, 62% of no. of. Pores in a square inch (R_2>0.62), 78% of carbohydrate (R_2>0.78), 61% of fat (R_2>0.61), 99% of protein (R_2>0.99), 62% of fibre (R_2>0.62) and 58% of overall acceptability (R_2>0.58) of the developed RaAGF incorporated idly. According to Nazni *et.al.*, (2010) reported in her study that the number of pores increases the softness of the idli will also increases width and volume of the idli

EFFECT OF VARIABLES ON WEIGHT OF THE PRODUCT

The values of regression coefficients, sum square, F values and P values for coded form of process variables are presented in table 4.

Table --4 -ANOVA for response surface quadratic model for the weight of raw amaranth grain flour idly

Source	**Weight**			
	Coefficient	**Sum Square**	**F- value**	**P- value**
Model	338.17	18854.22	1.30	0.3083^{NS}
X_1	-5.04	610.04	0.59	0.4543^{NS}

X_2	1.29	40.04	0.039	0.8466 NS
X_3	2.46	145.04	0.14	0.7132 NS
X_4	-5.54	737.04	0.71	0.4117 NS
X_1^2	-17.53	8430.03	8.15	0.0120**
X_2^2	-11.53	3647.17	3.53	0.0799 NS
X_3^2	-11.66	3726.67	3.60	0.0770 NS
X_4^2	-7.78	1660.74	1.61	0.2243NS
X_1X_2	-2.56	105.06	0.10	0.7543 NS
X_1X_3	0.81	10.56	0.010	0.9208 NS
X_1X_4	-8.06	1040.06	1.01	0.3318 NS
X_2X_3	4.81	370.56	0.36	0.5583 NS
X_2X_4	-13.06	2730.06	2.64	0.1250 NS
X_3X_4	-3.69	217.56	0.21	0.6530 NS
Lack of fit	0.74			
R^2	0.5487			
AdjR- Squared	0.1275			
Pred R-Squared	-0.8110			
Adeq- Precision	3.777			

X_1 – Parboiled Rice flour, X_2 - Raw amaranth grain X_3 – Fenugreek X_4 – Yeast
* = 5% level of significant, ** = 1% level of significant, NS = Not Significant

The weight of the developed idly was range from 232 to 335g. The developed model for idly in the form of uncoded (actual) process variables as follows:

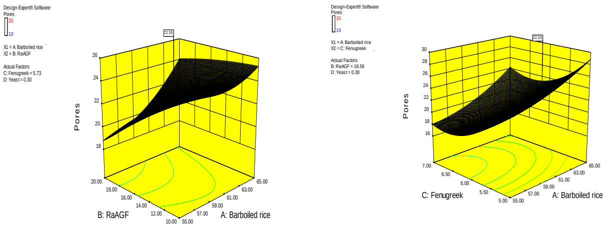
Weight (%) (Y_1) $338.17-5.04X_1+1.29X_2+2.46X_3-5.54X_4-17.53X_1^2-11.53X_2^2-11.66X_3^2-7.78X_4^2-2.56X_1X_2+0.81X_1X_3-8.06X_1X_4+4.81X_2X_3-13.06X_2X_4-3.69X_3X_4$……*Equation 1*

In coded form of process variables, the model equation is as follows:

Weight (%) (Y_1): $-3349.57+90.15X_1+24.92X_2+132.89X_3+2147.70X_4-0.70X_1^2-0.46X_2^2-11.65X_3^2-778.12X_4^2-0.10X_1X_2+0.16X_1X_3+16.12X_1X_4+0.96X_2X_3-26.12X_2X_4-36.87X_3X_4$……*Equation 1*

The magnitude of P and F value in table 35 point out that the positive and negative contribution between the X_1, X_2, X_3 and X_4. The above equation states that the linear, quadratic and interaction variables of X_1, X_4, X_1^2, X_2^2, X_3^2, X_4^2 and X_1X_4, X_2X_4 and X_3X_4havenegativeeffect in the uncoded process. The variable of quadratic such as X_1^2, X_2^2, X_3^2 andX_4^2 and the variables of interaction like X_1X_2, $X_2X_4$and X_3X_4show negative effect in the coded process. The effect of ingredients on product weight has been shown in the 3D fig --- to ---.

Figure 1 - 3 D Effect of RSM on Parboiled rice flour, Raw amaranth grain flour, fenugreek and yeast on number of pores in a square inch in idlyof raw amaranth grain flour idly



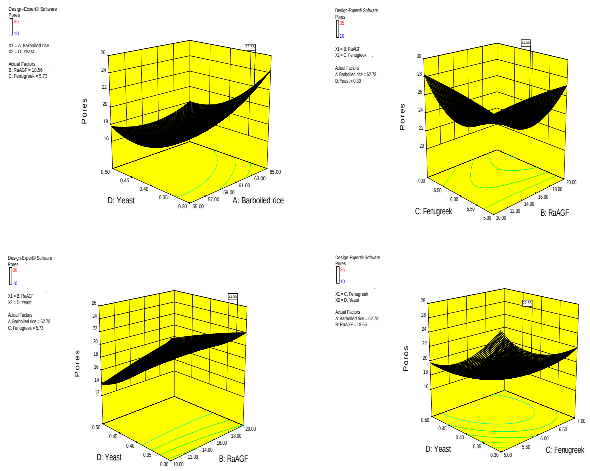
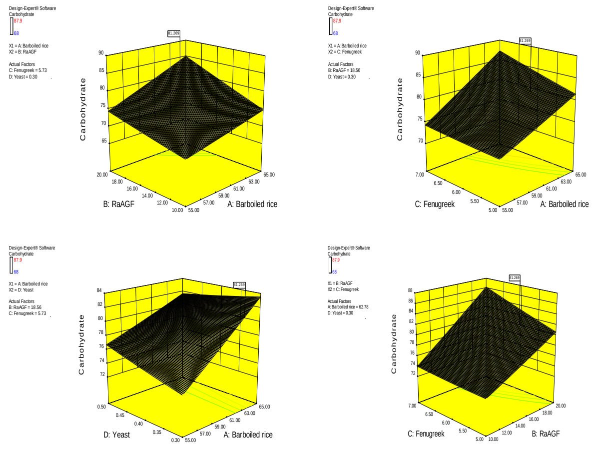


Figure 2 - 3 D Effect of RSM on Parboiled rice flour, Raw amaranth grain flour, fenugreek and yeast on Carbohydrate of raw amaranth grain flour idly



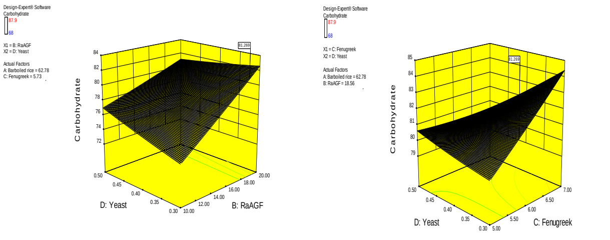


Figure 3 - 3 D Effect of RSM on Parboiled rice flour, raw amaranth grain flour, fenugreek and yeast on Fat of raw amaranth grain flour idly

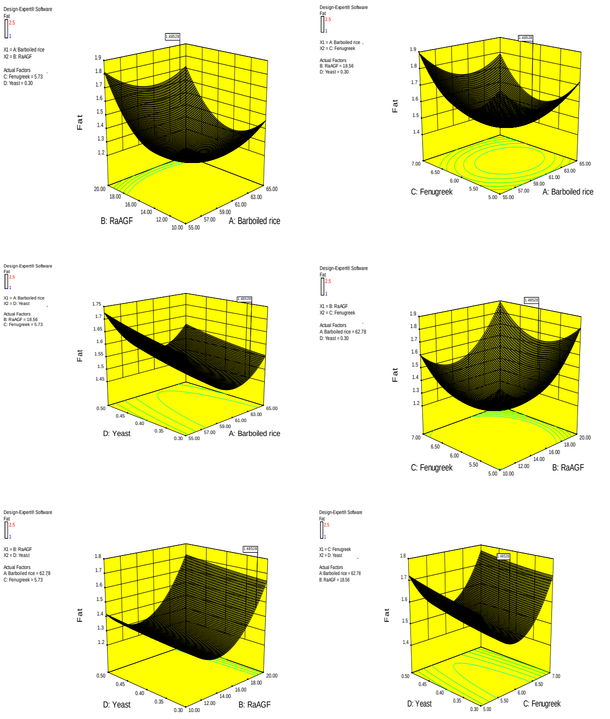
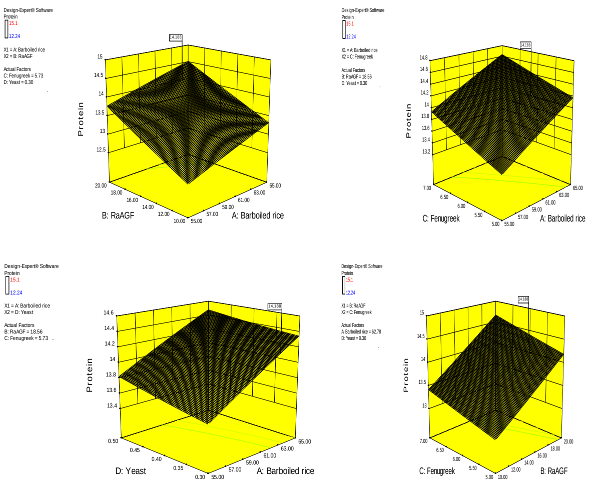


Figure 4 - 3 D Effect of RSM on Parboiled rice flour, Raw amaranth grain flour, fenugreek and yeast on Protein of raw amaranth grain flour idly



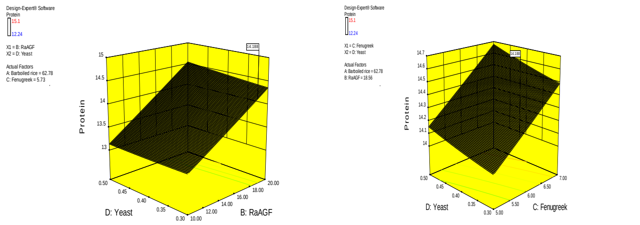


Figure 5- 3 D Effect of RSM on Parboiled rice flour, raw amaranth grain flour, fenugreek and yeast on Fiber of raw amaranth grain flour idly

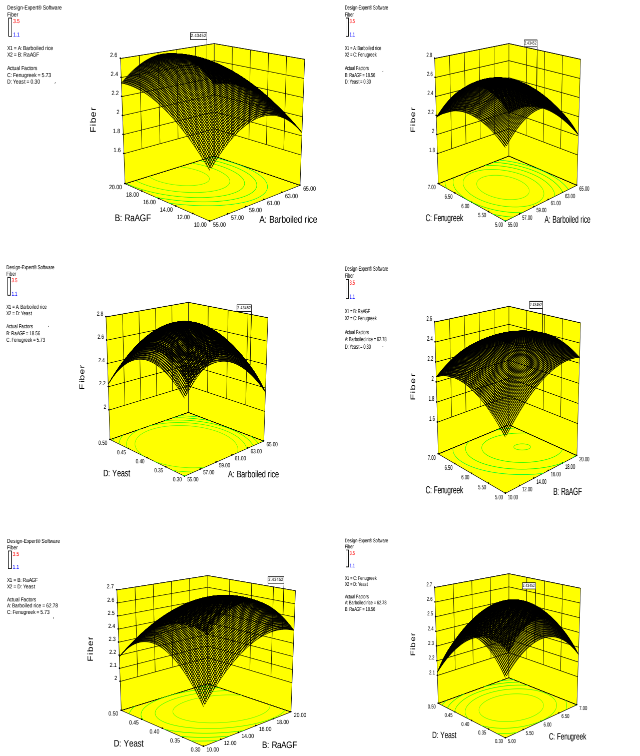
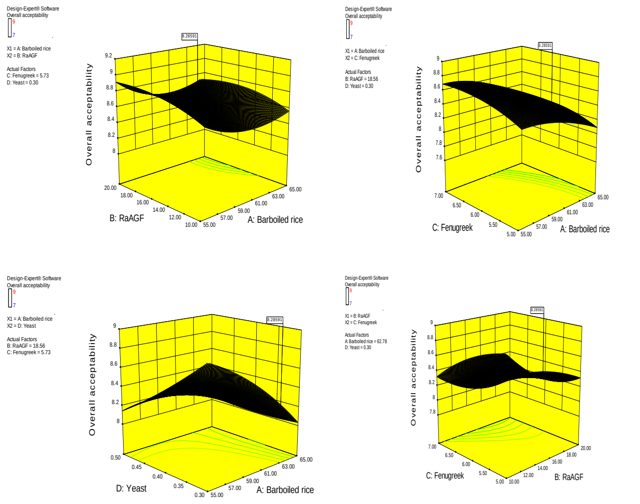
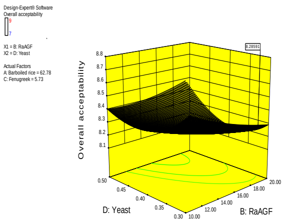
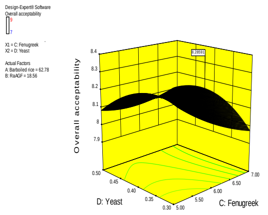


Figure 6- 3 D Effect of RSM on Parboiled rice flour, Raw amaranth grain flour, fenugreek and yeast on Overall acceptability of raw amaranth grain flour idly







EFFECT OF VARIABLES ON NUMBER OF PORES IN A SQUARE INCH IN IDLY

The values of regression coefficients, sum square, F values and P values for coded form of process variables are presented in table 5.

Table ---5 - ANOVA for response surface quadratic model for the Pores of raw amaranth grain flour idly

Source	Number of Pores in a Square inch in Idly			
	Coefficient	Sum Square	F-value	P- value
Model	17.17	734.92	1.77	0.1426 NS
X_1	0.46	5.04	0.17	0.6861 NS
X_2	-0.88	18.37	0.62	0.4437 NS
X_3	-0.13	0.37	0.013	0.9120 NS
X_4	-2.79	187.04	6.30	0.0240 NS
X_1^2	1.18	38.00	1.28	0.2756 NS
X_2^2	-0.20	1.07	0.036	0.8517 NS
X_3^2	3.05	255.50	8.61	0.0103**
X_4^2	1.80	89.07	3.00	0.1037NS
X_1X_2	1.31	27.56	0.93	0.3505 NS
X_1X_3	0.69	7.56	0.25	0.6211
X_1X_4	-1.06	18.06	0.61	0.4475 NS
X_4^2	1.80	89.07	3.00	0.1037NS
X_1X_2	1.31	27.56	0.93	0.3505 NS
X_1X_3	0.69	7.56	0.25	0.6211
X_1X_4	-1.06	18.06	0.61	0.4475 NS
X_2X_3	-1.94	60.06	2.02	0.1754 NS
X_2X_4	1.56	39.06	1.32	0.2693 NS
X_3X_4	1.44	33.06	1.11	0.3080 NS
Lack of fit	4.25			
R^2	0.6227			
AdjR-Squared	0.2706			
Pred R-Squared	-1.0017			
Adeq-Precision	4.229			

X_1 – Parboiled Rice flour, X_2 - Raw amaranth grain X_3 – Fenugreek X_4 – Yeast
* = 5% level of significant, ** = 1% level of significant, NS = Not Significant

The number of pores in a square inch in idly was range from 9 to 24. The developed model for idly in the form of uncoded (actual) process variables as follows:

Number of pores in a square inch in idly (Y_2) $17.17+0.46X_1-0.88X_2-0.13X_3-2.79X_4 +1.18X_1^2-0.20X_2^2+ 3.05X_3^2+ 1.80X_4^2+ 1.31X_1X_2+0.69X_1X_3-1.06X_1X_4-1.94X_2X_3+1.56X_2X_4+1.44X_3 X_4$……*Equation 2*

In coded form of process variables, the model equation is as follows:

Number of pores in a square inch in idly (Y_2) $396.76-6.32X_1-2.012X_2-44.93 X_3-177.70 X_4 +0.04X_1^2-7.91X_2^2+3.052X_3^2+180.20X_4^2+0.05X_1X_2+0.13X_1X_3-2.12X_1X_4-0.38X_2X_3+3.12X_2X_4+14.37X_3 X_4$……*Equation 2*

The magnitude of P and F value in table 36 point out that the positive and negative contribution between the X_1, X_2, X_3 and X_4. The above equation explains that the linear, quadratic and interaction variables of X_2, X_3, X_4, X_2^2, X_1X_4 and X_2X_3 havenegative effect in the uncoded process. All the variable of linear, quadratic variables of X_2^2 and theinteraction variables of X_1X_4 show negative effect in the coded process. The effect of ingredients on product weight has been shown in the 3D fig.

EFFECT OF VARIABLES ON CARBOHYDRATE

The values of regression coefficients, sum square, F values and P values for coded form of process variables are presented in table 6.

Table ---6- ANOVA for response surface quadratic model for the Carbohydrate of raw amaranth grain flour idly

Source	Carbohydrate			
	Coefficient	Sum Square	F-value	P- value
Model	76.71	613.17	3.97	0.0060**
X_1	3.14	236.25	21.43	0.0003**
X_2	2.94	207.33	18.80	0.0006**
X_3	-0.39	3.65	0.33	0.5735 NS
X_4	0.87	18.13	1.64	0.2192 NS
X_1^2	0.080	0.18	0.016	0.9013 NS
X_2^2	0.084	0.19	0.017	0.8967 NS
X_3^2	0.099	0.27	0.024	0.8783 NS
X_4^2	0.084	0.19	0.017	0.8967 NS
X_1X_2	1.25	24.80	2.25	0.1544 NS
X_1X_3	1.24	24.65	2.24	0.155 NS
X_1X_4	-1.25	24.90	2.26	0.1536 NS
X_2X_3	1.22	23.91	2.17	0.1615 NS
X_2X_4	-1.24	24.75	2.24	0.1548 NS
X_3X_4	-1.23	24.21	2.20	0.1591 NS
Lack of fit	28.93			
R^2	0.7876			
AdjR-Squared	0.5893			
Pred R-Squared	-0.2080			

X_1 – Parboiled Rice flour, X_2 - Raw amaranth grain X_3 – Fenugreek X_4 – Yeast
* = 5% level of significant, ** = 1% level of significant, NS = Not Significant

The carbohydrate of the developed idly was range from 68 to 87%. The developed model for idly in the form of uncoded (actual) process variables as follows:

Carbohydrate (%) (Y_3) $76.71+3.14X_1+2.94 X_2-0.39X_3+ 0.87X_4 + 0.08X_1^2 +0.08 X_2^2+0.09X_3^2+ 0.08X_4^2+ 1.25X_1X_2+ 1.24X_1X_3- 1.25X_1X_4+ 1.22X_2X_3-1.24X_2 X_4-1.23X_3 X_4$……*Equation 3*

In coded form of process variables, the model equation is as follows:

Carbohydrate (%) (Y_3) 98.14-0.99X_1-2.97 X_2-15.21X_3+262.80X_4 +3.20X_1^2+3.35 X_2^2 + 0.09X_3^2+ 8.37X_4^2+ 0.04X_1 X_2+ 0.24X_1 X_3-2.49X_1 X_4-0.24X_2 X_3-2.48X_2 X_4-12.30X_3 X_4……Equation 3

The magnitude of P and F value in table 37 point out that the positive and negative contribution between the X_1, X_2, X_3 and X_4. The above equation explains that the linear and interaction variables of X_3, X_1X_4,X_2X_4andX_3X_4 havenegative effect in the uncoded process. All the variable of linear except $X_4$and theinteraction variables of X_1X_4, X_2X_3, X_2X_4 and X_3X_4show negative effect in the coded process. The effect of ingredients on product weight has been shown in the 3D fig --- to ---.

EFFECT OF VARIABLES ON FAT

The values of regression coefficients, sum square, F values and P values for coded form of process variables are presented in table 7.

Table ---7- ANOVA for response surface quadratic model for the Fat of raw amaranth grain flour idly

Source	Fat			
	Coefficient	Sum Square	F-value	P- value
Model	1.25	3.54	1.74	0.1505 NS
X_1	-0.038	0.034	0.23	0.6373 NS
X_2	0.15	0.57	3.91	0.0665 NS
X_3	0.029	0.020	0.14	0.7134 NS
X_4	0.029	0.020	0.14	0.7134 NS
X_1^2	0.13	0.48	3.29	0.0896 NS
X_2^2	0.26	1.82	12.46	0.0030**
X_3^2	0.21	1.18	8.09	0.0123**
X_4^2	7.292	1.458	0.010	0.9216 NS
X_1X_2	-0.019	5.625	0.039	0.8469 NS
X_1X_3	-6.250	6.250	4.289	0.9486 NS
X_1X_4	-6.250	6.250	4.289	0.9486 NS
X_2X_3	6.250	6.250	4.289	0.9486 NS
X_2X_4	6.250	6.250	4.289	0.9486 NS
X_3X_4	-6.250	6.250	4.289	0.9486 NS
Lack of fit	2.27			
R^2	0.6183			
AdjR-Squared	0.2621			
Pred R-Squared	-0.9006			
Adeq-Precision	5.063			

X_1 – Parboiled Rice flour, X_2 - Raw amaranth grain X_3 – Fenugreek X_4 – Yeast , * = 5% level of significant, ** = 1% level of significant, NS = Not Significant

The fat of the developed idly was range from 1.3 to 2.5%. The developed model for idly in the form of uncoded (actual) process variables as follows:

Fat (%) (Y_5) 1.25-0.03X_1+0.15X_2+0.02X_3+0.02X_4 +0.13X_1^2+0.26X_2^2+0.21X_3^2+7.29X_4^2-0.019X_1X_2-6.25X_1X_3-6.25X_1X_4+6.25X_2X_3+6.25X_2 X_4-6.25X_3 X_4……Equation 4

In coded form of process variables, the model equation is as follows:

Fat (%) (Y_5) 28.50-0.61X_1-0.24 X_2-2.37X_3+0.64X_4 + 5.29X_1^2+ 0.01 X_2^2+ 0.20X_3^2+0.72X_4^2-7.50X_1 X_2-1.25X_1 X_3-0.01X_1 X_4+1.25X_2 X_3+0.012X_2 X_4-0.06X_3 X_4……Equation 4

The magnitude of P and F value in table 37 point out that the positive and negative contribution between the X_1, X_2, X_3 and X_4. The above equation explains that the linear and interaction variables of X_1, X_1X_2, X_1X_3 and X_1X_4 have negative effect in the uncoded process. In the coded equation form X_1, X_2 and X_3 of linear variables, X_1X_2, X_1X_3, X_1X_4 and $X_3X_4$of interaction variables have the negative effects on the selected Y variable. The effect of ingredients on product weight has been shown in the 3D fig 3.

EFFECT OF VARIABLES ON PROTEIN

The values of regression coefficients, sum square, F values and P values for coded form of process variables are presented in table 8.

Table ---8 ANOVA for response surface quadratic model for the Protein of raw amaranth grain flour idly

Source	Protein			
	Coefficient	Sum Square	F- value	P- value
Model	13.65	15.59	268.48	<0.0001**
X_1	0.36	3.10	793.31	<0.0001**
X_2	0.67	10.81	2781.89	<0.0001**
X_3	0.25	1.51	387.17	<0.0001**
X_4	0.059	0.83	21.31	0.0003**
X_1^2	-0.012	4.215	1.08	0.3142 NS
X_2^2	8.854	2.150	0.55	0.4685 NS
X_3^2	3.854	4.074	0.10	0.7506 NS
X_4^2	8.854	2.150	0.55	0.4685 NS
X_1X_2	-0.019	6.006	1.55	0.2329 NS
X_1X_3	-0.026	0.011	2.70	0.1210 NS
X_1X_4	-0.026	0.011	2.70	0.1210 NS
X_2X_3	0.018	5.256	1.35	0.2631 NS
X_2X_4	0.051	0.041	10.55	0.0054**
X_3X_4	0.012	2.256	0.58	0.4580 NS
Lack of fit	9.61			
R^2	0.9963			
AdjR-Squared	0.9928			
Pred R-Squared	0.9793			
Adeq-Precision	61.215			

X_1 – Parboiled Rice flour, X_2 - Raw amaranth grain X_3 – Fenugreek X_4 – Yeast , * = 5% level of significant, ** = 1% level of significant, NS = Not Significant

The protein of the developed chapatti was range from 63 to 77 g. The developed model for chapatti in the form of uncoded (actual) process variables as follows:

Protein (%) (Y_4) 13.65+0.36X_1+0.67X_2+0.25X_3+0.05X_4-0.01X_1^2+8.85X_2^2+3.85X_3^2+8.85X_4^2-0.01X_1X_2-0.02X_1X_3-0.02X_1X_4+0.01X_2 X_3+0.05X_2 X_4+0.01X_3 X_4……Equation 5

In coded form of process variables, the model equation is as follows:

Protein (%) (Y_4) 1.60+0.19X_1+0.10X_2+0.40X_3+0.72X_4-4.95X_1^2+3.54X_2^2+3.85X_3^2+0.88X_4^2-7.75X_1 X_2-5.12X_1 X_3-0.05X_1 X_4+3.62X_2 X_3+0.10X_2 X_4+0.11X_3 X_4……Equation 5

The magnitude of P and F value of protein in table 39tells that the positive and negative contribution between the X_1, X_2, X_3 and X_4. The above equation explains that the most of the variables in linear, quadratic and interaction havepositive effect in both coded and uncoded process. The quadratic and interaction variables of X_1^{2}, X_1X_3, X_1X_4has the negative effects on the Y variable. The effect of ingredients on product weight has been shown in the 3D figure 4.

EFFECT OF VARIABLES ON FIBER

The values of regression coefficients, sum square, F values and P values for coded form of process variables are presented in table 9.

Table ---9 -ANOVA for response surface quadratic model for the Fiber of raw amaranth grain flour idly

Source	Fiber			
	Coefficient	**Sum Square**	**F- value**	**P- value**
Model	2.78	5.38	1.80	0.1346 NS
X_1	-0.050	0.060	0.28	0.6034 NS
X_2	0.11	0.28	1.32	0.2682 NS
X_3	0.058	0.082	0.38	0.5451 NS
X_4	-8.333	1.667	7.823	0.9307 NS
X_1^2	-0.33	2.93	13.77	0.0021**
X_2^2	-0.16	0.74	3.49	0.0815 NS
X_3^2	-0.18	0.86	4.04	0.0629 NS
X_4^2	-0.25	1.74	8.18	0.0119**
X_1X_2	-0.075	0.090	0.42	0.5256 NS
X_1X_3	-0.012	2.500	0.012	0.9152 NS
X_1X_4	-0.012	2.500	0.012	0.9152 NS
X_2X_3	-0.087	0.12	0.57	0.4600 NS
X_2X_4	-0.087	0.12	0.57	0.4600 NS
X_3X_4	0.000	0.000	0.000	1.0000 NS
Lack of fit	0.72			
R^2	0.6273			
AdjR-Squared	0.2794			
Pred R-Squared	-0.4876			
Adeq-Precision	4.315			

X_1 – Parboiled Rice flour, X_2 - Raw amaranth grain X_3 – Fenugreek X_4 – Yeast
* = 5% level of significant, ** = 1% level of significant, NS = Not Significant

The fibre of the developed idly was range from 1.1 to 2.5%. The developed model for idly in the form of uncoded (actual) process variables as follows:

Fiber (%) (Y_6) $2.78-0.05X_1+0.11X_2+0.05X_3-8.33X_4-0.33X_1^2-0.16X_2^2-0.18X_3^2-0.25X_4^2-0.07X_1X_2-0.01X_1X_3-0.01X_1X_4-0.08X_2X_3-0.08X_2X_4+0.00X_3X_4$ ……*Equation 6*

In coded form of process variables, the model equation is as follows:

Fiber (%) (Y_6) $-63.07+1.63X_1+0.57X_2+2.59X_3+24.20X_4-0.013X_1^2-6.58X_2^2-0.17X_3^2-25.20X_4^2-3.00X_1X_2-2.50X_1X_3-0.025X_1X_4-0.01X_2X_3-0.17X_2X_4-6.58X_3X_4$ ……*Equation 6*

The magnitude of P and F value of fibre in table 40reveals that the positive and negative contribution between the X_1, X_2, X_3 and X_4. The above equation explains that the most of the variables in linear, quadratic and interaction have negative effect in both coded and uncoded process. The linear, quadratic and interaction variables of X_1, X_2, X_3, X_4, X_3X_4, X_1X_4have the positive effects on the Y variable. The effect of ingredients on product weight has been shown in the 3D figure 5.

EFFECT OF VARIABLES ON OVERALL ACCEPTABILITY

The values of regression coefficients, sum square, F values and P values for coded form of process variables are presented in table 10.

Table ---10 - ANOVA for response surface quadratic model for the Overall acceptability of raw amaranth grain flour idly

Source	Over all acceptability			
	Coefficient	**Sum Square**	**F- value**	**P- value**
Model	8.33	5.08	1.52	0.2153 NS
X_1	-0.21	1.04	4.36	0.0542 NS
X_2	-0.31	0.38	1.57	0.2294 NS
X_3	-0.31	0.38	1.57	0.2294 NS
X_4	-0.21	1.04	4.36	0.0542 NS
X_1^2	-0.094	0.24	1.01	0.3310 NS
X_2^2	0.16	0.67	2.80	0.1148 NS
X_3^2	-0.094	0.24	1.01	0.3310 NS
X_4^2	0.031	0.027	0.11	0.7424 NS
X_1X_2	-0.062	0.062	0.26	0.6165 NS
X_1X_3	-0.062	0.062	0.26	0.6165 NS
X_1X_4	0.19	0.56	2.35	0.1457 NS
X_2X_3	0.063	0.063	0.26	0.6165 NS
X_2X_4	0.063	0.063	0.26	0.6165 NS
X_3X_4	0.063	0.063	0.26	0.6165 NS
Lack of fit	0.84			
R^2	0.5865			
AdjR-Squared	0.2006			
Pred R-Squared	-0.7169			
Adeq-Precision	4.943			

X_1 – Parboiled Rice flour, X_2 - Raw amaranth grain X_3 – Fenugreek X_4 – Yeast
* = 5% level of significant, ** = 1% level of significant, NS = Not Significant

The overall acceptability of the developed idly was range from 7 to 8. The developed model for idly in the form of uncoded (actual) process variables as follows:

Overall acceptability (%) (Y_7) $8.33-0.21X_1-0.31X_2-0.31X_3-0.21X_4-0.09X_1^2+0.16X_2^2-0.09X_3^2+0.03X_4^2-0.06X_1X_2-0.06X_1X_3+0.19X_1X_4+0.06X_2X_3+0.06X_2X_4+0.06X_3X_4$…*Equation 7*

In coded form of process variables, the model equation is as follows:

Overall acceptability (%) (Y_7) $3.44+0.37X_1-0.18X_2+1.31X_3-32.70X_4-3.75X_1^2+6.25X_2^2-0.09X_3^2+3.12X_4^2-2.50X_1X_2-0.01X_1X_3+0.37X_1X_4+0.01X_2X_3+0.12X_2X_4+0.62X_3X_4$……*Equation 7*

The magnitude of P and F value of overall acceptability in table 41 reveals that the positive and negative contribution between the X_1, X_2, X_3 and X_4. The equation of uncoded and coded forms explain that all the linear variables have negative effect in uncoded form of process whereas the same variables have the mixture of positive and negative effect in the coded form equation. The quadratic terms of variable X_1^2andX_3^2 have the negative effect on Y variable. Moreover X_1X_2 and X_1X_3 interaction variables have the negative effect on the overall acceptability of the product. The effect of ingredients on product weight has been shown in the 3D fig 6.

Table – 11- Mean organoleptic evaluation of RAGF incorporated Idlis

Variation	Appearance	Flavour	Colour	Texture	Taste	Overall acceptability
V_1	8.00±0.66^{a}	8.20±.788^{ab}	7.70±.823^{abc}	8.1000±.737^{abc}	7.900±.87^{a}	8.3000±.674^{abc}
V_2	7.700±.9486^{a}	7.80±.636^{ab}	7.30±.948^{ab}	7.50±1.082^{abc}	7.80±.918^{a}	7.700±.9486^{ab}
V_3	7.500±.7071^{a}	7.80±0.78^{ab}	7.90±.870^{abc}	8.00±.942^{abc}	8.10±0.56^{a}	8.20±.63246^{abc}
V_4	7.600±.8432^{a}	7.70±.675^{ab}	7.80±.918^{abc}	8.100±.994^{abc}	8.20±.632^{a}	8.30±.67495^{abc}
V_5	8.100±.7378^{a}	8.10±.737^{ab}	8.20±.788^{bc}	8.40±.96609^{c}	8.10±.738^{a}	8.60±.51640^{c}
V_6	7.800±.7888^{a}	7.70±.823^{ab}	7.50±.701^{abc}	7.6000±.847^{abc}	7.90±.736^{a}	8.00±.66667^{abc}
V_7	7.700±.9486^{a}	8.10±.567^{ab}	7.60±1.04^{abc}	7.900±.9943^{abc}	8.00±.942^{a}	7.90±.99443^{abc}
V_8	7.600±.5164^{a}	7.60±.699^{ab}	7.50±.973^{abc}	7.8000±.918^{abc}	7.80±.632^{a}	8.00±.6667^{abc}
V_9	7.700±.9486^{a}	7.90±.736^{ab}	7.40±.966^{abc}	7.30±.94868^{ab}	7.80±.918^{a}	7.7000±.94868^{ab}
V_{10}	7.600±.8432^{a}	7.70±.674^{ab}	7.80±.914^{abc}	8.00±.94281^{abc}	8.10±.567^{a}	8.20±.63246^{abc}
V_{11}	7.700±.8232^{a}	7.90±.736^{ab}	7.80±.918^{abc}	8.40±.6991^{c}	8.30±.674^{a}	8.40±.69921^{abc}
V_{12}	8.000±.8165^{a}	7.90±.737^{ab}	8.20±.781^{bc}	8.10±1.192^{abc}	8.10±.736^{a}	8.6000±.51640^{c}
V_{13}	7.800±.7888^{a}	7.90±.870^{ab}	7.50±.707^{abc}	7.80±.91894	7.90±.737^{a}	8.00±.66667^{abc}
V_{14}	7.90±.7378^{a}	8.20±.632^{ab}	7.50±.973^{abc}	7.80±1.032^{abc}	7.90±.875^{a}	7.80±.91894^{abc}
V_{15}	7.800±.7888^{a}	7.70±.827^{ab}	7.50±.707^{abc}	7.60±.84327^{abc}	7.90±.737^{a}	8.00±.66667^{abc}
V_{16}	7.500±.8498^{a}	7.80±.632^{ab}	7.20±.914^{a}	7.20±.78881^{a}	7.80±.788^{a}	7.6000±.84327^{a}
V_{17}	7.800±.9189^{a}	7.90±.737	8.10±.737^{abc}	8.10±.994^{abc}	8.20±.632^{a}	8.30±.67495^{abc}
V_{18}	7.500±.8498^{a}	7.90±0.73^{ab}	7.50±1.02^{abc}	8.3000±.823^{bc}	8.20±.788^{a}	8.30±.82327^{abc}
V_{19}	8.100±.7378^{a}	7.70±.674^{ab}	8.30±.674^{c}	8.00±1.150^{abc}	8.30±.483^{a}	8.500±.52705^{abc}
V_{20}	7.900±.5676^{a}	8.40±.691^{b}	7.80±.636^{abc}	8.40±.69921^{c}	7.70±.823^{a}	8.30±.67495^{abc}
V_{21}	7.600±.8432^{a}	7.60±.699	7.40±.843^{abc}	7.40±.699^{abc}	7.80±.632^{a}	7.80±.63246^{abc}
V_{22}	7.600±.8432^{a}	7.70±.675^{ab}	7.20±.914^{a}	7.30±.82327^{ab}	7.70±.823^{a}	7.7000±.82327^{ab}
V_{23}	8.000±.6666^{a}	8.30±.674^{ab}	7.80±.632^{abc}	8.20±.78881^{abc}	8.00±.816^{a}	8.100±.73786^{abc}
V_{24}	7.8000±.918^{a}	7.70±.823^{ab}	7.30±.823^{ab}	7.40±.699^{abc}	8.10±.565^{a}	8.00±.66667^{abc}
V_{25}	7.7000±.948^{a}	8.00±.666^{ab}	7.40±.966^{abc}	7.50±1.080^{abc}	7.80±.914^{a}	7.700±.9486^{ab}
V_{26}	7.4000±.699^{a}	7.40±.5160^{a}	7.90±1.10^{abc}	7.70±1.150^{abc}	7.90±.565^{a}	8.100±.7378^{abc}
V_{27}	7.6000±.843^{a}	8.00±.667^{ab}	7.70±.948^{abc}	8.40±.699^{c}	8.30±.675^{a}	8.40±.699^{abc}
V_{28}	8.0000±.816^{a}	7.80±.788^{ab}	8.20±.788^{bc}	8.10±1.197	8.20±.636^{a}	8.60±.5160^{c}
V_{29}	8.0000±.471^{a}	8.00±.816^{ab}	7.60±.691^{abc}	8.00±.666^{abc}	7.90±.737^{a}	8.10±.567^{abc}
V_{30}	7.7000±.948^{a}	8.00±.666^{ab}	7.40±.966^{abc}	7.50±1.082^{abc}	7.80±.914^{a}	7.7000±.948^{ab}
F Value	.573	.968	1.277	1.558	.618	1.678
Significant	.963	.516	.162	.038	.940	.019

**- Significant at 0.01% level; * - Significant at 0.05% level; NS- No Significant
Values with different superscripts are significantly different from each other on application of Duncan multiple Range test

The nutritional and health status point idly appears to be an ideal human food for all ages and at all times. All the food products incorporated with RaAGF mixture were found to be organoleptically acceptable. It has been found that when the level of incorporation of RaAGF increased beyond the accepted levels in any food preparation, the mean scores for all organoleptic characteristics decreased. The most acceptable level of GF incorporation was 15 to 20% and the mean scores for overall acceptability were 8.60 ± 0.51 to 7.60 ± 0.84 in developed 30 verities of idly.

CONCLUSION

Current research study concluded that, RSM based RaAGF incorporated idli was found to be a best tool for predicting the relationship between the rice to black gram dhal ratio and its nutrients and organoileptic qualities. From the study it was concluded that the optimum mixture of parboiled rice, RaAGF, fenugreek and yeast by numerical optimization technique, equal importance was given to all the seven parameters (Weight, No. of. Pores in a square inch, carbohydrate, fat, protein, fiber and overall acceptability). The optimum conditions were PRF (62.78g), RaAGF (18.56g), fenugreek (5.7g) and yeast (0.30g) respectively. Corresponding to these values of process variables, the value of weight (332g), No. of. Pores in a square inch (22), carbohydrate (81g), fat (1.4), protein (14), fiber (2.4) and overall acceptability (8). Among the thirty variations the optimum conditions was observed in V7 variations.

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