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OPTIMIZATION OF FIBER RICH FOXTAIL MILLET BRAN CHAPPATIS USING RESPONSE SURFACE METHODOLOGY

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ABSTRACT

Millets are small seeded grasses that are hardy and grow well in dry zone. Millets are not much costly than that of rice and wheat known as poor people's food which is 3-5 times nutritionally superior to the widely promoted rice and wheat in terms of protein, minerals and vitamins. Millets were easily digestible and helps to reduce weight. The whole millets were stored properly; it will be kept for more than 2 years. Hence the present study was undertaken to enhance and formulate the chappatis and to determine the optimal level incorporation of whole Wheat Flour (WWF) and Foxtail Millet Bran (FMB) for the acceptable level of chappatis considering with its textural and sensory properties as a response variables. Results revealed that, Response Surface Methodology (RSM) was applied for optimization to get optimum levels and it was found that desirable values of 0.803gm,7900, 0.42 for hardness, elasticity and overall acceptability scores 7 was obtained for the corresponding optimum condition of WWF 80gm as X1 and FMB 19.98gm as X2. Hence it was concluded that, RSM was used successfully to optimize the level of WWF and FMB for the development of value added chappatis.

Key words: Millets, Wheat Flour, Foxtail Millet, Bran, Response Surface Methodology

INTRODUCTION

The word millet is used to describe seeds from several taxonomically divergent species of grass. Millets are rich in essential amino acids, methionine, and cysteine and are higher in fat content than maize, rice and sorghum (Kamara *et al.*, 2009; Parameshwari and Nazni, 2012). Millets are considered as crop of food security because of their sustainability in adverse agro-climatic conditions (Ushakumari *et al.*, 2004). The bran is the hard outer layer of rice consisting of pericarp and aleurone (Hernandez *et al*, 2000; Millet is processed into a wide array of foods. For production of most foods, the grains are decorticated using mechanical dehullers or mortars and pestles. This treatment removes the outer layers of the grains, i.e., the bran. Millet bran is therefore a byproduct of millet-based food manufacturing (Hemery *et al.*, 2007). Response surface methodology (RSM) is a collection of statistical and mathematical techniques used for development, improvement and optimization of processes or formulations. In addition to analyzing the effects of the independent variables, this experimental methodology generates a mathematical model that accurately describes the overall process. It has been successfully applied to optimizing conditions in food, chemical and biological processes (Ismail, 2005; Nazni and Gracia, (2014); Nazni and Karuna Thara, (2011), Nazni and Garcia, 2010, Nazni and Shemi George, 2012, Shemi George and Nazni, 2012 and Durgadevi and Nazni, 2012; Nazni and Gracia, 2014, Nazni and Bhuvaneswari, 2011). The most staple food of the country like *chapati* lacks in fi ber content, particularly soluble fiber. Therefore, the present investigation was planned to develop optimally acceptable fiber rich *chapaties* as well as to study the effect of fibers (foxtail and little millet bran).

MATERIALS AND METHODS

SELECTION OF MILLETS

The foxtail millet was selected for this study. These millets were purchased in local market at Dharmapuri District, Tamil Nadu. Whole wheat flour, cumin seeds, fennel seeds, omum seeds, salt, sugar and oil were purchased from local market from Dharmapuri District.

PROCESSING OF SELECTED MILLETS

PREPARATION OF MILLET BRANS

The foxtail millet was cleaned to remove stone, stick and other foreign materials. The traditional technology (hand pounded) used for preparation of millet bran. The cleaned millets were used to separate millet rice and millet bran. The millets bran was ground and sieved (60mesh) BSS. This millets bran used for future study.

PREPARATION OF SPICE MIX FOR CHAPATHI

A spice mix containing cumin seeds, fennel seeds and omum all in equal proportion were roasted and coarsely ground and prepared as a taste adjunct for chappathi.

EXPERIMENTAL DESIGN

Response surface methodology (RSM) was used to investigate the effects of whole wheat flour (WWF) and millet brans (Foxtail millet), of the developed Chappatis. A central-composite rotatable design consisting of two variables was plotted. This design was used to develop models of the texture (Hardness and elasticity) and sensory score of the developed chappatis. Responses were mostly affected by the specific combinations of independent variables. The results was included the estimated model coefficients, the regression coefficients and the lack-of-fit test. For the preparation of the chappatis, the Millet brans were optimized using CCRD. The variables were standardized to simplify computation and deduce their relative effect of variable on the responses.

Ingredients	Weight (g)
Wheat flour	Variable
Millet brans	Variable
Oil	1 tsp
Salt	To taste
Spice mix	1g

The central composite rotatable design was used for selecting combination levels of variables in each experiment. The variables used were, level of whole wheat flour (80-85 g/100 g flour) and millets bran (15-20 g/100 g flour). The levels of these variables along with experimental plan have been given in Table 1. The relationship between standardized variables value is given as

Variable for millet brans (Foxtail millet) incorporated Chappatis

$$X_1 = \frac{wwf - 82}{2.5}$$

$$X_2 = \frac{millet\ brans - 17.5}{2.5}$$

STATISTICAL ANALYSIS AND OPTIMIZATION

The second order polynomial equation was fitted to the experimental data of each dependent variable as given below

$$\mathbf{Y = \beta + X_1 + X_2 + X_{12} + X_{22} + X_1 X_2}$$

Where Y = response variable; Y1 = Hardness, Y2 = Elasticity, Y3 = Overall acceptability. X1 represent the uncoded independent variables of WWF and X2 represent the uncoded independent variables of Foxtail millet bran. The response surface and contour plots were generated for interaction of any two independent variables, while holding the value of the third variable as constant (at the central value). Such three-dimensional surfaces could give accurate geometrical representation and provide useful information about the behavior of the system within the experimental design. The optimization of process was aimed at finding the optimum percentage proportion of WWF and Foxtail millet bran that would give minimum Hardness, maximum elasticity and maximum overall acceptability. Response surface methodology was applied to the experimental data using a commercial statistical package, Design-Expert version 6.01 (Trial version, Stat-Ease Inc., Minneapolis, MN). The same software was used for the generation of response surface plots and optimization of fiber rich Chappatis formulation.

Table- 1 Variables for the preparation of chappatis from Foxtail Millet Bran

Variations	X1-Whole Wheat Flour	X2 - Foxtail Millet Bran
V0	100	-
V1	80	15
V2	85	15
V3	80	20
V4	85	20
V5	78.96	17.5
V6	86.03	17.5
V7	82.5	13.96
V8	82.5	21.03
V9	82.5	17.5
V10	82.5	17.5
V11	82.5	17.5
V12	82.5	17.5
V13	82.5	17.5

PREPARATION OF CHAPPATIS

METHOD OF PREPARATION

Add millet bran
↓
Mix thoroughly and add salt, spice mix and water
↓
Mix well for few minutes
↓
Made into dough
↓
Kept for 10 – 15 minutes
↓
Divide into balls
↓
Thin it in roll board and pin
↓
Heat the tawa and cook till it was done Reverse the chappathi with ladle till it cook.

ANALYSIS OF TEXTURE PROFILE OF THE MILLET BRANS (FOXTAIL MILLET) INCORPORATED CHAPPATIS

All the variation of chappatis incorporated with the millet bran along with the control product was subjected to texture analysis using a Texture Analyzer (TVT-300XP, Perten Instruments, Sweden) after the preparation. Hardness and elasticity of the optimized products were measured using the Texture Profile Analysis (TPA).

ORGANOLEPTIC EVALUATION

Chappatis prepared by varying proportion of functional ingredients were evaluated for organoleptic

characters like colour, appearance, texture, aroma, taste and overall acceptability by scoring method using nine point hedonic scales. The evaluation was done by 10 semi-trained panelists of Department of Food Science, Periyar University, Salem.

RESULT AND DISCUSSION

REGRESSION COEFFICIENT FOR THE RESPONSE VARIABLES OF FOXTAIL MILLET INCORPORATED CHAPPATIS

The regression coefficient for the response variables of Foxtail millet bran incorporated Chappathi were shown in figure 1 to figure 4.

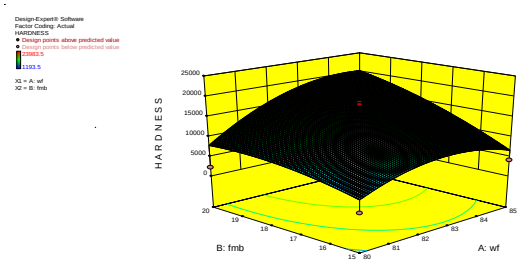

Figure –1 3D Graph Response showing the effect of Wf and Foxtail millet bran on hardness of Chappathi

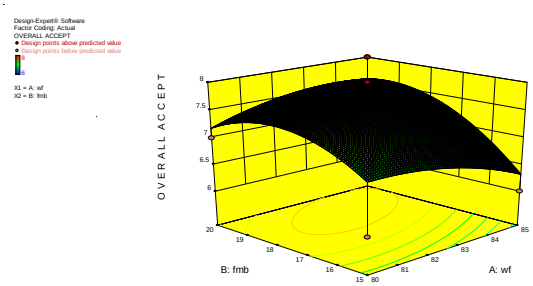

Figure 2: 3D Graph response showing the effect of Wf and Foxtail millet bran on Overall acceptability of Chappathi

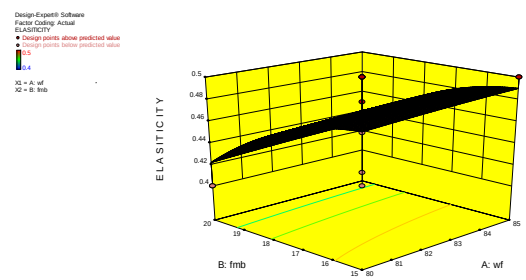

Figure :3 -3D graph Response showing the effect of Wf and Foxtail millet bran on Elasticity of Chappathi

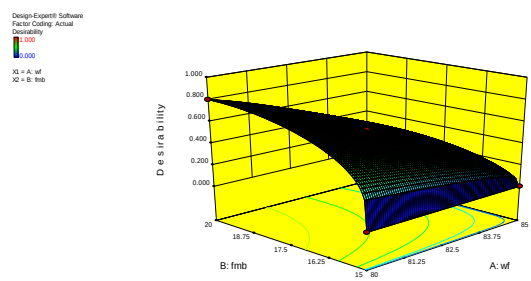

Figure: 4 -3D Graph Response showing the effect of Wf and Foxtail millet bran on Desirability of Chappathi

Table – 2
Levels of different variables in real and coded values form for preparation of chappatis using FMB for experimental design

Independent Variables		Coded value		
		-1	0	+1
Real value	Whole Wheat Flour	80	82.5	85
	Foxtail Millet Bran	15	17.5	20

Table- 3
Central composite design with experimental values and obtained results of sensory and texture properties of the Foxtail millet bran incorporated Chappathi

Runs	Uncoded form of process variable		Responses		
	X1	X2	Y1	Y2	Y3
V1	80	15	1193.5	6	0.45
V2	85	15	4138.5	6	0.5
V3	80	20	2242.5	7	0.4
V4	85	20	15097.5	8	0.45
V5	78.9645	17.5	6778	8	0.5
V6	86.0355	17.5	16422.5	7	0.45
V7	82.5	13.9645	8179.5	7	0.5
V8	82.5	21.0355	23983.5	7	0.4
V9	82.5	17.5	18078.5	8	0.5
V10	82.5	17.5	18653.3	7	0.45
V11	82.5	17.5	18085.5	8	0.4
V12	82.5	17.5	11315	8	0.5
V13	82.5	17.5	8583	7	0.5

Y1=hardness, Y2= overall acceptability, Y3= elasticity

Table-4

Regression coefficients for texture and sensory properties of the foxtail millet bran incorporated Chappathi

Coefficient	Y1	Y2	Y3
Intercept	14943.06	7.60	0.47
X1	3679.92	-0.052	3.66
X2	4294.78	0.38	-0.030
X_1^2	-3714.62	-0.17	-6.250
X_2^2	-1474.00	-0.42	-0.013
X_1X_2	2477.50	0.25	-3.055
R^2	0.62	0.43	0.41

Table-5

Regression coefficient for the response variables of Foxtail millet bran incorporated chappatis

Coefficients	Y1 (Hardness)	Y2 (Overall acceptability)	Y3 (Elasticity)
Model	7.667	0.55	1.720
X1	1.083	0.021	1.072
X2	1.476	1.13	7.286
X_1^2	9.599	0.21	2.717
X_2^2	1.511	1.26	1.198
X_1X_2	2.455	0.25	1.735
R^2	0.6203	0.4366	0.4140
Adj R	0.3491	0.0342	-0.0045
Pred R^2	-0.9179	-1.9506	-1.0295

The R^2 value of the Foxtail millet bran incorporated chappatis was 0.43 for the regression model predicting the overall acceptability, which shows 43% variability in the data. R^2 value of the Foxtail millet bran incorporated Chappatis was 62% and 41% for the hardness and elasticity of the foxtail millet bran incorporated Chappatis. The effect of X variables on the Y variable has shown in figure. The 3D response surface plot is a graphical representation of the regression equation.

Table - 6

Regression model adjusted to the coded experimental data (texture and sensory property) with Wheat Flour (X1) and Foxtail millet bran (X2) incorporated Chappathi

Parameters	Regression equation
Hardness	$Y_1=14943.06+3679.92*X_1+4294.78*X_2+2477.50*X_1X_2-3714.62*X_1^2-1474.00*X_2^2$
Overall acceptability	$Y_{2=}7.60-0.052*X_1+0.38*X_2+0.25*X_1X_2-0.17*X_1^2-0.42*X_2^2$
Elasiticity	$Y3=0.47+3.66*X_1-0.030*X_2-3.055*X_1X_2-6.250*X_1^2-0.013*X_2^2$

Table -7

Conditions and obtained results of optimization process to foxtail millet bran incorporated Chappathi

Factors	Goal	Experimental Design		Importance	Optimum value
		Lower limit	Upper limit		
Process variable					
Wheat flour (X_1)	Minimum	80	85	3	80.0
Foxtail millet bran (X_2)	Maximum	15	20	3	19.98
Response variable					
Hardness	Minimum	2242.5	23983.5	3	7900
Overall acceptability	Maximum	6	8	3	7.18
Elasticity	Maximum	0.40	0.50	3	0.42

OPTIMIZATION OF CHAPPATHI FORMULATION

Optimization of foxtail millet bran formulations were show in table 6. For the optimization variables, the responses, the Hardness, elasticity and Overall acceptability were selected on the basis that these responses had direct effect on the acceptability and quality of Chappathis.

To consider all the responses simultaneously for optimization, the multiple regression was used to get compromise optimum conditions and it has found that the scores were 7900, 0.42, and 7 corresponding to the optimum condition of WWF 80gm as X1 and Foxtail millet bran 19.98 gm as X2.

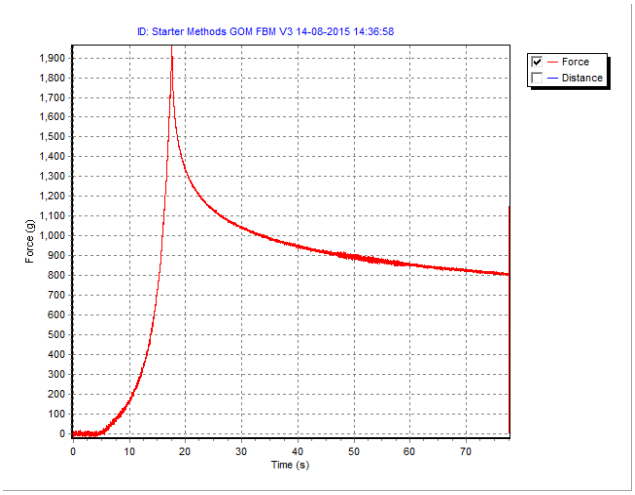

Figure 1: Textural analysis of foxtail millet bran incorporated chappatis

The above figure shows that the texture of optimum conditions of foxtail millet bran incorporated chappatis.

CONCLUSION

Response surface methodology was an effective in optimizing the formulation of fiber rich chappatis with the ingredients at 80 to 85% levels whole wheat flour (WWF) and 15% to 20% foxtail millet bran**.** The regression equations obtained in this study can be used for optimum levels for the desired responses within the range of ingredient levels applied in this study. Optimum solution by numerical optimization obtained was 80% proportion of WWF and 19.98% foxtail to get maximum quality and acceptability of fiber rich chappatis.

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