Optimization of Wheat Bran and Refined Flour for The Development of Fiber Rich Pasta

***Running Title**: Development of fiber rich pasta by using response surface methodology*

Nidhi, Reshma Saroj, Monika Singh and Devinder Kaur*

Center of Food Technology, University of Allahabad, Allahabad, 211002

*Email Id.: devi_sonu@yahoo.com

Background- As a by-product derived from roller milling of wheat flour production, wheat bran has high dietary fiber content, which contains 44-50% of fiber and can be incorporated into food products to alter the nutritional quality of foods.

Objective- In this research paper, the development of fiber-rich pasta with supplementation of wheat bran and analyzed by dietary fiber, total phenolic acid, free radical scavenging capacity, color value, overall acceptability and flavour.

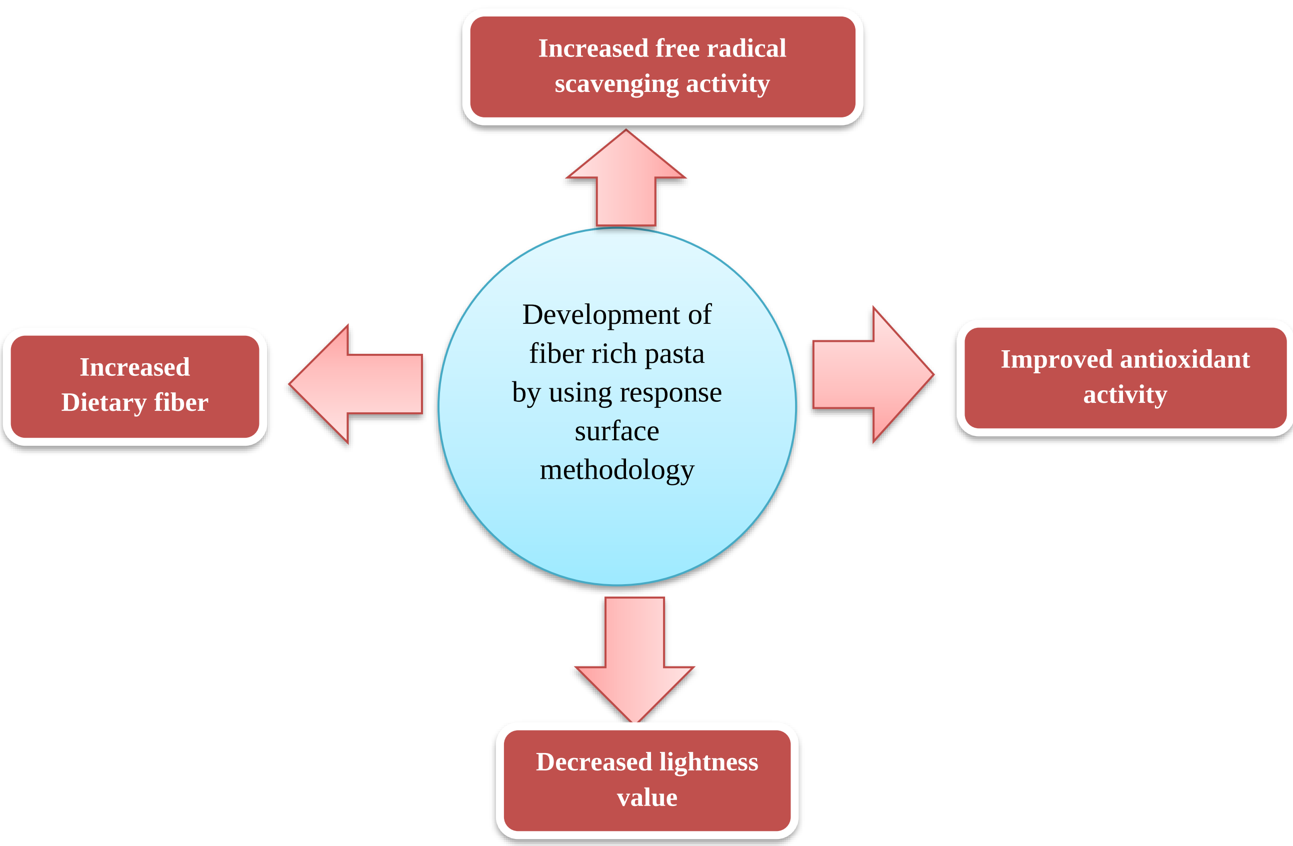
Methods- In present study, the methods used i.e., TPC and FRAP content for antioxidant properties, dietary fiber determined by enzyme-gravimetric method.

Results- This study was found out that an increase in bran ratio increased the percent of dietary fiber, total phenolic acid, and free radical scavenging capacity of pasta. Percentage of wheat bran can also affected the color value of pasta in which reduced L* values while a* and b* values increased. The flavour and overall acceptability of the wheat bran enriched pasta increases at certain after that, it could be decrease and the flavour of pasta was reduced with the increasing of wheat bran.

Conclusion- The functionality of wheat bran enriched pasta has observed more high dietary fiber and health benefits. In future, the wheat bran enriched pasta food products can be used in the prevention of chronic diseases like colon cancer, heart diseases, diabetics, etc.

Keywords- Wheat bran**,** Dietary fiber, Total Phenolic acid, Free radical scavenging capacity, Response surface methodology

Graphical Abstract



1. Introduction

Pasta is wet extrudes, it would be any kind of shape and size which is made from ground grain with or without the addition of eggs and/or additives by dough formation, shaping and drying without the use of any fermentation or baking process. Pasta is a staple food of traditional Italian cuisine. Pasta is considered healthy snack, it has a low level of fat and sodium and rich in carbohydrates, and a good source of protein content [1]. Commonly, traditional pasta is made by using durum wheat semolina to deliver a protein-rich food product with unique quality properties [2]. Typically, pasta is a noodle made from an unleavened dough of semolina, mixed with water or eggs and formed into sheets of various shapes and dried in an oven then cooked by boiling or baking. It can also be made with flour from other cereals or grains. Usually, the basic ingredients of pasta are wheat flour or semolina, water, salt, and oil. Alternatives include potato flour and maize flour (in gluten-free products). As wheat bran derived staple food, pasta is the second most consumed in the world after bread. It is almost worldwide acceptance, and it attributed to its low cost, easy preparation, versatility, nutritional quality, sensory attributes, and long self-life [3] [4]. Marketing of pasta is fast growing in India as it is very much acceptable between young generations of India. With changing life style, the food habits of people are also changing. Now the food habits are changing towards a more balanced and fiber rich diet. Fiber is considered as one of the important constituents of modern diet. High fiber food generally has a low fat content, especially saturated fatty acids, cholesterol, and is normally low in sugar. High fiber is a very good way to prevent obesity. As a source of wheat bran provides a number of health benefits in relation to coronary heart disease, colon cancer, and obesity related diseases.

In the present study, attempts were made to optimize and develop pasta to improve the nutritional quality by incorporating wheat bran with semolina. Further physical and chemical analysis of pasta has been done.

2. Materials and Methods

2.1 Preparation of pasta

Wheat bran, semolina, and water were weighed according to the experimental design (Table1). Dough was prepared by mixing all ingredients, and rested for half an hour. Then it was extruded in the extruder machine. Extruded samples were dried in a tray at 60^0C to final moisture content 7-8%. Samples were packed in polythene and stored for analysis at room temperature.

2.2 Dietary fiber

Dietary fiber of enzymatically treated wheat bran pasta was determined according to the enzyme-gravimetric method [5]. 1g fat-free dried pasta samples were kept in 250 ml of beaker with the addition of heat-stable α-amylase (3,000 Ceralpha units/ml) to gelatinization and then enzymatically digested with proteases (350 tyrosine unites/ml) and amyloglucosidase (3,300 unites/ml of soluble starch) at 60℃ for 30 minutes. Insoluble dietary fiber was filtered with Whattman (no. 42) filter paper, and then the obtained residue was washed with distilled water. Combined solution of filtrate and water washing are precipitated with 4 volumes of 95% ethanol for soluble dietary fiber determination. The remaining residue was filtered two times with 20ml of 78% ethanol and 20ml of acetone, and then the precipitate was dried in an oven (at 105℃ for 3 hour) and weighed for further steps. Soluble and insoluble dietary fiber was calculated as weight of the residue subtracting from the weight of the ash, protein, and blank of the sample. Total dietary fiber was calculated as the sum of the soluble dietary fiber content and insoluble dietary fiber content.

2.3 Total phenolic content

The total polyphenol content of the aqueous methanolic extract of pasta samples was determined according to the 'Folin ciocalteu method'. A 1ml aliquot of the sample extract was taken in a test tube. After that, 5ml. of diluted folin ciocalteu reagent (1:10 with distilled water) and 4ml of sodium carbonate solution (7.5%, w/v) were added sequentially to each tube. Soon after mixing, the test tubes were placed in the dark for 60 minutes at room temperature and the absorbance was monitored by UV-VIS spectrophotometer (model Evolution 600) at 765nm against a blank as standard. A standard curve was prepared with "Gallic acid" and the results were expressed in terms of mg/100g of polyphenols present in the sample. Samples were analyzed in triplicate and the mean was calculated [6].

2.4 Percent Free Radical Scavenging Activity (DPPH activity)

The DPPH (2,2-diphenyl 1-pycril hydrazil) radical scavenging activity of pasta sample extracts was measured according to the method given by [7] with slight modification. As per method, 150µl of DPPH solution (4.3mg in 3.3ml. of methanol) was mixed with 3ml acidified methanolic extract of selected cereal varieties. The mixture was shaken and the decrease in absorbance was measured at 515nm with the help of UV/VIS spectrophotometer after 15 minutes incubation at room temperature. DPPH solution was used as control.

$$\% \text{ free radical scavenging activity} = \frac{(A_{control} - A_{sample}) \times 100}{A_{control}}$$

2.5 Color value

Color value of the pasta sample was measured using X-rite (Grandville, MI, USA). The color attributes, i.e., Hunter lightness (L^*), redness (a^*), and yellowness (b^*), were recorded three times for each sample (n=3) according to the method of [8].

2.6 Sensory evaluation

The sensory properties of the developed product samples were evaluated by a semi-trained panel of 10 judges recruited from amongst the research scholars and faculty members of the Centre of Food Technology, University of Allahabad, India. A sensory score sheet specially designed comprising 3 sensory attributes namely color, flavour and overall acceptance was given to each judge. A structured 9 point hedonic scale ranging from „like extremely", „like very much or „high" rated 9 points, to „dislike extremely", „dislike very much" or „low" rated 1 point was used to numerically describe the sensory attributes of the samples [19].

2.7 Optimization of wheat bran and refined flour for the development of pasta

The Interest on cereal fibers due to their important physiological role is growing increased to produce high functional quality pasta from unconventional raw materials [10]. However, fiber rich pasta is essential micronutrients with low glycemic index components may be preferred by the consumers. Indeed, consumers are increasingly interested in foods containing health-promoting ingredients due to their benefits associated with satiety, digestion, weight management and obesity prevention [11]. Other studies have also been reported the awareness use of wheat bran, wheat germ, and whole wheat grains in pasta matrix [12] [13].

The aim of the study is to develop a high fibre pasta supplement with wheat bran with the help of response surface methodology (RSM). Table 4 shows the actual and coded values of the independent variables used for the experimental design. Table 2 shows the 13 experimental combinations and the effect of the two selected independent variables, i.e., wheat bran and refined flour on the dependent variables viz. Dietary fibre, total phenolic content, free radical scavenging activity, color, overall acceptability, and flavour. The response variables were fitted with quadratic model. The second-order polynomial equation was used to model the efficient correlation between the process variables (independent variables) and the responses (dependent variables). Table 1 shows the regression coefficient which represents the relationship between the responses and the process variables. It is important to analyse the significance of the data which is done by analysis of variance (ANOVA). The model for all the responses was found to be fit as coefficient of determination (R^2) varied between 0.927-0.997% and the lack of fit was found to be non-significant for all responses (Table 2). The observed data showed comparability with the second-order regression model supporting the high value of R^2 and also confirmed normal distribution of all errors. The adjusted coefficient of determination (adjusted R^2) was also high ranging between 0.84 -996 % showing that the developed model was significant. The predicted R^2 is the measure of amount of variation in new data as explained by the model. The adequate precision indicates the signal-to -noise ratio which compares the range of predicted values to the average prediction error. The ratio greater than 4 is desirable and indicates adequate model discrimination [14]. The sufficient variability of the model is explained by the linear term, square term, and interaction term.

Table 1. Actual and coded values of independent variables used for the experimental design of pasta

Variables	**Code**	**Coded level**				
		-α	**-1**	**0**	**+1**	**+α**
Refined flour (g)	A	5.86	10	20	30	34.14
Wheat bran (g)	B	8.96	10	12.5	15	16.04

The three-dimensional surface representation was plotted to study the interaction among the two process factors and to predict the combined effects of factors, i.e., refined flour (A) and wheat bran (B) on the responses of the pasta.

3. Response surface methodology

The effect of wheat bran and refined flour on dietary fibre, total phenolic content, free radical scavenging activity, color, overall acceptability, and flavour of pasta is shown in (Table 2). The independent and dependent variables were fitted to the second-order model equation and evaluated for the goodness of fit. The lack of fit was measured of the failure of the model to represent data in the experimental domain in which parts were not included in the regression.

Figure 1. Development of wheat bran supplement pasta

4. Results and Discussion

4.1 Effect of independent variables on dietary fiber wheat bran supplemented with pasta

Dietary fiber from wheat bran mainly contains cellulose, lignin, and hemicellulose, of which the major portion consists of insoluble fiber. Present study showed the fine particle sizes were obtained from the inner layers of the bran fraction, which contain less fiber then the outer layers of wheat. Wheat bran was known as a low-cost and rich source of dietary fiber (36-52%) [15] [16]. The importance in the development of dietary fiber enriched foods has increased significantly due to the consciousness about the health of consumers and food industry [17]. The regression coefficients for second-order polynomial equation represent the relationship between the process variables and responses (Table 1). It showed the linear, square, and interaction effects of independent variables on the responses. The magnitude of p-value implies that the linear terms, i.e., refined flour (A) and wheat bran (B); and the square term of wheat bran (B_2^2) has significant effect ($p < 0.05$) on the dietary fiber of pasta. These results showed that the increase in the dietary fiber (12.87) was basically due to the increase in the amount of wheat bran and this increased value of dietary fiber was desirable. The highest dietary fiber content was found in experiment no. 7 where wheat bran (B) was 34.14g and refined flour (A) was 12.5g. The magnitude of coefficient (β) values showed that the linear term of variables had a positive effect on the dietary fiber content. Similar study was conducted by [18], [19] demonstrating that commercially available whole-grain pasta is often characterized by considerably lower levels of dietary fiber.

Table 2 Matrix of experimental central composite rotatable design (CCRD) for the optimization of quantity of wheat bran (g) and refined flour (g) for the preparation of pasta

Run	Factor 1 A: refined flour (g)	Factore 2 B:Wheat bran (g)	Response 1 Dietary fibre (%)	Response 2 TPC (GAE mg/100g)	Response 3 DPPH (%)	Response 4 Color	Response 5 Overall acceptability	Response 6 Flavour
1	15.00	10.00	7.12	92.36	32.87	9.3	9.5	9.4
2	8.96	20.00	9.41	112.54	42.36	8.5	8.9	8.3
3	12.50	20.00	11.02	112.02	41.65	8.7	7.2	6.9
4	12.50	20.00	10.88	113.32	41.25	8.1	7.8	7.3
5	10.00	30.00	12.02	124.85	50.12	7.6	7.3	7.2
6	12.50	20.00	10.54	111.54	41.05	8.3	7.1	7.1
7	12.50	34.14	12.87	130.67	53.58	5.4	6.1	6.8
8	15.00	30.00	11.65	125.87	50.62	7.2	7.6	7.5
9	12.50	20.00	10.12	113.98	42.65	8.6	7.3	7.4
10	10.00	10.00	7.93	93.22	32.24	9.4	9.2	9.1
11	16.04	20.00	8.32	111.84	41.58	8.6	8.1	8.7
12	12.50	20.00	11.24	112.68	42.74	8.5	7.5	7.5
13	12.5	5.86	5.44	83.68	25.64	9.6	8.8	9.2

The wheat bran has a positive effect ($\beta_2 = 2.39$) and refined flour has a negative effect ($\beta_1 = -0.37$) than wheat bran supplemented pasta. The interaction term ($\beta1, \beta_2 = 0.11$) as well as the square term (${\beta_1}^2 = -0.78$) & (${\beta_2}^2 = 0.63$) showed negative effect on dietary fiber content. The response surface quadratic model showed F- value of 34.81 at $p<0.05$ (Table 3) "lack of fit value" of 0.45 indicates that the lack of fit is non –significant. The coefficient of determination (R^2) 0.96, which indicates that 96% of the variation was explained by the model. The adjusted R^2 was 0.93, which indicates that 93% of the variation as explained by the model. The multiple regression equation of the model was obtained for the dietary fiber content (in terms of actual factors) is as follows:

Dietary fibre =-13.26097+2.89593A +0.43810B + +4.40000E-003AB -0.12480A^{2}-6.35000E-003 B^{2}

The regression equation was graphically represented by the 3D response plot (Figure 1) in which the curve lines represent the line of responses and the effect of two factors on the responses could be visualized at one time. The plot showed that an increase in wheat bran caused enhancement in the dietary fiber content. The dietary fiber content of the wheat bran is high, and it is shown by the contour line that as the wheat bran increase, the appreciable increase of dietary fiber content was found in pasta. Recently, the importance of consuming dietary fiber has increased owing to its relation to the reduction of blood cholesterol level, lower inulin demand, and improved laxative properties [20]**.** The recommended daily intake of total dietary fiber ranges from 30 to 38g/day for males and 21to 26g/day for females [20]**.** Dietary fibers play many important physiological functions and can play an important role in reducing the potential glycemic index [21].

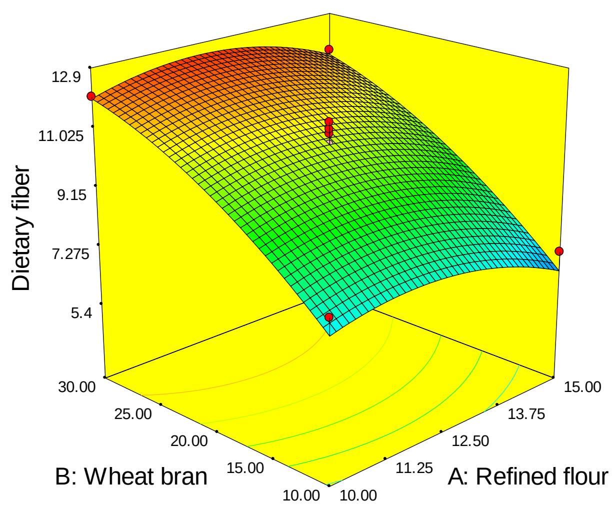


Figure 2. Response surface plot showing the effect of wheat bran (g) and refined flour (g) on dietary fibre content of pasta (X)- Refined flour

(Y)- Wheat bran

(Z)- Dietary fibre

4.2 Effect of independent variables on total phenolic content of wheat bran supplemented with pasta

Total phenolic content (TPC) was expressed as milligrams of gallic acid equivalent (mg GAE/100g) per 100 grams (mg/g) of dry flour samples. The total phenolic contents (mgGAE/100g) were determined by the Folin-Ciocalteau assay. The regression coefficients for second-order polynomial equations represent the relationship between the process variables and responses (Table 1). It showed the linear, square and interaction effects of independent variables on the responses of pasta. The magnitude of p-value implies that the linear terms, i.e., refined flour (A) and wheat bran (B); and the square term of wheat bran (B_2^2) has significant effect ($p < 0.05$) on the total phenolic content of pasta. This showed that the increase in the total phenolic content was basically due to the increase in the amount of wheat bran in pasta. The highest total phenolic content (130.67) was found in experiment no. 7 where wheat bran (B) was 34.14 g and refined flour (A) was 12.50g. The magnitude of coefficient (β) values showed that the linear term of variables had a positive effect on the total phenolic content. The wheat bran has positive effect ($\beta_2 = 0.79$) and refined flour has negative effect ($\beta_1 = -0.0057$) on wheat bran supplemented pasta. The interaction term ($\beta 1$, $\beta_2 = 0.0.023$) as well as the square term ($\beta_1^2 = -0.019$) & ($\beta_2{}^2 = -0.17$) showed negative effect on the total phenolic content. The response surface quadratic model showed F- value of 643 at p<0.05 (Table 3) "lack of fit value" of 0.009 indicates that the lack of fit is non–significant. The coefficient of determination (R^2) 0.997, which indicates that 97% of the variation was explained by the model. The adjusted R^2 was 0.996, which indicates that 99% of the variation as explained by the model. The multiple regression equation of the model was obtained for the total phenolic content (in terms of actual factors) is as follows:

$$\textit{Total Phenolic Content} = +6.17024-0.47965A -0.025819B +5.90171E\text{-}005AB +0.018958A^2+2.02307E\text{-}004\, B^2$$

The regression equation was graphically represented by the 3D response plot (Figure 2) in which the curve lines represent the line of responses and the effect of two factors on the responses could be visualized at one time. The plot showed that an increase in wheat bran caused an enhancement in the total phenolic content. The total phenolic content of the wheat bran is high, and it is shown by the contour line that as the wheat bran increase, the appreciable increase of total phenolic content was found in pasta.

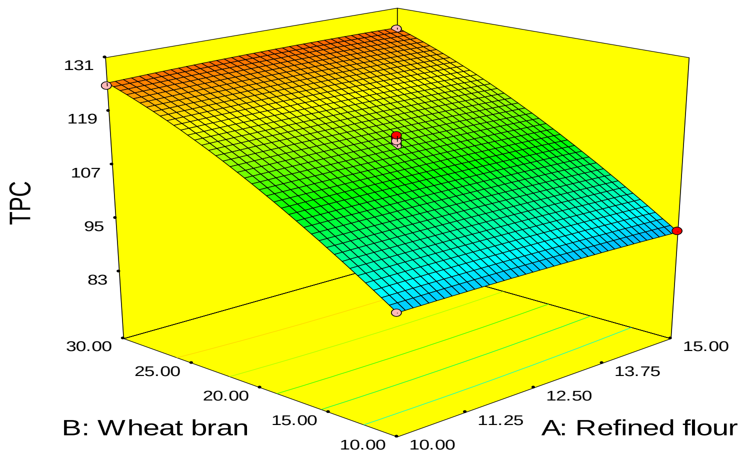


Figure 3. Response surface plot showing the effect of wheat bran (g) and refined flour (g) on total phenolic content

(X)- Refined flour

(Y)- Wheat bran

(Z)- Total phenolic content

4.3 Effect of independent variables on free radical scavenging activity of wheat bran supplemented pasta

The regression coefficients for second-order polynomial equations represent the relationship between the process variables and responses (Table1). It shows the linear, square and interaction effects of independent variables on the responses. The magnitude of p-value implies that the linear terms, i.e., refined flour (A) and wheat bran (B); and the square term of wheat bran (B_2^2) has significant effect ($p < 0.05$) on the free radical scavenging activity of pasta. This showed that the increase in the free radical scavenging activity was basically due to the increase in the amount of wheat bran and this increase of free radical scavenging activity was desirable. The highest free radical scavenging activity (53.58) was found in experiment no. 7 where wheat bran (B) was 34.14 g and refined flour (A) was 12.5. The magnitude of coefficient (β) values showed that the linear term of variables had a positive effect on the free radical scavenging activity. The wheat bran has a positive effect ($\beta_2 = 0.75$) and refined flour has a negative effect ($\beta_1 = -0.0006$) on the free radical scavenging activity of pasta. The interaction term ($\beta 1, \beta_2 = 0.000499$) as well as the square term ($\beta_1^2 = -0.021$) & ($\beta_2^{\,2} = -0.21$) showed negative effect on free radical scavenging activity. The response surface quadratic model showed F- value of 132.9 at $p<0.05$ (Table 3) "lack of fit value" of 0.011 indicates that the Lack of fit is not –significant. The coefficient of determination (R^2) 0.989, which indicates that 98% of the variation was explained by the model. The adjusted R^2 was 0.982, which indicates that 98% of the variation as explained by the model. The multiple regression equation of the model was obtained for the free radical scavenging activity (in terms of actual factors) is as follows:

$$\text{Free radical scavenging activity } \% = +4.94792-0.078169A+0.12626B-1.99833E-004AB+3.29721E-003A^2-1.22712E-003B^2$$

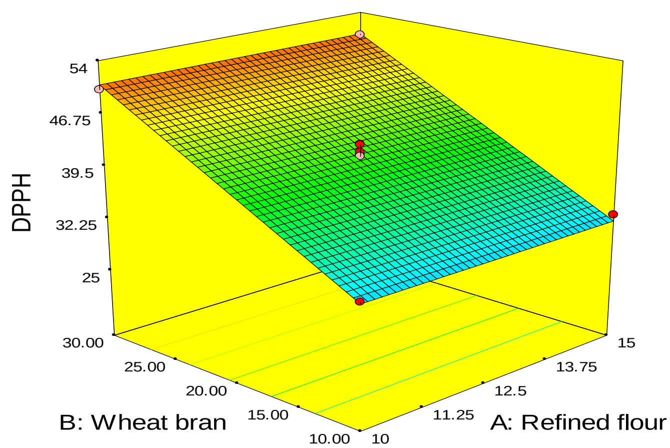


Figure 4. Response surface plot showing the effect of wheat bran (g) and refined flour (g) on free radical scavenging activity.

(X)- Refined flour

(Y)- Wheat bran

(Z)- DPPH

4.4 Effect of independent variables on the color of wheat bran supplemented pasta

The color of the pasta was measured by the X-rite color lab using 'L', 'a' and 'b' values. 'L' value decreased significantly with the increase in the levels of wheat bran. The regression coefficients for second-order polynomial equations represent the relationship between the process variables and responses (Table 1). It shows the linear, square and interaction effects of independent variables on the responses. The magnitude of p-value implies that the linear terms, i.e., refined flour (A) and wheat bran (B); and the square term of wheat bran (B_2^2) has significant effect ($p < 0.05$) on the color of pasta. This showed that the decrease in the color value was basically due to the increase in the amount of wheat bran. The highest color value (9.6) was found in experiment no. 13 where wheat bran (B) was 5.86 g and refined flour (A) was 12.5. The magnitude of coefficient (β) values showed that the linear term of variables had negative effect on the color value. The wheat bran ($\beta_2 = -1.23$) and refined flour had a negative effect ($\beta_1 = -0.045$) on the color of pasta. The interaction term ($\beta 1, \beta_2 = -0.075$) as well as the square term ($\beta_1^2 = 0.14$) & ($\beta_2{}^2 = 0.38$) showed positive effect on the total phenolic content of pasta. The response surface quadratic model showed F- value of 13.35 at $p<0.05$ (Table 3). The "lack of fit value" of 0.0011 indicates that the lack of fit is non–significant. The coefficient of determination (R^2) 0.927, which indicates that 92% of the variation was explained by the model. The adjusted R^2 was 0.87, which indicates that 87% of the variation as explained by the model. The multiple regression equation of the model was obtained for the color value (in terms of actual factors) is as follows:

$$Color = +3.61406--0.10139A+0.016644B-5.71764E-004AB+4.38162E-003A^2- 7.90836E-004\,B^2$$

The regression equation was graphically represented by the 3D response plot (Figure 4) in which the curve lines represent the line of responses and the effect of two factors on the responses could be visualized at one time. The plot showed that an increase in the wheat bran caused a decrease in color value. The color of the wheat bran pasta is low, and it is shown by the contour line that the color of pasta was reduced with increasing percentage of wheat bran. [22] Reported lightness, redness, blueness of wheat bran was 66.60, 7.17, and 2.20, respectively which supported the present study. [23] Reported lightness and hue value of wheat bran were 65.84 & 59.25, respectively, which were found lower than the present study. Measurements of the color of the pasta showed that the pasta became darker with increasing level of wheat bran [24]. [25] reported the textural properties of pasta that were recognized as more important parameter for consumers. [26] Reported color value of pasta samples with 20% corn intensified the pasta color by a significant increase in *a** and *b** values. [27]

Reported the color value of noodles and observed that with the increase in wheat bran, the dough sheet had reduced L* values while a* and b* values increased, which was similar to the present study.

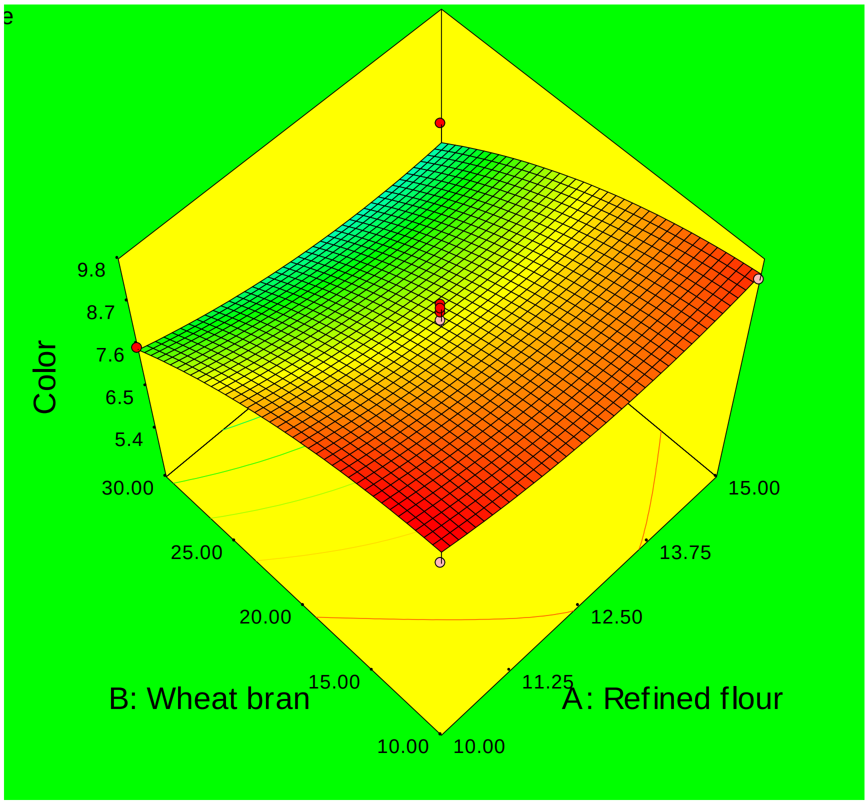


Figure 5. Response surface plot showing the effect of wheat bran (g) and refined flour (g) on color value

(X)- Refined flour

(Y)- Wheat bran

(Z)- Colour value

4.5 Effect of independent variables on overall acceptability of wheat bran supplemented pasta

The regression coefficients for second-order polynomial equations represent the relationship between the process variables and responses (Table 1). It shows the linear, square and interaction effects of independent variables on the responses. The magnitude of p-value implies that the linear terms, i.e., refined flour (A) and wheat bran (B); and the square terms of wheat bran (B_2^2) have significant effect ($p < 0.05$) on the overall acceptability of pasta. This showed that the decrease in the overall acceptability (6.1) was basically due to the increase in the amount of wheat bran. The highest overall acceptability (9.5) was found in experiment no. 1 where wheat bran (B) was 10 g and refined flour (A) was 15g. The magnitude of coefficient (β) values showed that the linear term of variables had a negative effect on the overall acceptability. The wheat bran ($\beta_2 = -1.7$) and refined flour had a negative effect ($\beta_1 = -0.011$) on the overall acceptability of pasta. The interaction term ($\beta 1, \beta_2 = -0.0014$) as well as the square term ($\beta_1^2 = 0.12$) & ($\beta_2^2 = 0.020$) showed negative effect on the overall acceptability. The response surface quadratic model showed F- value of 13.74 at $p<0.05$ (Table 3) "lack of fit value" of 0.007 indicates that the Lack of fit is non-significant. The coefficient of determination (R^2) 0.90, which indicates that 90% of the variation was explained by the model. The adjusted R^2 was 0.84, which indicates that 84% of the variation as explained by the model. The multiple regression equation of the model was obtained for the overall acceptability (in terms of actual factors) is as follows:

$$\text{Overall Acceptability} = +6.17024-0.47965A-0.025819B+5.90171E\text{-}005AB+0.018958\,A^2+2.02307E\text{-}004\,B^2$$

The regression equation was graphically represented by the 3D response plot (Figure 5), in which the curve lines represent the line of responses and the effect of two factors on the responses could be visualized at one time. The plot showed that an increase in the wheat bran caused an increase in overall acceptability. The overall acceptability of the wheat bran pasta increases at a certain level after that it could be decrease with the increasing of wheat bran. The results of overall acceptability were in accordance with the results of earlier studies, where it was also concluded that pasta acceptance decreased with wheat bran incorporation [12] [28] [13]. Overall, the results obtained in the present study were in agreement with data reported by other studies, specifically, pasta enriched with dietary fiber was significantly darker when compared with reference [29] [30][10].

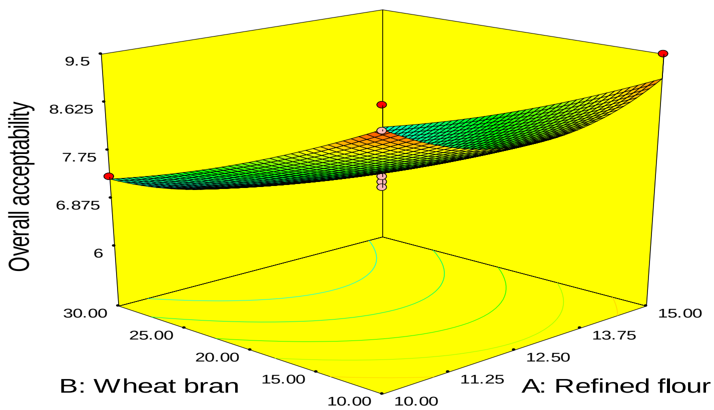


Figure 6. Response surface plot showing the effect of wheat bran (g) and refined flour (g) on overall acceptability

(X)- Refined flour

(Y)- Wheat bran

(Z)- overall acceptability

4.6 Effect of independent variables on Flavor of wheat bran supplemented pasta

The regression coefficients for second-order polynomial equations represent the relationship between the process variables and responses (Table 1). It shows the linear, square and interaction effects of independent variables on the responses. The magnitude of p-value implies that the linear terms, i.e., refined flour (A) and wheat bran (B); and the square term of wheat bran (B_2^2) has significant effect ($p < 0.05$) on the flavor of pasta. This showed that the decreases in the flavour were basically due to the increase in the amount of wheat bran. The highest flavor (9.4) was found in experiment no. 1 where wheat bran (B) was 10 g and refined flour (A) was 15g. The magnitude of coefficient (β) values showed that the linear term of variables had a negative effect on the flavor. The wheat bran ($\beta_2 = -1.6$) and refined flour had a negative effect ($\beta_1 = -0.025$). The interaction term ($\beta 1$, $\beta_2 = -0.00015$) as well as the square term ($\beta_1^2 = 0.11$) & ($\beta_2^{\ 2} = 0.067$) showed positive effect on flavor. The response surface quadratic model showed F- value of 50.99 at $p<0.05$ (Table 3) "lack of fit value" of 0.0019 indicates that the Lack of fit is not significant. The coefficient of determination (R^2) 0.97, which indicates that 97% of the variation was explained by the model. The adjusted R^2 was 0.94, which indicates that

94% of the variation as explained by the model. The multiple regression equation of the model was obtained for the flavor (in terms of actual factors) is as follows:

$$Flavor=+6.02554-0.44909A-0.043356B+6.00990E\text{-}005AB+0.018319\ A^2+6.70626E\text{-}004\ B^2$$

The regression equation was graphically represented by the 3D response plot (Figure 6), in which the curve lines represent the line of responses and the effect of two factors on the responses could be visualized at one time. The plot showed that an increase in the wheat bran caused a decreased in flavor. The flavor of the wheat bran pasta increases at a certain level, after that, it could be decreases, and it was shown by the contour line that the flavor of pasta was reduced with the increasing of wheat bran.

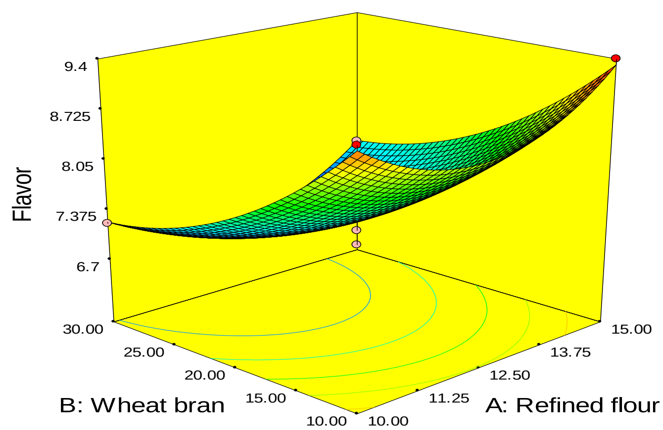


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Figure 7. Response surface plot showing the effect of wheat bran (g) and refined flour (g) on flavor

(X)- Refined flour

(Y)- Wheat bran

(Z)- Flavor

Table 3. Analysis of variance (ANOVA) data for the responses

Source of variance	Df	Dietary fibre (%) (mean square)	F Value	TPC (GAE mg/100g) (mean square)	F Value	DPPH (%)(mean square)	F Value	Color (mean square)	F Value	Overall Accept	F Value	Flavour (mean square)	F Value
Regression	5	10.59	34.81	1.05	643	352.9	132.9	0.089	15.35	0.066	13.74	0.063	50.99
Linear	2	46.66	153.3	5.08	3090	705.8	648.2	0.395	68.2	0.231	48.12	0.2	165.4
Square	2	7.04	23.13	0.20	124.4	0.10	15.65	0.049	1.4	0.098	20.95	1.4	99.21
Interaction	1	0.048	0.16	0.002	1.24	0.009	0.015	0.008	0.14	0.0018	0.0018	0.009	0.007
Lack of Fit	3	0.45	2.35	0.009	0.46	0.011	3.03	0.0011	6.53	0.007	3.00	0.0019	0.96
Pure error	4	0.19		0.0021		0.003		0.0017		0.0021		0.002	
Total	12												
R^2 (%)		0.96		0.997		0.989		0.927		0.907		0.97	
R^2 (adj) (%)		0.93		0.996		0.982		0.875		0.84		094	

Table 4. Regression co-efficient for second-order polynomial equations representing the relationship between response and process variables for pasta

Variables	Dietary fiber		TPC		DPPH		Color		Flavor		Overall acceptability	
	Co-efficie	P-value	Co-efficie	P-value	Co-efficie	P-value	Co-efficie	P-value	Co-efficie	P-value	Co-efficie	P-
Intercept	10.7	<0.0001	10.62	<0.0001	6.47	<0.0001	8.44	0.0007	2.69	<0.0001	2.72	0.0017
A	-0.34	0.1246	-0.0057	0.7006	0.0006	0.9935	-0.045	0.7528	0.025	0.0820	-0.011	0.6597
B	2.39	<0.0001	0.79	<0.0001	0.75	<0.0001	-1.23	<0.0001	-0.16	<0.0001	-0.17	0.0002
AB	0.11	0.7019	0.023	0.3014	0.00499	0.9075	-0.075	0.7098	0.0015	0.9342	0.0014	0.9672
A^2	-0.78	0.0074	-0.019	0.2618	0.021	0.533	0.14	0.3638	0.11	<0.0001	0.12	0.0028
B^2	-0.63	0.0189	-0.17	<0.0001	-0.21	0.0059	0.38	0.0351	0.067	0.0015	0.020	0.4663

Wheat bran enriched pasta has specific organoleptic characteristics that influence their consumer acceptability. Although this product is a safe and effective remedy against certain digestive and metabolic diseases, it remains little appreciated by the consumer. This study aimed to determine the possibility of producing wheat bran enriched pasta to obtain high-quality functional food products.

4.7 Optimization and characterization of pasta

Numerical optimization for determining the best possible combination of the independent variables in order to produce the product of desired characteristics. The desired goals (maximize or minimize) for each independent variable and the responses were set as per requirement and importance (+ to +++++) was given to each factor as shown in Table -6. In order to get optimized result, the formulation was done with maximum TPC, DPPH, dietary fiber, flavor and overall acceptability. This was obtained by targeting the Refined flour to 30 g. The optimized combination of independent variables with the predicted values of responses was obtained by numerical optimization (Table-6). The optimized predicted responses were validated experimentally. The experimental trials were done in triplicate and found to be near to the predicted values within the acceptable limit (Table-6). Optimization was done by using a multiple response method called desirability. The optimum concentration was determined by superimposing the contour plots of all the responses and finding the region where amount of pasta was 'near' optimal for all the responses. Based on the results, it can be asserted that the *pasta* production was dependent on the interaction of the different factors. The predicted values of the responses under optimum condition of concentration are TPC126.331, DPPH 50.5426, Dietary fiber 11.57, Color 7.020, Flavor 7.703 and overall acceptability 5.748 respectively. The calculated desirability for this formulation was 0.905. This set of concentration was determined to be optimum by the RSM optimization approach and was used to validate experimentally. The experimental values, mean of three trials (Table- 6) were found to be in close agreement with the predicted values and were within the acceptable limits showed the adequacy of selected models.

Table 5. Constraints Set for the Optimization

Variables	Goal	Limits	Importance
Refined flour	is in range	10 – 15	3
Wheat bran	maximize	10 – 30	3
TPC	maximize	83.68 – 130.67	3
DPPH	maximize	25.64 – 53.58	3
Dietary fiber	maximize	5.44-12.87	3
Colour	is in range	5.4-8.9	3
Pasta flavour	Maximize	5.1-7.9	3
Overall acceptability (OAA)	Maximize	4.8-6.1	3

Table 6. Predicted and experimental values of responses for *pasta* using optimum process parameters

Independent variables		**Response variables**														**Desirability**
Refined flour	Wheat bran	**Dietary fiber**		TPC		DPPH		Color		Flavor		Overall acceptability				
		P	E	P	E	P	E	P	E	P	E	P	E			
14.83	30.00	11.57	12.85 ±0.88	126.331	125.84 ±0.79	50.5426	50.75 ±0.84	7.020	7.47 ±0.98	7.703	7.87 ±0.73	5.748	6.25 ±0.93			0.888

P=Predicted value, E= Experimental

5. Conclusion

Wheat bran rich in dietary fiber and an important ingredients for the new generations of healthy food products and increased the nutritional value of pasta. In addition, to the different level of wheat bran in refined flour, the dietary fiber and antioxidant properties of pasta samples were increased while the color and flavor was observed reduced. Thus, the quality of the high fiber pasta was acceptable, and good that higher level of bran was added to the refined flour. Therefore, this knowledge can be used to make more commercial food products.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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