Journal of
Food Processing & Technology

OPEN ACCESS Freely available online

Research Article

Development of Pearl Millet (*Pennisetum glaucum*) Pizza Base Using Response Surface Methodology

Asim Sabha, Devaki. C.S, Florence Suma P, Asna Urooj*

Department of Studies in Food Science and Nutrition, University of Mysore, Karnataka, India

ABSTRACT

Background: Pearl millet is the most widely cultivated cereal in India after rice and wheat. The major pearl millet growing state is Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana. They provide a high quantity of essential amino acids especially the sulphur-containing amino acids (methionine and cysteine), fatty acids, minerals, vitamins, dietary fibre and polyphenols. Besides its nutritional quality utilization of the pearl millet is less. Therefore, the Incorporation of Pearl millet flour could be used as value addition in the preparation of the pizza base.

Aim of the study: The present study aimed to develop a nutritionally rich pearl millet pizza base by optimizing the major ingredients like pearl millet flour and refined wheat flour by using the statistical software, Response Surface Methodology (RSM).

Materials and Methods: To lead this study, the flours mentioned above were optimized by using Response Surface Methodology (RSM) and Central Composite Rotatable Design. The sensory parameters and physical attributes were evaluated.

Results: It appears from the study that, the statistical design suggested 13 formulations, with the whole pearl millet flour concentration ranging from 21.72 nm, 78.28 g and refined wheat flour varied from 25.86 nm, 54.14 g. The optimized results of sensory parameters were colour 6.28, flavour 6.37, texture 6.64, taste 5.84, overall acceptability 6.33 score on 9-hedonic scale and physical attributes were dough weight 81.61gms, proofing area- before 11.77 cm and after 11.94 cm, proofing height-before 3.86 cm and after 3.73 cm, baking area-before 11.50cm and after 13.30 cm, baking height-before 0.69 cm and after 1.71 cm. Pearl millet flour-30 g and refined wheat flour-30g was the optimized composition with the best fit desirability of 0.824.

Conclusion: All this shows that the response surface methodology could be useful in optimizing the pearl millet flour and refined wheat flour with maximum retention of sensory parameters and physical attributes of the value-added pizza base.

Keywords: Pearl millet flour; Response Surface Methodology (RSM); Sensory parameters; Physical Attributes; Overall acceptability

INTRODUCTION

Pearl millet (Pennisetum glaucum) is the most extensively cultivated millet in the world, after some of the cereals like rice, wheat and sorghum. Pearl millet being gluten-free, marketing opportunities for this grain exists in the health-food outlets particularly in arid to semi-arid regions. Pearl millet is one of the drought-tolerant crops with better nutritive properties and it is used diversely over other cereals. The energy value, protein, fat and mineral content of pearl millet is superior when compared with major cereals. The high-quality proteins and high levels of calcium, iron, zinc, lipids makes it an important contribution to the human diet. Pearl millet is also a very good source of dietary fibre and other micronutrients [1,2].

Pizza base developed by using refined wheat flour contains fatter and lacks dietary fibre and other vital vitamins and minerals. Value addition to the pizza base by incorporating pearl millet flour helps in increasing the nutrients. Pearl millet is the major source of amino acids especially the sulphur-containing amino acids (methionine

Correspondence to: Asna Urooj, Department of Studies in Food Science and Nutrition, University of Mysore, Karnataka, India, E-mail asnaurooj@foodsci.uni-mysore.ac.in

Received: April 17, 2021; **Accepted:** May 18, 2021; **Published:** June 15, 2021

Citation: Sabha A, Devaki. C. S, Suma F, Urooj A (2021) Development of Pearl Millet (Pennisetum glaucum) Pizza Base Using Response Surface Methodology, J Food Process Technol. 12:899

and cysteine), antioxidants, dietary fibre, vitamins and minerals [1,2]. Though Pearl millet is rich in nutrients, the utilization of this millet is not seen much. In the present study, an attempt was made to develop a pearl millet pizza base using Response Surface Methodology (RSM), a statistical software. Response surface methodology has been widely applied to optimize conditions and processes for many food products [3-7]. The studies on optimizing the pizza base for sensory parameters and physical attributes have not received much attention. Thus, the optimization conditions followed for the pizza base and the changes in their sensory parameters and physical attributes still needs a radical approach to achieve the best quality product. Response Surface Methodology (RSM) is a collection of mathematical and statistical techniques, which are useful for developing, improving and optimizing processes [8]. The principles of the approach are explained by designing a regression analysis [9-11]. Regression analysis is meant to predict the value of a dependent variable based on the controlled values of the independent variables [12,13]. The importance of Response Surface Methodology (RSM) in the stage of process optimization leads to the need for an experimental design. This design can generate a lot of samples for consumer evaluation in a short period and therefore, laboratory level tests are more efficient [14]. The time for product optimization is greatly reduced from traditional "cook and look" optimization techniques [15]. From the estimated parameters, variables that contribute the most to the prediction model can be determined, thereby allowing to focus on the variables that are most important to the product acceptance [16]. Response Surface Methodology (RSM) has been successfully applied for optimizing conditions in food research. Therefore, In the present study, a nutritionally rich pearl millet pizza base was prepared using response surface methodology, a statistical design and an effective tool for optimization which have been used with an attempt to bring out the best pizza base with more emphasis on sensory parameters and physical attributes.

MATERIALS AND METHODS

Good quality raw materials i.e. pearl millet (Pennisetum glaucum) and refined wheat flour, yeast, sugar were procured from the local market of Mysore, Karnataka, India.

Raw material processing

The grains were cleaned manually to remove dust, broken seeds and other extraneous materials. Pearl millet milling fractions were produced by pulverizing the grains in a plate mill to obtain Whole Flour (WF) and the whole flour was further sieved through a 60 mesh sieve (BSS). The moisture content (wet weight basis) of milling fractions and refined wheat flour was 8.5% and 12% respectively. These milling fractions were kept in airtight polythene bags and stored at room temperature (18°C-33°C) in a cool and dry place until further use.

Development of pearl millet pizza base

The pizza base was developed according to the runs obtained by design expert statistical software. Refined wheat flour and Pearl millet flour were added as per the runs obtained by the software and the product was prepared by adding yeast mixture (fresh yeast, a pinch of sugar, Kept it in a warm temperature for 10 min till it bubbles) followed by proofing for 45 minutes and Baked in an oven at 205°C for 10 min.

EXPERIMENTAL DESIGN

The percentage of pearl millet flour and refined wheat flour was as per the runs obtained by design expert statistical software. A Central Composite Rotatable Design was used without blocking. A quadratic model was selected for the study. On basis of independent variables decided numbers of design points were obtained. The statistical software package design expert 7.1.5, Stat-Ease Inc, Minneapolis, MN, was used to construct the experimental design as well as analysed the data. Variables pearl millet flour and refined wheat flour were selected as independent variables and sensory parameters such as colour (score), flavour (score), texture (score), taste (score) and overall acceptability (score) and physical attributes such as dough weight (gms), proofing area-before and after (cms), proofing height-before and after (cms), baking area-before and after (cms), baking height-before and after (cms) were selected as the responses. The factorial design considered 4 factorial points, 4 axial points and 5 central point's leading to 13 sets of experiments [15,16]. Optimized ranges of the variables are shown in (Table 1). Pearl millet flour ranged from 21.72 gms to 78.28 gms and refined wheat flour ranged from 25.86 gms to 54.14 gms. Each independent variable investigated in this experiment had five levels which were -1.4142, -1, 0, +1 and +1.4142.

A total of 13 combinations were generated for the two independent variables and the alpha values in the design outside the ranges were selected for rotatability of the design. The centre point was repeated five times for the two-variable design and was selected keeping the ingredients at levels expected to yield, at least, satisfactory experimental results.

The regression analysis of the responses was conducted by fitting suitable models represented by (Equations 1 and 2).

$$Y = \beta_0 + \sum_{i=1}^{n} \beta_i X_i \quad (1)$$

$$Y = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + \sum_{i=1}^{n} \beta_{ii} X_i 2 + \sum_{i \neq j}^{n} \beta_{ij} X_i X_{ij} \quad (2)$$

Where, βo was the value of the fitted response at the centre point of the design, while βi, βii, and βıj were the linear, quadratic and interactive-effect regression terms, respectively and n denoted the number of independent variables i.e. in this case n is 2 and xi, xij are independent variables in coded values represented by X1 and X2 in (Table 2).

Organoleptic evaluation

A semi-trained panel of members evaluated the samples for sensory parameters such as colour (score), flavour (score), texture (score), taste (score), and Overall Acceptability (OAA) (score) using a nine-point hedonic scale [15]. Samples were randomly drawn for each experimental block, coded and served to the panellists.

Physical characteristics

Samples were evaluated for physical attributes such as dough weight

Table 1: Experimental design for pearl millet pizza base with process variables and their levels.

Process variables	-1.414	-1	0	1	1.414
Forms	(augmented form)	(factorial point)	(centre point)	(factorial point)	(augmented form)
Pearl millet (g)	21.72	30	50	70	78.28
Refined wheat flour (g)	25.86	30	40	50	54.14

X1	X2	Runs
± 1	± 1	4
± 1.414	0	2
0	± 1.414	2
0	0	5

Table 2: Actual experimental combinations and response values of sensory and physical attributes.

Runs	Pearl millet flour	Refined wheat flour	Sensory parameters					Physical attributes								
			Colour	Flavour	Texture	Taste	OAA**	Dough Weight	Proofing Area-Before	Proofing Area-After	Proofing height-Before	Proofing Height-After	Baking Area-Before	Baking Area-After	Baking Height-Before	Baking Height-After
	Grams	Grams	Score	Score	Score	Score	Score	gm	cm	cm	cm	cm	cm	cm	cm	cm
	X_1	X_2	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}	Y_{11}	Y_{12}	Y_{13}	Y_{14}
1	50	40	6.01 ± 1.27	5.26 ± 1.37	5.25 ± 1.42	w4.88 ± 1.54	5.17 ± 1.43	82	11	12	3.4	3	13.9	15	0.44	1.1
2	70	30	6.00 ± 1.12	5.58 ± 1.34	5.53 ± 1.18	5.28 ± 1.38	5.43 ± 1.37	83.52	11	12	3.47	3.7	13.07	5.55	0.3	0.5
3	21.72	40	6.74 ± 1.50	6.23 ± 1.17	6.51 ± 1.56	5.89 ± 1.52	6.23 ± 1.56	80	11.1	11.5	3.4	2.5	13.28	13	0.4	1.1
4	50	40	5.91 ± 1.27	5.92 ± 1.44	6.55 ± 1.18	5.60 ± 1.37	5.85 ± 1.24	82.4	10.88	12	3.5	2.5	13.5	14.5	0.5	1.5
5	30	50	6.23 ± 1.41	5.61 ± 1.69	6.24 ± 1.45	5.41 ± 1.82	5.71 ± 1.63	82	11.1	11.5	4.1	3	12.5	13	0.5	1.3
6	50	25.86	6.43 ± 1.33	6.37 ± 1.32	6.88 ± 1.06	6.15 ± 1.29	6.44 ± 1.37	82	10.98	12	4	3.5	12.5	13.5	0.48	1.8
7	50	40	6.14 ± 1.14	6.04 ± 1.15	6.56 ± 1.55	5.72 ± 1.64	6.12 ± 1.56	78	11	11.5	3.4	2.89	12	12.5	0.6	1.3
8	78.28	40	6.26 ± 1.38	5.72 ± 1.54	6.16 ± 1.49	5.60 ± 1.55	6.00 ± 1.52	81.98	10.84	11.46	3.4	3.13	12.5	12.8	0.48	1.3
9	50	54.14	6.20 ± 1.60	5.60 ± 1.77	6.16 ± 1.74	5.66 ± 1.83	5.90 ± 1.92	85.54	10.5	12.18	3.64	4.3	11.98	9.65	0.5	1.4
10	50	40	5.88 ± 1.12	5.80 ± 1.13	5.98 ± 1.12	5.28 ± 1.58	5.68 ± 1.25	81.04	11.5	11.5	3.57	3.3	14	9.93	0.4	0.84
11	70	50	5.88 ± 1.28	5.73 ± 1.18	6.33 ± 1.25	5.38 ± 1.49	5.88 ± 1.18	84	11.04	11.8	3.4	3.5	12	13.5	0.59	2
12	30	30	6.18 ± 1.46	6.00 ± 1.70	6.20 ± 1.56	5.55 ± 1.72	5.95 ± 1.43	82	11.39	11.5	3.69	3.5	13	13.5	0.59	1.66
13	50	40	6.63 ± 1.60	6.65 ± 1.39	6.73 ± 1,51	6.43 ± 1.71	6.64 ±1.52	82	11	12	4	3.74	11.5	13.5	0.7	1.7

Sensory parameters scored on nine points Hedonic scale
OAA: Overall Acceptability

(gms), proofing area-before and after (cms), proofing height-before and after (cms), baking area-before and after (cms), baking height-before and after (cms).

RESULT AND DISCUSSION

The experimental central composite rotatable design with independent variables and responses on sensory parameters and physical attributes is given in (Table 2). The table represents the design points along with the observed values for the responses in the design which were used to fit the second-order polynomial equations. The regression analysis of the responses was conducted by fitting quadratic models as suitable for the respective response. Since overall acceptability is an important criterion for product acceptance, it has been taken as one of the responses. Over the 13 combinations, colour ranged from 5.88 to 6.74, flavour 5.26 to 6.65, texture 5.25 to 6.88, taste 4.88 to 6.43, overall acceptability 5.1 to 6.44 score and physical parameters were Dough weight 78 gm to 85.54 gm, proofing area:10.5 cm to 11.39 cm (before) and 11.46 cm to 12.18 cm (after), height:3.4 cms to 4.1cms (before) and 2.5 cms to 4.3 cms (after), baking area:11.5 cms to 14 cms (before) and 9.65 cms to 15 cms (after), baking height:0.3 cms to 0.7 cms (before) and 0.5 cms to 1.8 cms (after).

The effects of the independent variables pearl millet flour and refined wheat flour on the response at linear, quadratic and interactive levels are presented in (Table 3). The effect of the variable on the responses depends on the sign and magnitude of the coefficients. The negative sign of a coefficient at the linear level indicates a decrease in response with an increase in the level of the variable whereas at the interactive level, an increase in the level of one variable decrease the level of another variable to obtain the same response.

All linear, quadratic and interactive effects were calculated for each model. Quadratic response surface models were selected for all the responses. The adequacy was calculated by F-ratio, mean, standard deviation, coefficient correlation and lack of fit test. The degree of freedom was 5 for all the selected responses. The R2 value for colour was 0.83, flavour 0.91, texture 0.87, taste 0.76, overall acceptability 0.88, dough weight 0.88, proofing area-before 0.89 and after 0.63, height before 0.33 and after 0.77, baking area before 0.77 and after 0.93, and height before 0.94 and after was 0.81. R^2 value was more than 90% for flavour, baking area-after and baking height-before and more than 80% for colour, texture, overall acceptability, dough weight, proofing area-before and baking height after. For other responses like taste, proofing area-after, proofing height-before and after, and baking area before, the R2 value was lesser than 80% but because of the subjective nature of the response the model is considered significant. The empirical models fits the actual data as the value of R2 was closer to unity. On the other hand, the smaller the value of R2 the less relevance the dependent variables in the model have in explaining the behavior of variations [17]. The predicted R2 and adjusted R2 are in close agreement with each other which indicated high suitability of the fit models. Lack of fit was highly non-significant for all the responses.

Effect of variables on sensory parameters

Sensory evaluation is useful in measuring responses to ingredient and the effects of process changes which improves sensory quality of a product. Sensory score and texture were used as responses for optimization of sweet potato based pasta product [18]. Sensory score was also used as one of the important responses for optimization of ready to eat munches [19,20]. (Table 3) reveals that for the response colour, at linear and quadratic level, refined wheat flour had negative significant effect and positive significant effect (p<0.01). The p-value indicates the probability of F-value which should be less than 0.05 for model to be significant, otherwise the model cannot be used for further navigation or prediction. All the polynomial models were fit using design expert software. At linear level refined wheat flour and pearl millet flour had negative significant effect on flavor where as in interactive level pearl millet flour and refined wheat flour had a positive significant level (p<0.01) of texture (p<0.001), taste (p<0.01), and overall acceptability (p<0.05). At quadratic level refined wheat flour and pearl millet flour affected negatively on texture at a significant level of (p<0.05) and (p<0.0001) respectively. Pearl millet flour had a positive significant effect on taste (p<0.001) and overall acceptability (p<0.05) at quadratic level. The multiple coded equations in terms of coded factors generated for their responses are shown below:

$$Colour=6.058-0.12851X_1+0.023713X_2+0.125375X_1^2+0.027875X_2-0.035X_1X_2 \quad R^2=0.83$$

$$Flavour=5.924-0.16266\,X_1-0.15162\,X_2-0.002\,X_1^2-0.069\,X_2^2+0.205\,X_1X_2 \quad R^2=0.91$$

$$Texture=6.548-0.13187\,X_1-0.03639\,X_2-0.11213X_1^2-0.14463\,X_2^2+0.185X_1X_2 \quad R^2=0.87$$

$$Taste=5.462-0.13726\,X_1-0.01673\,X_2+0.085875\,X_1^2+0.025875+0.1175\,X_1X_2 \quad R^2=0.76$$

$$OAA = 5.804-0.07191X_1-0.09075\,X_2+0.13175\,X_1^2+0.03925\,X_2^2+0.1975\,X_1X_2 \quad R^2=0.88$$

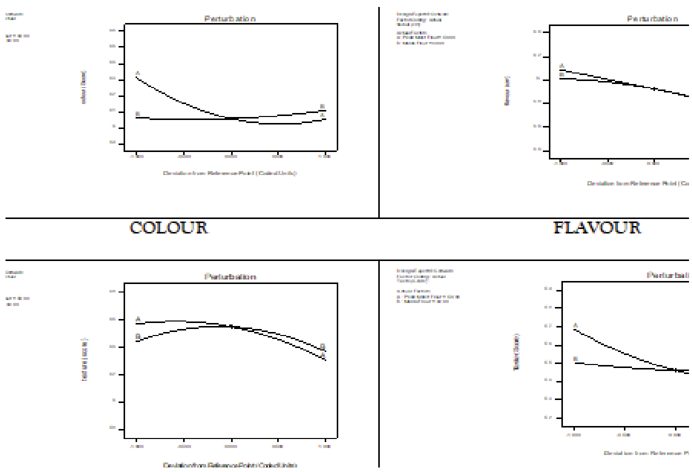

Figure 1: Perturbation graph depicting effect of independent variables on sensory parameters.

The response surface plots for colour, flavor, taste, texture and OAA in relation to pearl millet flour and refined wheat flour is shown in (Figure 1) respectively. The effect of change in the levels of selected ingredient variables on the response parameters has been represented by perturbation graph. Pearl millet flour showed a great impact on sensory parameters. It was observed that as there was decrease in Pearl millet flour, scores of colour, flavour, texture and taste decreased. Refined wheat flour showed slight increase in scores of colour, while it decreased the scores of flavour, texture and overall acceptability. Therefore, Pearl millet flour contributed for the sensory parameters in pizza base. Pearl millet upma mix was developed and the ingredients were optimized using RSM [21]. The authors optimized upma mix with independent variables such as vanaspati, water and citric acid and reported that the graph of Over All Acceptability (OAA) score tended to rise with added water at constant amount of citric acid within the selected range. A central composite design was used to develop ginger-based ready-to-eat appetizers [19]. The formulation varied in relation to the content of raisins, red sugar, and ginger powder; samples were analysed in terms of sensory acceptability and total sugars. The data were subjected to multiple regression analysis and 3D surface plots were built to explain the experimental results. The quadratic polynomial equations were significant for sensory score and total content of sugars, showing that such models describe the actual data well. Appetizer was optimized by the numerical optimization procedure in order to maximize its sensory acceptability. This study showed that it is possible to develop new food products with enhanced functionality by using a response surface approach.

Effect of variables on physical attributes

Dough weight, proofing area-before and after, proofing height-before and after, baking area-before and after, baking height-before and after were considered as physical attributes for the independent variables. Table 3 reveals that at linear level, Pearl millet flour had positive effect on dough weight ($p<0.05$), proofing area-after, proofing height-before and after for refined wheat flour had a negative effect on the above mentioned response. At the linear level, pearl millet flour and refined wheat flour had positive significant effect on proofing area-before and baking area-before. Refined wheat flour had a negative effect on baking area-after at the significant level of $p<0.05$ and baking height-after at the significant level of $p<0.00$. Whereas, refined wheat flour had a positive significant effect on baking area-after ($p<0.01$), baking height-before and after ($p<0.05$).

At quadratic level, Pearl millet flour had a negative effect on dough weight ($p<0.05$), proofing area-after, proofing height-before, baking area-before and after ($p<0.01$) and baking height-after ($p<0.05$). Whereas, it had a positive effect on proofing area-before ($p<0.05$), proofing height-after and baking height-before. Refined wheat flour had a positive effect on dough weight ($p<0.01$), proofing area-after, proofing height-after ($p<0.0001$), baking height-before and after ($p<0.05$). At interactive level, it was observed that both the variables were positively significant for responses, such as proofing area-before and after, baking area-after, proofing height-before and after and baking area-after were affected positively. The multiple coded equations in terms of coded factors generated for their responses are shown below:

Dough weight$=81.6+0.7299X_1-0.46474X_2-1.0225X_1^2+1.6025X_2^2-0.375X_1X_2$

$R^2=0.88$

Proofing area-before$=11.012+0.15714X_1+0.1242X_2+0.13088X_1^2-0.1091X_2^2+0.1375X_1X_2$

$R^2=0.89$

Proofing area-after$=11.8+0.005X_1-0.1972X_2-0.1513X_1^2+0.09375X_2^2+0.01X_1X_2$

$R^2=0.628$

Proofing height-before$=3.680+0.00005X_1-0.0899X_2-0.063125X_1^2-0.045625X_2^2+0.205X_1X_2$

$R^2=0.33$

Proofing height-after$=2.9+0.11373X_1-0.24267X_2+0.1025X_1^2+0.505X_2^2+0.1025X_1X_2$

$R^2=0.768$

Baking area-before$=13.136+0.6123X_1+0.11979X_2-0.0624X_1^2-.5674X_2^2-0.2675X_1X_2$

$R^2=0.766$

Baking area-after $= 13.8-1.3606X_1+1.58684X_2-1.3069X_1^2-1.1269X_2^2+2.1625X_1X_2$

$R^2=0.93$

Baking height-before $= 0.464-0.07161X_1+0.02466X_2+0.01675X_1^2+0.03925X_2^2+0.1275X_1X_2$

$R^2=0.94$

Baking height-after $= 1.36-0.1863X_1+0.20107X_2-0.1688X_1^2+0.14625X_2^2+0.39X_1X_2$

$R^2=0.81$

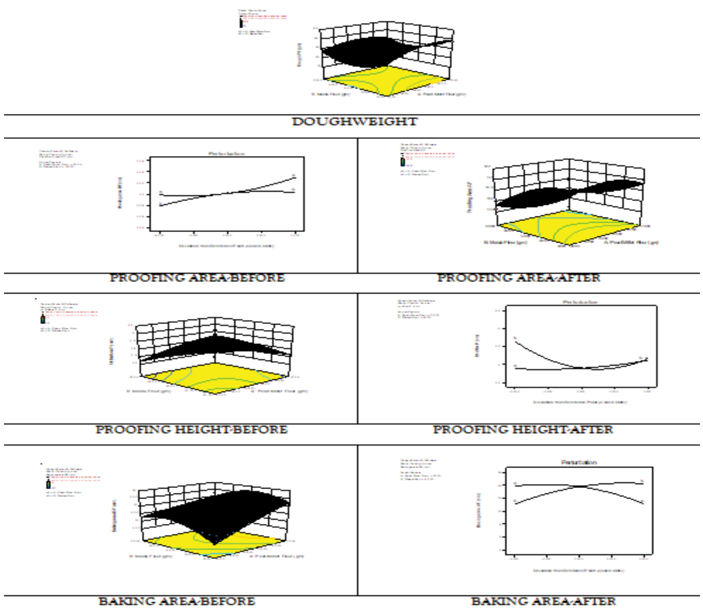

Figure 2: Perturbation graph and 3D plots depicting effect of independent variables on physical parameters.

The response surface for dough weight, proofing area-before and after, proofing height-before and after, baking area-before and after, baking height-before and after in relation to pearl millet flour and refined wheat flour is shown in (Figures 2) (vi to xiv) respectively. Both the variables influenced the physical attributes. Dough weight increased with increase in pearl millet flour and refined wheat flour. Pearl millet flour helped to increase proofing area-before, proofing height-before and after and baking area-before, while it decreased proofing area-after and baking height-before and after.

Refined wheat flour increased proofing area-before, baking area-after and baking height-before and after, while it decreased the values of proofing area-after, proofing height-before and after and baking area-after. From the graph it can be observed that pearl millet flour contributed to improve the physical attributes of pizza base.

Optimization of independent variables

Numerical optimization of independent variables, Pearl millet flour and refined wheat flour were optimized using Design Expert Software. The criteria used along with the predicted and actual values of the response are given in (Table 4). The aim of the experiment was to utilize pearl millet flour to develop pizza base by maximizing the sensory parameters and physical attributes. The solution which was obtained was pearl millet flour of 30g and refined wheat flour of 30g with best fit desirability of 0.824 as showed in Figure 2 and indicated that the present design successfully meets the optimisation criteria. The optimized results of sensory parameters were colour 6.28, flavour 6.37, texture 6.64, taste 5.84, OAA 6.33 in (score) and physical attributes were dough weight 81.61 g, proofing area- before 11.77 cm and after 11.94 cm, proofing height-before 3.86 cm and after 3.73 cm, baking area-before 11.50 cm and after 13.30 cm, baking height-before 0. 69 cm and after 1.71 cm. The predicted response value as against actual value for responses as shown in Table 4 were in concurrence with each other, hence the similar fitted models are suitable for predicting the responses. Tasty cereal bars were developed with prebiotic functional properties using three sources of fibres: inulin, oligo fructose and gum acacia [22]. The authors used a simplex-centroid design, considering these three components. The response variables were degree of liking and the attributes selected (brightness, dryness of cereals flakes, banana volatile odour, cinnamon volatile odour, banana flavour, sweetness, crunchiness, hardness, chewiness). Applying the optimization technique of Derringer-Suich, two optimal formulations were detected: 50% inulin, 50% oligofructose and 50% gum acacia and/or 8.46% inulin, 66.16% oligofructose, and 25.38% gum acacia. Pepper-based appetizers were developed in the form of convenient beverage mixes [23]. They used a central composite rotatable design without any blocking. The authors tested the effect of black-gram flour, milk powder, salt and pepper powder on the overall acceptability of test samples. The experimental data were used to fit a second order polynomial equation, indicating the model was not so suitable to express the actual results, once it presented a low adjusted regression coefficient. Corn–flaxseed snacks were prepared aiming at obtaining the maximum Expansion Ratio (ER), as the sensory quality and the acceptance of snack foods depend mainly on this variable and texture parameters [24]. They analysed the effects of three independent extrusion parameters (variables), moisture content, temperature and flaxseed flour content on the expansion ratio. By using a centre composite design, the authors concluded that the factor levels that resulted in a maximum expansion ratio (3.93) were: humidity-19%, temperature -123°C, and flaxseed content of about 25%. By many of the research conducted it is proven that RSM is utilised for the development of foods products by using a statistical approach. Therefore, in the present study, RSM was very useful to optimize the concentration of pearl millet flour and refined wheat flour in the development of Pearl millet pizza base (Figure 3).

Table 4: Predicted and actual response values.

Parameters	Predicted	Actual (n=4)
Pearl millet flour (gm)	30	-
Refined wheat flour (gm)	30	-
Colour (Score)	6.28	7.25 ± 0.67
Flavour (Score)	6.37	7.28 ± 0.70
Texture (Score)	6.64	7.28 ± 0.79
Taste(Score)	5.84	7.27 ± 0.77
OAA(Score)	6.33	7.40 ± 0.71
Dough weight (gms)	81.61	82
Proofing area-before (cms)	11.77	9.5
Proofing area-after (cms)	11.94	11
Proofing height-before (cms)	3.86	1.3
Proofing height-after (cms)	3.73	3.6
Baking area-before (cms)	11.5	12
Baking area-after (cms)	13.3	14
Baking height-before (cms)	0.69	0.3
Baking height-after (cms)	1.71	1.4
Desirability	0.824	

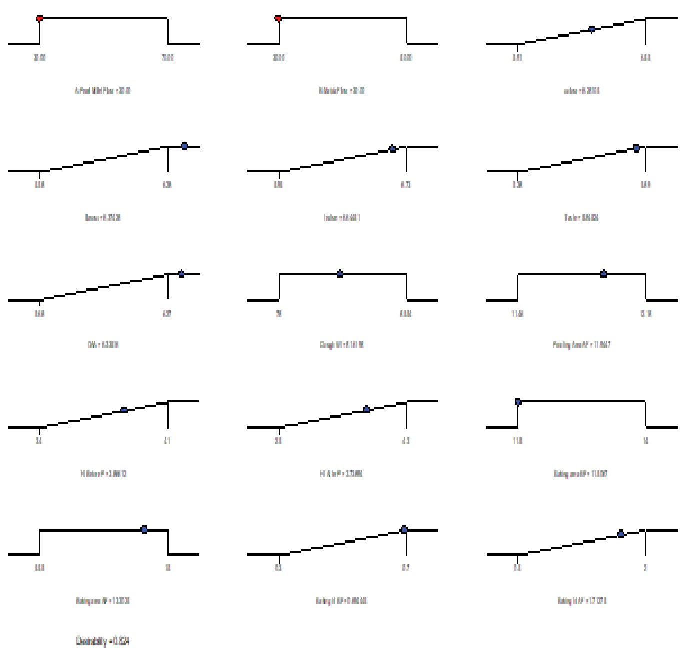

Figure 3: Optimised batch of pearl millet pizza base.

CONCLUSION

The result of the study showed the application of Response Surface Methodology (RSM) for optimizing the ingredients and process showed that quadratic response surface models were fitted. R2 value was more than 80 - 90% showed fitness of the polynomial regression models for describing the effect of variables. For other responses like taste, proofing area-after, proofing height-before and after, and baking area- before, the R2 value was lesser than 80%, but because of the subjective nature of the response the model is considered significant. The empirical models fits the actual data as the value of R2 was closer to unity. The result of the study indicated that the effect of pearl millet flour and refined wheat flour were significant to all the selected responses. Response surface methodology could be useful in optimizing the pearl millet flour and refined wheat flour with maximum retention of sensory parameters and physical attributes. The sensory parameters of product with good colour, texture and flavour were acceptable with 6.6 score on 9-point hedonic scale. The pearl millet flour and refined wheat flour were optimized with 30 g each with the best fit desirability of 0.824. From the study, it can be concluded that the optimized pearl millet pizza base was nutritionally superior and helps to promote utilization of pearl millet grain in urban areas and to open new markets for farmers to improve their income.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

1. Malik M, Singh U, Dahiya S. Nutrient composition of Pearl millet as influenced by genotypes and cooking methods. J Food Sci Technol. 2002;39(5):463-468.
2. Anu Sehgal S, Kwatra A. Nutritional evaluation of pearl millet based sponge cake. J Food Sci Technol. 2006;43(3):312-313.
3. Mudahar GS, Toledo RT, Floros JD, Jen JJ. Optimization of carrot dehydration process using response surface methodology. J Food Sci. 1989;54(3):714-719.
4. Shieh RC, John SA, Lee JK, Weiss JN. Inward rectification of the IRK1 channel expressed in Xenopus oocytes: Effects of intracellular pH reveal an intrinsic gating mechanism. J Physiol. 1996;494(2):363-376.
5. Vega A, Espinoza G, Gomez C. Lobster fishery spp. In: Study of the fishing potential of Baja California Sur. 1 CIBNOR. 1996;227-261.
6. Devaki CS, Premavalli KS. Development of fermented beverage using RSM and nutrients evaluation-I. fermented ashgourd beverage. J Food Res. 2012;1(3):138.
7. Devaki CS, Premavalli KS. Development of bittergourd fermented beverage using response surface methodology. J Pharma Nutr Sci. 2012;2(1):94-103.
8. Myers RH, Montgomery DC, Vining GG, Borror CM, Kowalski SM. Response surface methodology: A retrospective and literature survey. J Qual technol. 2004 Jan 1;36(1):53-77.
9. Henika RG. Simple and effective system for use with response surface methodology. Cereal Sci Today. 1972;17(10):309.
10. Henika RG. Use of response surface methodology in sensory evaluation. Food Technol. 1982;36(11):96-101.
11. Giovanni M. Response surface methodology and product optimization. Food technol. 1983;37(11):41-45.
12. Meilgaard MC, Carr BT, Civille GV. Sensory evaluation techniques. CRC press. 1999;24:419.
13. Resurreccion AV. Consumer sensory testing for product development. Food Sci. Nutr. 1998;1:268.
14. Lee WC, Yusof S, Hamid NS, Baharin BS. Optimizing conditions for hot water extraction of banana juice using Response Surface Methodology (RSM). J Food Engineer. 2006;75(4):473-479.
15. Rudolph MJ. The food product development process. In developing new food products for a changing marketplace. CRC Press. 2007:75-89.
16. Schutz HG. Multiple regression approach to optimization. J Food Technol. 1983;37(11): 46-48.
17. Mendenhall W, Beaver RJ, Beaver BM. Introduction to Probability and Statistics: Study Guide. Duxbury Press; 1975;4:753.
18. Singh SB, Sharma A, Yadav DK, Verma SS, Srivastava DN, Sharma KN et al. High altitude effects on human taste intensity and hedonics. Aviat Space Environ Med. 1997;68(12):1123-1128.
19. Wadikar DD, Nanjappa C, Premavalli KS, Bawa AS. Development of ginger based ready-to-eat appetizers by response surface methodology. Appetite. 2010;55(1):76-83.
20. Wadikar DD, Nanjappa C, Premavalli KS, Bawa AS. Development of ready-to-eat appetisers based on pepper and their quality evaluation. J Food Sci Technol. 2010;47(6):638-643.
21. Balasubramanian S, Yadav DN, Kaur J, Anand T. Development and shelf-life evaluation of pearl millet based upma dry mix. J food sci technol. 2014;51(6):1110-1117.
22. Dutcosky SD, Grossmann MV, Silva RS, Welsch AK. Combined sensory optimization of a prebiotic cereal product using multicomponent mixture experiments. Food chem. 2006;98(4):630-638.
23. Wadikar DD, Majumdar TK, Nanjappa C, Premavalli KS, Bawa AS. Development of shelf stable pepper based appetizers by Response Surface Methodology (RSM). LWT-Food Sci Technol. 2008;41(8):1400-1411.
24. Trevisan AJ, Arêas JA. Development of corn and flaxseed snacks with high-fibre content using Response Surface Methodology (RSM). Int J Food Sci Nutr. 2012;63(3):362-367.