ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 4, Issue, 11, pp.231-239, November, 2012

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

OPTIMIZATION OF PROCESSED AMARANTH GRAIN FLOUR CHAPATTI USING RESPONSE SURFACE METHODOLOGY

[1]Durgadevi R. and [1]Nazni .P

[1]Department of Food Science, Periyar University, Salem-636 011, TamilNadu, India

ARTICLE INFO

Article History:
Received 04th August, 2012
Received in revised form
03thSeptember, 2012
Accepted 26th October, 2012
Published online 23th November, 2012

Key words:
Chapatti,
Boiled amaranth grain flour,
Water,
Response Surface Methodology.

ABSTRACT

In the present investigation attempts have been made to process boiled amaranth grain (*amaranthus cruentus*) into flour and analyzing the physiochemical properties and proximate composition of flour and to develop fiber rich chapatti by the addition of optimized proportions of Wheat flour (WF), Boiled Amaranth Grain Flour (BAGF) and Water(W) with other ingredients using Response Surface Methodology (RSM) for acceptable Chapatti considering Carbohydrate, Protein, Fat, Fiber, Diameter, Product weight and overall acceptability as a response variables. Combinations of wheat flour, Boiled amaranth grain flour and Water with their lower and upper limits are 80-90g, 10-20g and 60-70g respectively were optimized by varying proportions to result a better quality chapatti. Whereas iodized salt and vegetable oil were kept constant for all formulations. Results revealed that, Response Surface Methodology (RSM) was applied for optimization, the multiple regressions was used to get optimum levels and it was found that desirable values of Carbohydrate (75.83g), Protein (13.16), Fat (3.45), Fiber (2.80 g), Diameter (6.19cm), Product weight (162.99g) and Overall Acceptability (7.30) was obtained for the corresponding optimum condition of wheat flour (80gm), boiled amaranth grain flour (20gm) and Water (70ml). Hence it is concluded that RSM was used successfully to optimize the level of wheat flour and boiled amaranth grain flour for the development of value added Chapatti.

INTRODUCTION

Wheat (Triticum aestivum) is the major food produce among all the cereal crops. It is a staple food of large segment of world population. Wheat is extensively used for production of flat breads (Shewry, 1994) such as the steam-leavened chapatti, a major source of nutrients (Dhingra, 2001) and staple diet common to Pakistan, India, and some parts of Africa (Nurul-Islam, 1987). About 85% of wheat consumption in India is in the form of chapattis. Amaranth grains are lentil-shaped, very small (approximately 1 mm diameter) and light (Belton & Taylor, 2002). These grains have high nutritional and functional values which are associated with the quality and quantity of their proteins, fats and antioxidant potential (Gorinstein *et al.,* 2007). Amaranth grains have been identified as low glycaemic index food.

A low glycaemic index food are very important in the dietary treatment of diabetes mellitus, increases satiety, facilitate the control of food intake and has other health benefits for healthy subject in terms of post-prandial glucose and lipid metabolism (Rizkalla, 2002). Regular consumption of Amaranth grains may have important protective effects on risk for cardiovascular disease. Unleavened bread (chapatti and roti) is the staple diet of people in the India, utilizing almost 90 percent of the wheat produced in the region. The objective of this study is to investigate the effect of boiling on Physiochemical and microstructure of the amaranth grain and to assess the nutritional characteristics and sensory quality of chapattis supplemented with boiled amaranth grain flour.

***Corresponding author:** naznip@gmail.com

MATERIALS AND METHODS

Boiling of Amaranth grain

Amaranth grain (*Amaranthus Cruentus*), wheat flour and table salt used for this investigation were procured from the Local market. All the ingredients procured from the market were checked for its purity. The boiling process of Amaranth grain was carried out with the standard procedure suggested by Sidhu and Scribel (1998).The boiled grains were dried and made into flour and paced in a air tight container for further analysis.

Physiochemical properties and microstructure of boiled amaranth grain and flour

Physical properties such as thousand grain weight and volume, hydration ratio and swelling capacity of the grain, rehydration ratio of grain flour was calculated by the method of Ranganna, (1986). Amylose and amylopectin content determined using spectrophotometer. The water absorption capacity and oil absorption capacity was determined by the method of Sathe *et al*, (1982) and the bulk density of the boiled amaranth grain flour was determined using Ige, (1984). The chemical properties such as moisture, total ash, crude fibre, protein and fat were determined using AOAC method. The carbohydrate was assessed using Anthrone method. Morphology of the grain was assessed by Scanning Electron Microscopy (SEM).

Preparation of chapatti

Whole wheat flour

↓

Boiled amaranth grains flour

↓

Add water and salt

↓

Made into dough

↓

Divided into balls

↓

Thin it in roll board and pin

↓

Heat the tawa and cook till it was done

Experimental design (central composite rotatable designs)

The Response Surface Methodology (RSM) is a widely adopted tool for the quality of optimizations processes (P.Nazni *et al.,* 2011). The RSM, originally described by Box and Wilson (1951) is effective for responses that affect many factors and their interactions. The central composite rotatable composite design (CCRD), (Box and Hunter, 1957) was adopted to predict responses based on few sets of experimental data in which all factors were varied within a chosen range. The experiment consisted of 8 factorial runs, 6 axial runs and 6 center runs. The 3 independent variables were Wheat flour (g) (X_1), Boiled amaranth grain flour (g) (X_2) and Water (ml) (X_3). Each variable was set at 5 levels and a total of 20 experiments were designed whereby formulation 15, namely the centre-point formulation, was repeated 6 times. The independent variables and their variation levels are shown in Table 1. The levels of each variable were established according to literature information and preliminary trials. The outline of the experimental layout with the coded and natural values is presented in Table 2.

Homogeneous variance is a necessary pre- requisite for (linear) regression models. Therefore, a reduction in variability within the objective response (dependent variables) was by transforming the data to standardized scores $Z = X - \bar{X} / S$ where X = dependent variable of interest; $\bar{X}$ = mean of dependent variable of interest and S = standard deviation). For each standardized scores, Analysis of Variance (ANOVA) was conducted to determine significant differences among the treatment combinations. Also, data were analyzed using multiple regression procedures (Design Expert Version 8.0). To estimate Wheat flour, Boiled amaranth grain flour and Water effect on each objective response such as Carbohydrate (Y_1), Protein (Y_2), Fat (Y_3), Fiber (Y_4), Diameter (Y_5), Cooked weight (Y_6) and Overall acceptability(Y_7) , the standardized scores were fitted to a quadratic polynomial regression model by employing a least square technique (Gacula and Singh, 1984; Wanasundara and Shahidi, 1996). The model proposed for each response of Y was:

$$Y= \beta_0+ \beta_1 X_1+ \beta_2 X_2+ \beta_3 X_3+ \beta_{11} X_1^2+ \beta_{22} X_2^2+ \beta_{33} X_3^2 + \beta_{12} X_1X_2+ \beta_{13} X_1X_3+ \beta_{23} X_2X_3$$

Where Y = the response, X_1= Wheat flour, X_2 = Boiled amaranth grain flour, X_3 = Water. β_0= intercepts, β_1, β_2, β_3 are linear, β_{11}, β_{22}, β_{33}, = are quadratic and β_{12}, β_{13} and β_{23} are interaction regression coefficient terms, respectively. Coefficients of determination (R^2) were computed. The adequacy of the model was examined based on three criterion, F value, Lack of Fit (LoF) and adequate precision value. The optimization was done by numerical optimization. Constraints were set to get the optimized coded value of the variable between the upper and lower limits of the variable. For each response, response surface plots were produced from the equations, by holding the variable with the least effect on the response equal to a constant value, and changing the other two variables.

Sensory evaluation of developed chapattis

The sensory evaluation was carried out in order to get consumer response for overall acceptability of the boiled amaranth grain flour supplemented chapatti compared to the control chapatti (Wheat). The developed chapattis were served hot for the sensory evaluation. Products were evaluated by a panel of 10 semi-trained judges for different sensory attributes like appearance, flavour, taste, texture and overall acceptability. A 9-point hedonic scale ranging from 1 to 9, where 1 = extremely dislike and 9 =like was used to evaluate acceptability of sample. Data were subjected to analysis of variance (ANOVA) using the SPSS software and differences among means were compared using Duncan's Multiple Range test. A significance level of 0.05 was chosen.

Statistical analysis

The analytical data obtained for BAGF chapattis were subjected to analysis of variance (ANOVA) (one way anova) using complete randomized design .The critical difference at $p<0.05$ was estimated and used to find significant difference if any.

FINDINGS

Microstructure and Physiochemical proprieties of Raw and Boiled amaranth grain and its flour

Microstructure of Boiled amaranth grain by SEM

Boiled grain microstructure assessed in the magnification range of 500. Boiled grain showed that the particles were clustered together in the way of shapeless or mud-like structure. In this sample starch grains are distributed evenly over the entire area and it had irregular-shape with relatively smooth surfaces compared to the raw amaranth grain with the spherical whole starch structures. However, the starch grains are spread evenly in the raw seed and it is clearly visible. The internal structure of starch is affected by heat treatment (Figures 1). Granules of small granule starches are characterized by their very irregular, polygonal shape (Jane et al., 1994). Afshari et al., 2011 stated that 1000 grain weight is a very important measure of grain quality, which is effective on sprouting, grain potential, graining growth, and plant performance. This quality is dependent on the size of embryo and reserved nutrients quantity used for sprouting and growth. When compared to raw grain (1.04g), the boiled amaranth grain weight was increased as 1.5g. This may be due to absorption water during boiling. Regarding grain volume,

Table 1. Independent Variables and Levels used for central composite rotatable design

Variable	Symbols	Coded variable level				
		-1.68(μ)	-1	0	1	1.68(μ)
Wheat flour (g)	X_1	76.59	80	85	90	93.40
Boiled amaranth grain flour (g)	X_2	5.47	10	15	20	26.47
Water (ml)	X_3	56.59	60	65	70	73.40

Table 2. Experimental design in their natural units and coded form

Design points	Independent variables in Uncoded form			Independent variables in coded form		
	X_1	X_2	X_3	x_1	x_2	x_3
1	80	10	60	-1	-1	-1
2	90	10	60	1	-1	-1
3	80	20	60	-1	1	-1
4	90	20	60	1	1	-1
5	80	10	70	-1	-1	1
6	90	10	70	1	-1	1
7	80	20	70	-1	1	1
8	90	20	70	1	1	1
9	76.59	15	65	-1.682	0	0
10	93.41	15	65	1.682	0	0
11	85	6.59	65	0	-1.682	0
12	85	23.41	65	0	1.682	0
13	85	15	56.59	0	0	-1.682
14	85	15	73.41	0	0	1.682
15	85	15	65	0	0	0
16	85	15	65	0	0	0
17	85	15	65	0	0	0
18	85	15	65	0	0	0
19	85	15	65	0	0	0
20	85	15	65	0	0	0

X_1= Wheat flour, X_2 = Boiled amaranth grain flour, X_3 = Water

Tablen 3. Physiochemical proprieties of both Raw and Boiled amaranth grain and its flour

S.No	Physiochemical proprieties	Raw Amaranth Grain (g/100g)	Boiled Amaranth Grain (g/100g)
1	Thousand Amaranth Grain weight	1.04 g	1.5g
2	Thousand Amaranth Grain volume	0.65ml	1ml
3	Amylose content	8.50 %	10.80%
4	Amylopectin content	38.50 %	48.20%
5	Water absorption of flour	2.13ml	3.84ml
6	Bulk density of flour	5.6g/ml	6.7g/ml
7	Moisture flour	7.4%	5.1 (%)
8	Total ash of flour	4.6%	4.2 (%)
9	Crude protein of flour	14.1%	13.3 (%)
10	Crude fibre of flour	7.2%	9.0 (%)
11	crude fat of flour	6.4%	6.6 (%)
12	Carbohydrate of flour	74.9	75(%)

Table 4. Regression coefficient (coded variables) from quadratic model and their significance

Coefficients	Carbohydrate (g)	Protein (g)	Fat(g)	Fiber (g)	Diameter (cm)	Cooked weight (g)	Overall acceptability (g)
Model	70.24^{**}	12.17^{**}	2.91^{**}	2.42^{**}	6.14^{**}	162.42^{*}	7.65^{NS}
X_1	3.39^{**}	0.61^{**}	0.095^{**}	0.084^{**}	0.58^{**}	3.04^{**}	-0.32^{NS}
X_2	3.81^{**}	0.64^{**}	0.45^{**}	0.33^{**}	0.029^{NS}	0.98^{NS}	-0.22^{NS}
X_3	-0.064^{NS}	0.000^{NS}	0.000^{NS}	0.000^{NS}	0.054^{NS}	0.07^{NS}	0.12^{NS}
X_1^2	-0.031^{NS}	0.058^{**}	0.018^{NS}	5.972^{*}	-0.059NS	-1.77^{NS}	-0.28^{NS}
X_2^2	-0.031^{NS}	-7.828^{NS}	0.019^{NS}	4.204^{NS}	-0.31^{**}	-0.36^{NS}	0.071^{NS}
X_3^2	-0.029^{NS}	0.029^{NS}	0.021^{NS}	5.972^{*}	-0.023^{NS}	-0.18^{NS}	0.071^{NS}
$X_1 X_2$	0.11^{NS}	0.000^{NS}	0.000^{NS}	0.000	0.025^{NS}	-1.00^{NS}	-0.25 NS
$X_1 X_3$	0.11^{NS}	-0.000^{NS}	0.000^{NS}	0.000	0.000^{NS}	-0.25^{NS}	0.000^{NS}
$X_2 X_3$	0.11^{NS}	0.08^{NS}	0.000^{NS}	0.000	0.000^{NS}	-0.25^{NS}	0.000^{NS}
F-value	<0.0001	<0.0001	<0.0001	<0.0001	0.0003	0.0299	0.8907
R^2	0.999	0.995	0.989	0.999	0.912	0.762	0.278
Adj R^2	0.9984	0.990	0.979	0.999	0.834	0.549	-0.370
Pred R^2	0.9931	0.966	0.984	0.998	0.457	-0.487	-3.926
Adeq precision	118.32	48.12	37.72	169.57	11.53	6.56	2.59
Lack of fit	NS	S	NS	NS	NS	NS	S

** - 1% significant level, * - 5% significant level
NS = Not Significant, S = Significant

boiled grain has more (1ml) value than raw grain (0.65ml), because boiling will explode the grain when subjected to high temperature. Amylose essentially consists of linear chains, with a small amount of branching. Approximately 25% of starch in the main cereal crops is amylose. Amylopectin, making up around 75% of the starch, consists of linear chains of glucose residues linked to other ramifications through alfa-1, 6 bonding. A high percentage of amylose in food leads to the formation of "resistant starch", stimulating the activity of the intestinal flora and inducing the production of protective substances against colon cancer. Besides, foods with "high amylose" have a low glycemic index, which is beneficial to 25% of the insulin-resistant population and, by stimulating the formation of HDL cholesterol, prevents cardiovascular disease (Kuswanto, *et al.,*

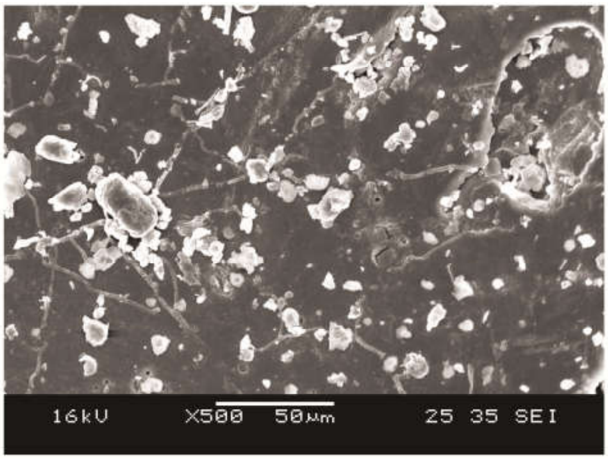

Fig. 1. Cross-Sectional morphologies of the boiled amaranth grain flour

2011). The amylose and amylopectin content of boiled amaranth grain was 10.08 and 48.20% respectively compared to raw grain which was only 8.5% and 38.5% respectively which showed that it has got high therapeutic value for the subjects with non-communicable diseases. The study results reports that, the water absorption capacity of the raw grain was less (2.13ml) compared to boiled grain (3.84ml), because higher the temperature, the greater the water absorption due to increased water diffusion rate (Sopade *et al*., 1992).

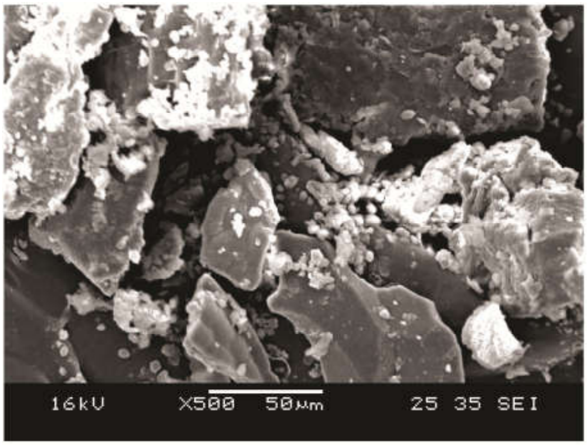

Fig. 2. Cross-Sectional morphologies of the raw amaranth grain flour

Bulk density is a measure of heaviness of a flour sample. The bulk density was affected by the processing method and dropped with moisture reduction. The high bulk density (6.7g/ml) compared to raw amaranth grain(5.6g/ml) may be due to the large particle size due to boiling as compared to the raw grain flour which had course particles. Grains are the storehouses of many chemical components including nutrients, phytochemicals, and non-nutritive plant protective functional constituents. The nutritive value of millets is comparable to other cereals with slightly higher contents of protein and minerals (Gopalan *et al.*, 2002). Except moisture, all the other nutrients value such as ash, protein, fiber and fat has been increased during processing compared to the raw amaranth grain.

Optimization of Boiled amaranth grain Flour Chapatti

The Chapatti prepared with the help of wheat flour, BAGF, water and Salt was characterized for its physiochemical and organoleptic characteristics. Carbohydrate (Y_1), Protein (Y_2), Fat (Y_3), Fiber (Y_4), Diameter (Y_5), Cooked weight (Y_6) and Overall acceptability (Y_7) was measured as response variables.

Diagnostic checking of fitted model and surface plot for various responses

Regression analysis indicated that the fitted quadratic model accounted that above 99% for carbohydrate, protein and fiber, 98% for fat, 91% for diameter, 76% for cooked weight and 27% for over all acceptability of the developed boiled amaranth grains flour incorporated chapatti. The values of regression coefficients, sum of squares, F values and P values for coded form of process variables are presented in Table 4.

Carbohydrate

The carbohydrate of the developed chapatti was ranged from 63.02 to 77.4g. The coefficient of determination R^2 was 99% of the regression model. The F value of the model is <0.0001 and lack of fit is not significant. The developed model for noodle in the form of uncoded (actual) process variables is as follows:

$Y_1(\text{Carbohydrate})=+70.24+3.39X_1+3.81X_2-0.064X3-0.031X_1^2-0.031X_2^2-0.029X_2^3+0.11X_1X_2-0.11X_1X_3+0.11X_2X_3$

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

$Y_1(\text{Carbohydrate})=-25.1258+1.1470x_1+0.061x_2+04865x_3-1.222x_1^2-3.3867x_2^2 1.1518x_2^3+2.3157x_1x_2-4.4000x_1x_3+2.3157x_2x_3$

The magnitude of P and F value in Table 4 indicates that the linear variables such as X1, X2 and interaction variables X_1X_2, X_1X_3, X_2X_3 had the positive contribution, the interaction variables such as X_1^2, X_2^2, X_3^2 and linear variable X_3 had negative contribution on Carbohydrate. The effect of Wheat flour, Boiled amaranth grains flour and Water on the carbohydrate level has been shown in Figs 3 to 5.

Diagnostic checking of fitted model and surface plot for various responses

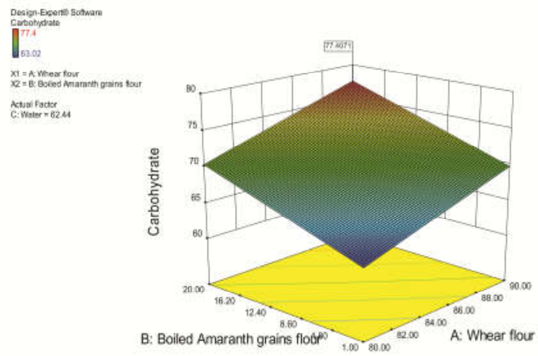

Fig. 3. Effect of BAGF and WF on Carbohydrate of Chapatti

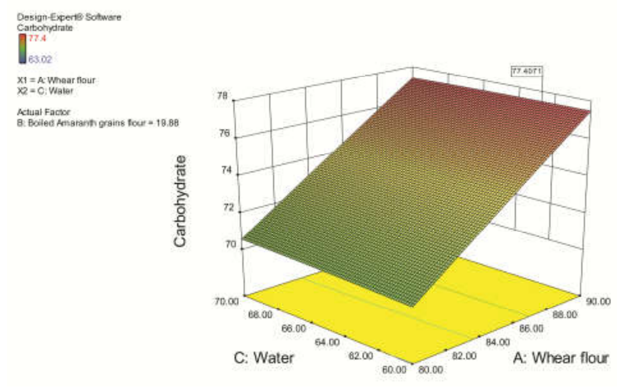

Fig. 4. Effect of Water and WF on Carbohydrate of chapatti

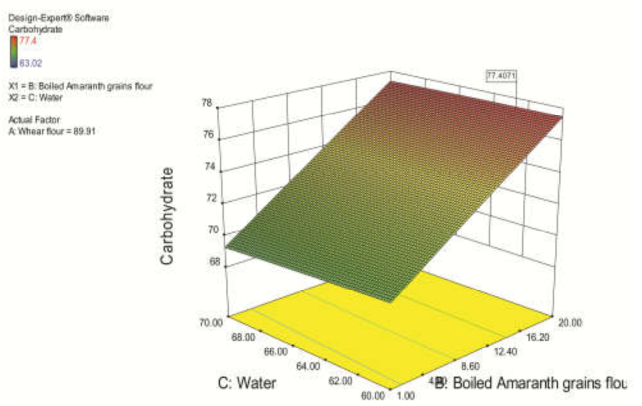

Fig. 5. Effect of Water and BAGF on Carbohydrate of chapatti

Protein

The Protein content of the developed noodles was ranged from 11.01 to 13.56g. The coefficient of determination R^2 was 99% of the regression model. The F value of the model is <0.0001 and lack of fit is significant. The developed model for chapatti in the form of uncoded (actual) process variables is as follows: Y_2(Protein)=$+12.17+0.61X_1+0.64X_2+0.000X3+0.058X_1^2 7.828 X_2^2+0.029X_2^3+0.000X_1X_2+0.000X_1 X_3+0.000X_2X_3$

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

Y_2(Protein)=$+22.6947-0.2698x_1+0.0691x_2-.1523x_3+2.3031x_1^2-8.6732x_2^2+1.1718x_2^3-1.6217x_1x_2+4.1607x_1 x_3-1.4461x_2x_3$

Diagnostic checking of fitted model and surface plot for various responses:

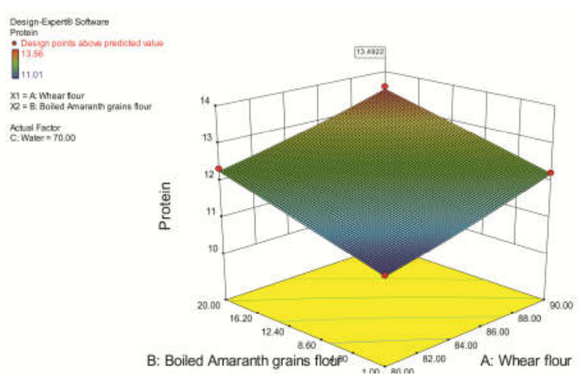

Fig. 6. Effect of BAGF and WF on Protein of chapatti

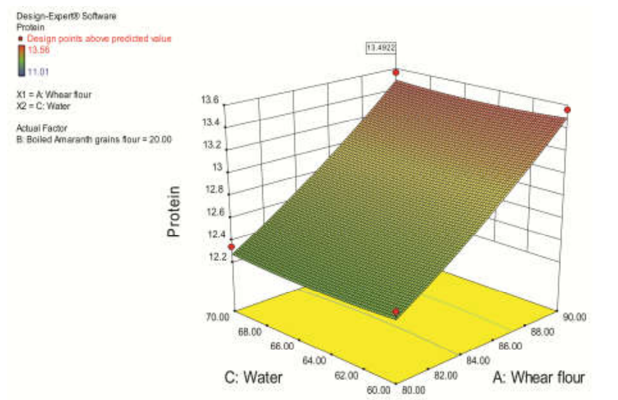

Fig. 7. Effect of Water and WF on protein of chapatti

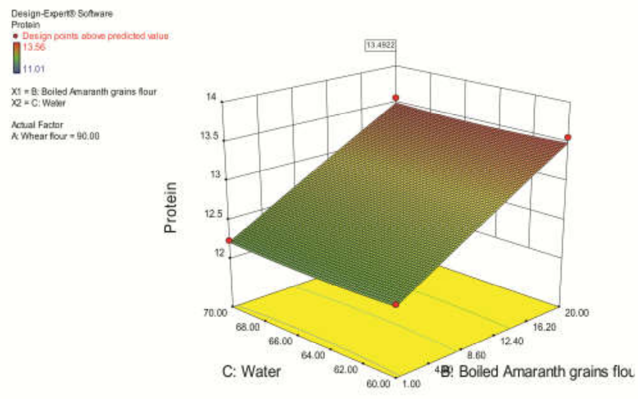

Fig. 8. Effect of Water and BAGF on protein of chapatti

The magnitude of P and F value of indicates the maximum positive contribution by the linear, quadratic and interaction variables. But X22 and X1X3 of quadratic and interaction variables had negative contribution for the fiber content. The effect of Wheat flour, BAGF and Water on the protein content has been shown in Figs 6 to 8.

Fat

The Fat content of the developed chapatti was ranged from 847.84±74.27 to 2.42to 3.51 g. The coefficient of determination R^2 was 98% of the regression model. The F value of the model is <0.0001 and lack of fit is not significant.

The developed model for noodle in the form of uncoded (actual) process variables is as follows:

Y_3(Fat)=$+2.91+0.095X_1+0.45X_2+0.000X3+0.018X_1^2+0.019X_2^2+0.021X_2^3+0.000X_1X_2+0.000X_1X_3+0.000X_2X_3$

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

Y_3(Fat)=$+9.45073-0.10027x_1+0.042829x_2-0.10960x_3+7.01662x_1^2+2.13954x_2^2+8.43083x_2^3-6.71421x_1x_2+1.15304x_1 x_3-8.00541x_2x_3$

The magnitude of P and F value indicates the maximum positive contribution on the fat content. The linear terms of X1, X2, X3 quadratic terms of X_1^2, X_2^2 and X_3^2 and interaction terms of X_1X_2, X_1X_3, X_2X_3 has the only positive effect on fat level. The effect of Wheat flour BAGF and Water on the fat content has been shown in Figs 9 to 11.

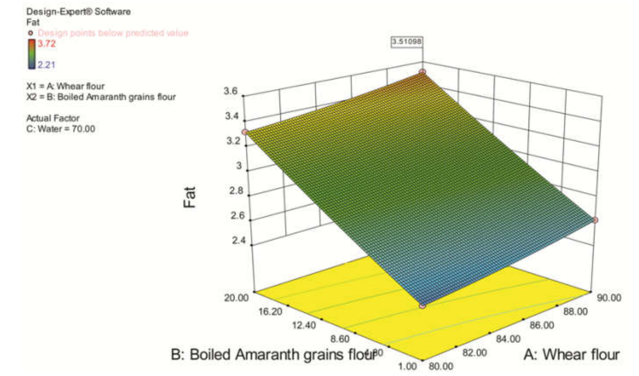

Fig. 9. Effect of BAGF and WF on Fat of chapatti

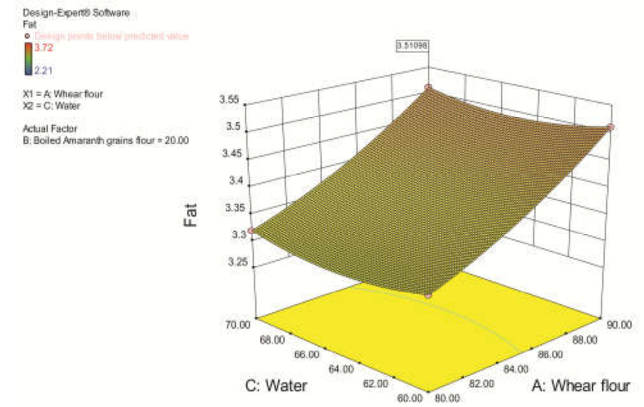

Fig. 10. Effect of Water and WF on Fat of chapatti

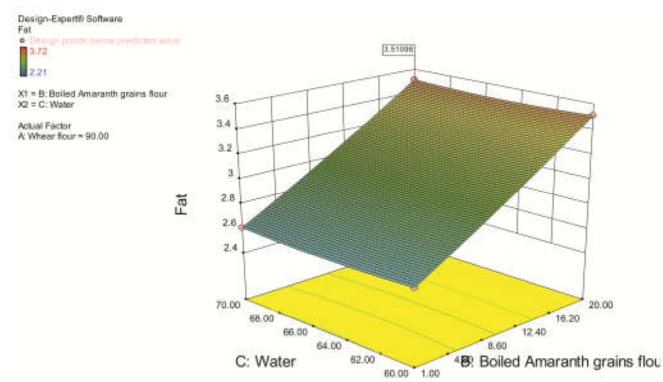

Fig. 11. Effect of water and BAGF on Fat of chapatti

Fiber

The Fiber content of the developed chapatti was ranged from 2.02 to 2.85 g. The coefficient of determination R^2 was 99% of the regression model. The F value of the model is <0.0001 and lack of fit is not significant.

The developed model for chapatti in the form of uncoded (actual) process variables is as follows

Y_4(Fiber)=$+2.42+0.084X_1+0.33X_2+0.000X3+5.972X_1^2+4.204X_2^2+5.972X_2^3+0.000X_1X_2+0.000X_1X_3+0.000X_2X_3$

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

Y_4(Fiber)=$+3.35919-0.02375x_1+0.033759x_2-0.031052x_3+2.38861x_1^2+4.65791x_2^2+2.38861x_2^3+0.0000x_1x_2+7.3598x_1x_3-1.23886x_2x_3$

The magnitude of P and F value indicates the maximum positive contribution on the fiber content. All the terms such as linear terms of X1, X2, X3 quadratic terms of X_1^2, X_2^2 and X_3^2 and interaction terms of X_1X_2, X_1X_3, X_2X_3 has only the positive effect on fiber input. The effect of Wheat flour, BAGF and Water on the fiber content has been shown in Figs 12 to 14.

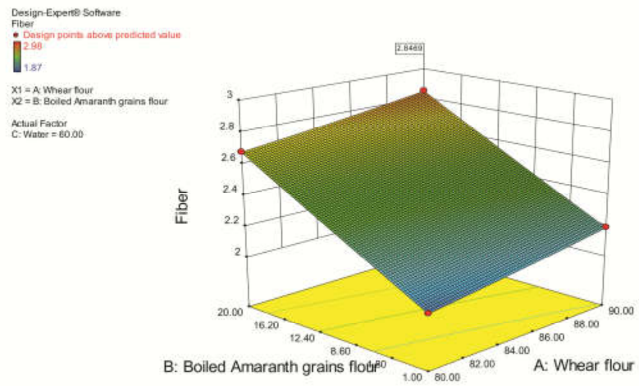

Fig. 12. Effect of BAGF and WF on Fiber of chapatti

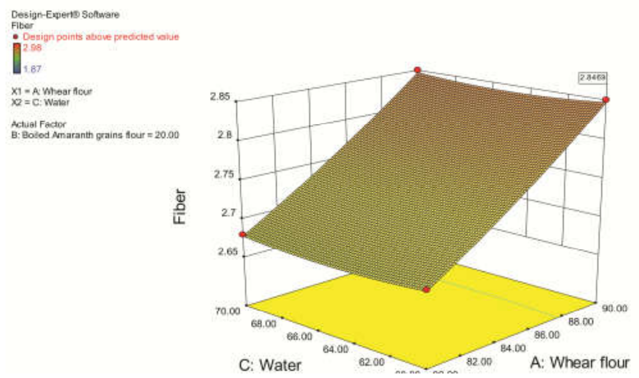

Fig. 13. Effect of Water and WF on Fiber of chapatti

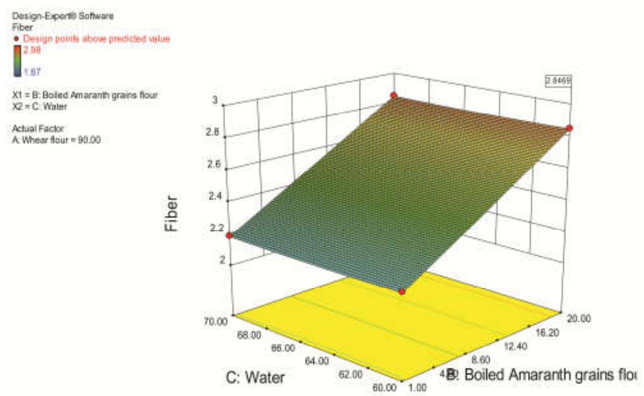

Fig.14: Effect of Water and BAGF on Fiber of chapatti

Diameter

The Diameter acceptability of the developed chapatti was ranged from 5 to 6.5. The coefficient of determination R^2 was 91% of the regression model. The F value of the model is 0.0003 and lack of fit is not significant.

The developed model for chapatti in the form of uncoded (actual) process variables is as follows

Y_5 (Diameter) =$+6.14+0.58X_1+0.029X_2+0.054X_3-0.059X_1^2-0.31X_2^2-0.023X_2^3+0.025X_1X_2+0.000X_1X_3+0.000X_2X_3$

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

Y_5 (Diameter=-5.32453+0.51026x_1+0.029522x_2+0.1321852x_3-2.34801x_1^2-3.39266x_2^2-9.33800x_2^3+5.26316x_1x_2-2.61028x_1 x_3-4.13699x_2x_3

The magnitude of P and F value indicates the maximum positive contribution and minimum negative contribution on the diameter of the product. All the terms such as linear terms of X1, X2, X3 quadratic terms of X_1^2, X_2^2 and X_3^2 and interaction terms of X_1X_2, X_1X_3, X_2X_3 has the positive effect on diameter. But X_1^2, X_2^2 and X_3^2.The effect of Wheat flour, BAGF and Water on the fiber content has been shown in Figs 15 to 17.

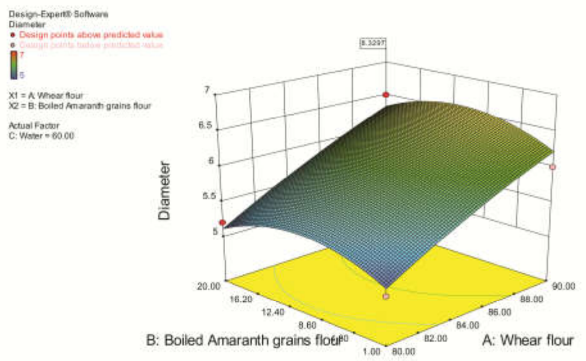

Fig. 15. Effect of BAGF and WF on Diameter of chapatti

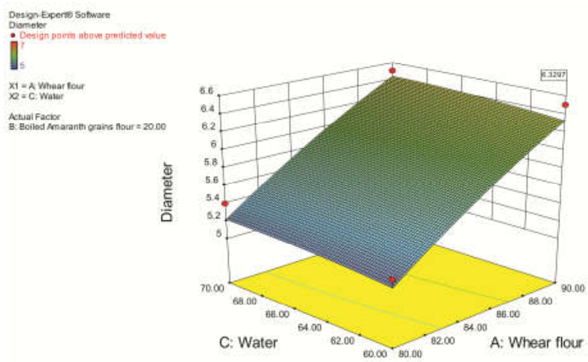

Fig. 16. Effect of Water and WF on Diameter of chapatti

Cooked chapatti weight (CCW)

The Cooked chapatti weight acceptability of the developed chapatti was ranged from 154 to 165. The coefficient of determination R^2 was 76% of the regression model. The F value of the model is 0.0299 and lack of fit is not significant.

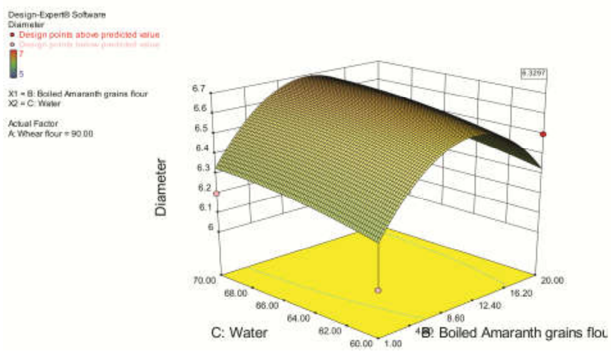

Fig. 17. Effect of Water and WF on Diameter of chapatti

The developed model for chapatti in the form of uncoded (actual) process variables is as follows

Y_6(CCW)=+162.42+3.04X_1+0.98X_2-0.077X3-1.77X_1^2-0.36X_2^2-0.18X_2^3-1.00X_1X_2-0.25X_1 X_3-0.25X_2X_3

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

Y_6 (CCW) = -509.2323+13.51555x_1+2.31737x_2+1.82087x_3-0.070800x_1^2-3.94237x_2^2-7.16089x_2^3-0.021053x_1x_2-0.010000x_1 x_3-5.26316x_2x_3

The magnitude of P and F value indicates the positive contribution and negative contribution on the cooked weight of the product. Expect the linear terms X_1, X_2, X_3, quadratic terms of X_1^2, X_2^2 and X_3^2 and interaction terms of X_1X_2, X_1X_3, X_2X_3 has the negative effect on product weight. The effect of Wheat flour, BAGF and Water on the weight of the product has been shown in Figs 18 to 20.

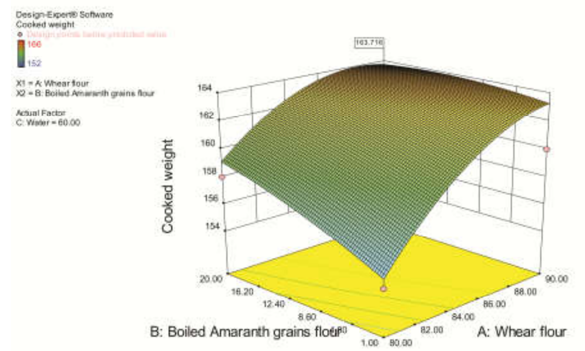

Fig. 18. Effect of BAGF and WF on Weight of chapatti

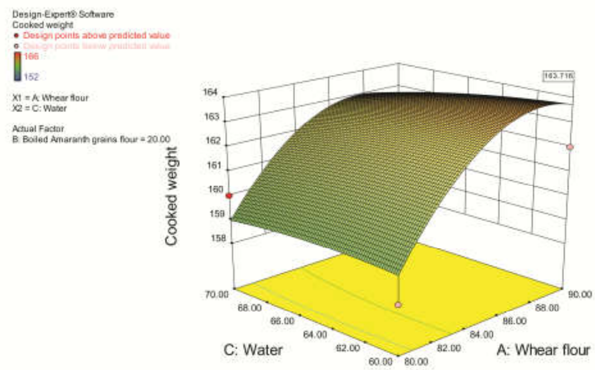

Fig. 19. Effect of Water and WF on weight of chapatti

Overall Acceptability

The overall acceptability of the developed chapatti was ranged from 7 to 9. The coefficient of determination R^2 was 27% of

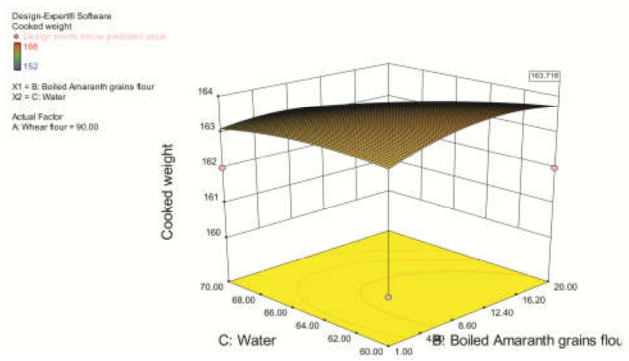

Fig.20. Effect of Water and BAGF on Weight of chapatti

the regression model. The F value of the model is 0.8907 and lack of fit is significant.

The developed model for noodle in the form of uncoded (actual) process variables is as follows:

Y_7(Overallacceptability)$=+7.65-0.32X_1-0.22X_2+0.12X_3-0.28X_1X_2+0.071X_1X_3+0.071X_2X_3-0.25X_1^2+0.000X_2^2+0.000X_3^2$

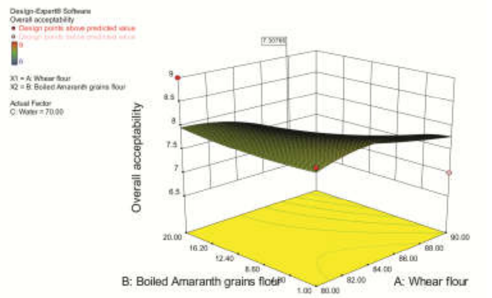

Fig. 21. Effect of BAGF and WF on Overall acceptability of chapatti

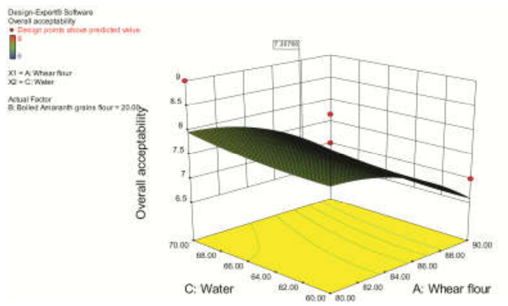

Fig. 22. Effect of Water and WF on Overall acceptability of chapatti

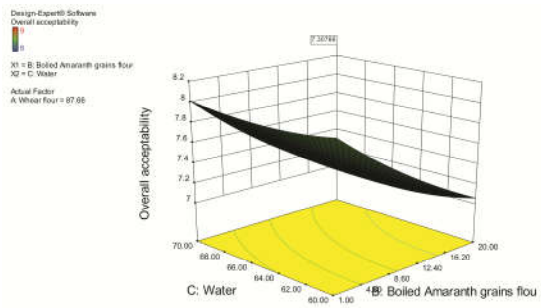

Fig. 23. Effect of Water and BAGF on Overall acceptability of chapatti

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

Y_7 (Overall acceptability) $=-62.79833+1.91630x_1+0.40747x_2-0.34235_{X3}-0.011319x_2+7.81963x_1x_3+2.82289x_2x_3-5.26316x_1^2-9.73457x_2^2+4.13182x_3^2$

The magnitude of P and F value in Table 4 indicates the linear terms of X_1 and X_2, quadratic terms of X_1^2, interaction terms of X_1X_2 had the negative effects. The effect of Wheat flour, Boiled amaranth grains flour and Water on the overall acceptability has been shown in Figs 21 to 23.

Criteria of optimum value for the responses

Table 5. Criteria of optimum value for the responses

Process variable	Optimum value	Response	Optimum value
Wheat flour (g)	80.00	Carbohydrate	75.83
Boiled amaranth grain flour (g)	20.00	Protein	13.16
		Fat	3.45
Water(g)	70.00	Fiber	2.80
		Diameter	6.19
		Cooked weight	162.99
		Overall acceptability	7.30

For the optimization variables, the responses, that is carbohydrate, protein, Fat, Fiber, Diameter, Cooked weight and overall acceptability were selected on the basis that these responses had direct effect on the acceptability and quality of chapattis. To consider all the responses simultaneously for optimization, the multiple regression was used to get compromise optimum conditions and it has found that the values were 75.83, 13.16, 3.45, 2.80, 6.19, 162.99 and 7.30 for carbohydrate (g), protein (g), Fat (g), Fiber (g), Diameter (cm), Cooked weight (g) and Overall acceptability respectively, corresponding to the optimum condition of Wheat flour 80g as X_1, Boiled amaranth grain flour 20g as X_2 and water 70ml as X_3. Among the 20 variations of chapattis, V10 have scored highest mean value (8.50) the other variations in appearance. In colour attributes, V8 obtained 8.70 of highest score than V6 (6.50). Regarding flavour attributes, the highest score 8.70 is obtained by the variation V7 which is followed by the variation V18 with least score of 8.00 is obtained.

Table 6. Organoleptic evaluation of the developed chapatti

Variations	Appearance	Colour	Flavour	Texture	Taste	Over all Acceptability
V_1	7.70 ±1.25[ab]	8.40 ±0.69	7.70 ±1.56[a]	6.70 ±2.00[abcde]	8.20 ±0.63[c]	8.20 ± 0.63[cd]
V2	8.0 ±0.66[b]	8.00 ±1.24[cd]	8.20 ±0.78[a]	7.20 ±1.75[abc]	8.30 ± 0.82[bc]	8.30 ± 0.82[cd]
V3	8.20 ±0.78[b]	8.10 ±0.99[bcd]	7.90 ±0.73[a]	8.20 ±0.78[abcd]	8.30 ±0.82[bc]	8.30 ±0.67[cd]
V4	8.40 ±0.69[b]	7.80 ±1.22[abcd]	8.40 ±0.69[a]	7.70 ±1.33[e]	8.30 ±0.67[bc]	8.10 ±0.56[cd]
V5	8.10 ±0.73[b]	7.80 ±1.22[abcd]	8.30 ±0.67[a]	7.00 ±2.00[abcde]	8.10 ±0.56[bc]	8.40 ±0.84[cd]
V6	8.40 ±0.69[b]	6.50 ±1.71[a]	8.10 ±0.73[a]	8.40 ±0.51[ab]	8.40 ±0.84[bc]	8.40 ±0.69[d]
V7	8.30 ±0.67[b]	7.40 ±1.50[abcd]	8.50 ±0.70[a]	8.10 ±0.73[abcde]	8.40 ±0.69[a]	8.30 ±0.67[cd]
V8	7.70 ±0.48[ab]	8.70 ±0.48[d]	8.20 ±0.78[a]	7.50 ±1.43[cde]	8.30 ±0.67[b]	8.00 ±0.66[cd]
V9	8.40 ±0.69[b]	7.60 ±1.83[abcd]	8.40 ±0.69[a]	7.90 ±1.28[abcde]	8.00 ±0.66[c]	8.40 ±0.84[cd]
V10	8.50 ±0.70[b]	6.70 ±2.00[ab]	8.20 ±0.63[a]	8.30 ±0.67[abcd]	8.40 ±0.84[c]	7.80 ±1.22[bc]
V11	8.00 ±1.05[b]	7.20 v1.75[abc]	8.30 ±0.82[a]	8.00 0.81[de]	8.20 ±0.78[bc]	7.80 ±1.22[cd]
V12	7.70 ±1.15[ab]	8.20 ±0.78[cd]	8.30 ±0.82[a]	7.70 ±1.25[cde]	8.40 ±0.69[c]	6.50 ±1.71[cd]
V13	7.80 ±1.39[ab]	7.70 ±1.33[abcd]	8.30 ±0.67[a]	8.0 ±0.66[abcde]	8.00 1.24[bc]	7.40 ±1.50[cd]
V14	6.80 ±1.61[a]	7.00 ±2.00[abc]	8.10 ±0.56[a]	8.20 0.78[bcde]	8.10 0.99[c]	8.70 ±0.48[d]
V15	8.00 1.56[b]	8.40 ±0.51[cd]	8.40 ±0.84[a]	8.40 ±0.69[cde]	7.80 1.22[c]	7.60 ±1.83[cd]
V16	7.70 ±1.25[ab]	8.10 ±0.73[cd]	8.40 ±0.69[a]	8.10 ± 0.73[bcde]	7.80 1.22[c]	6.70 ±2.00[cd]
V17	8.20 ±1.47[b]	7.50 ±1.43[abcd]	8.30 ±0.67[a]	8.40 ± 0.69[de]	6.50 1.71[c]	7.20 ±1.75[cd]
V18	8.20 ±0.78[b]	7.90 ±1.28[bcd]	8.00 ±0.66[a]	8.30 ± 0.67[abcde]	7.40 1.50[bc]	7.70 ±1.15[cd]
V19	8.10 ±0.73[b]	8.30 ±0.67[cd]	8.40 ±0.84[a]	6.80 ±1.61[abcde]	7.00 2.00[c]	7.80± 1.39[a]
V20	8.10 ±1.28[b]	8.00 ±0.81[bcd]	8.20 ±0.78[a]	8.00 ±1.56[a]	8.40 ±0.51[bc]	6.80 ±1.61[ab]
F value	1.35	1.976	0.599	2.082	3.018	3.856
P value	0 .158	0.012	0.904	0.007	0.000	0 .000

**-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)

In texture attributes, V6 scored highest of 8.40 than V1 which scored the least sore of 6.70. Regarding taste, the highest score of 8.40 is scored by the variations of V6, V7, V10, V12 and V20 and is followed by the least score by V18 and V19 with score of 7.40 and 7.00. Regarding over all acceptability attributes, the highest score 8.40 is scored by V5, V6 and V9 followed by the least score 6.50 is obtained by V12.Results of the Duncan's test revealed that there was significant difference for all the variations.

Conclusion

Response Surface Methodology (RSM) was used successfully to optimize the level of wheat flour, BASF and Water for the development of Chapatti. The incorporation of Boiled Amaranth Grain Flour (BASF) had an impact on the physicochemical and sensory properties of chapattis. The incorporation of BASF significantly increased in the nutrients. However, they had significantly decreased ($P<0.05$) acceptability of product when the flour increased. The sensory evaluation result showed there were only slight differences between the values of sensory attributes with the increasing incorporation of BASF. The overall acceptability of chapatti with high proximate composition (high fiber and normal carbohydrate) of the chapatti can be prepared using the combination of 80g of wheat flour, 20 g of boiled amaranth grain flour and 70ml of water. In conclusion, this study provides useful functional information for the future development of Amaranth Grain Flour-based food products.

REFERENCES

Atwell, W. 2001. Wheat Flour: practical guides for the food industry. USA: Eagan Press.

Belton, P. and Taylor, J. 2002. Pseudocereals and less common cereals: Grain properties and utilization potential, Springer, New York.

Billaud, C. Brun-Mérimée, S. Louarme, L. and Nicolas, J. 2004. Effect of glutathione and Maillard reaction products prepared from glucose or fructose with glutathione on polyphenoloxidase from apple—I: Enzymatic browning and enzyme activity inhibition. *Food Chemistry*, Vol. 84, pp. 223-233.

Box G.E.P. and Hunter J.S. 1957. Multifactor experimental design for exploring response surfaces. Annals Math. Stat, Vol. 28, pp.195-242.

Box G. E. P. and Wilson, K. B. 1951. On the Experimental Attainment of Optimum Condition". *Journal of the Royal Statistical Society*, Vol. 13, pp.1-45.

Dhingra S, Jood S. 2001. Organoleptic and nutritional evaluation of wheat breads supplemented with soybean and barley flour. *Journal of Food Chem,* Vol. 77, pp.479-488.

Fu B. X. 2008. Asian noodles: History, classification, raw materials, and processing Food Research International, Vol. 41, pp. 888-902.

Gacula Jr MC and Singh J. 1984. Statistical methods in food consumer research, New York; *Academic Press, Inc*, pp.214- 272.

Gorinstein, S. Vargas, O. J. M. Jaramillo, N. O., Salas, I. A. Ayala, A. L. M. Arancibia- Avila, P. Toledo, F. Katrich, E. & Trakhtenberg, S. 2007. The total polyphenols and the antioxidant potentials of some selected cereals and pseudocereals. European Food Research and Technology, Vol.225, pp.321–328.

Hou, G. and Kruk, M. 1998. Asian noodle technology. Technical Bulletin 20:10.

Hossein Afshari. Mostafa Eftekhari. Miad Faraji. Abdol Ghaffar Ebadi and Abbas Ghanbarimalidareh. 2011. Studying the effect of 1000 grain weight on the sprouting of different species of *Salvia* L. grown in Iran. *Journal of Medicinal Plants Research*, Vol. 5, pp. 3991-3993,

Khor. H and Chieng, D. 1997.*Journal of Nutr. Res*, vol. 17,pp. 475

Kaur, L. Singh, J. and Singh, N. 2005. Effect of glycerol monostearate on the physic-chemical, thermal, rheological and noodle making properties of corn and potato starches. *Food Hydrocolloids*, Vol.19, pp. 839-849.

Kuswanto K and Rahayu. 2004. Industrialization of tempe fermentation. In: Steinkraus KH. Industrialization of Indigenous Fermented Foods, 2nd ed, pp 587-635.

Lara N. & Rualse J. 2002. *J.Sci. Food Agric*, Vol. 82, pp.797-805.

Lim, H. X. 2006. Effects of konjac glucomnnan (KGM) and kansui addition of the physiochemical properties of wheat flour and yellow alkaline noodles. Universiti Sains Malaysia, Penang, Malaysia

Nazni.P. and Karuna thara, D. 2011. optimization of beetroot peel osmotic dehydration process using responseSurface methodology, *International journal of current research*, Vol. 3, issue, 8, pp.027-032.

Nurul-Islam MD, Johansen HB.1987. Physical chemical tests-A basis for selecting the size of wheat flour. *J Food Sci Technol*, Vol. 24, pp.136-138.

Owen,G. 2001. Cereal processing technology. Cambridge woodhead publishing.

Ranganna, S. 1986. "Handbook of analysis and quality control for fruit and vegetable products". Tata McGraw Hill Pub. Co. Ltd., New Delhi.

Rizkalla SW, Bellisle F, Slama G. 2002 Health benefits of low glycaemic index foods, such as pulses, in diabetic patients and healthy individuals*. Br. J. of Nutr*, Vol. 88, pp. 255-262.

Sopade, P.A., E.S. Ajisegiri and M.H. Badau. 1992. The use of Peleg's equation to model water absorption in some cereal grains during soaking. *Journal of Food Engineering*, Vol 15, pp. 269-283.

Shiau, S.Y. and Yeh, A.I. 2001. Effects of alkali and acid on dough rheological properties and characteristics of extruded noodles, *Journal of Cereal Science*, Vol.33, pp. 27-37.

Shewry PR, Tatham AS 1994 Wheat endosperm proteins and their impact on the human mankind. In Martino al Cimino S (Ed.), Wheat kernel proteins: molecular and functional aspects .Italy, University of Tuscia, Viterbo. pp. 19-26.

Sidhu and Scribel, 1998. Effect of flour milling conditions on the quality of Indian unleavened flat bread(chappathi) J.Fd.Sci.1998, 53;1563-1565.

Yalchin, S. and Basmani, A. 2008. Quality characteristics of corn noodles containing gelatinized starch, transglutaminase and gum. *Journal of Food Quality*, vol. 31, pp. 465-479.

Wanasaundara and Shahidi. 1996. Optimization of hexametaphosphate assisted extraction of flaxgrain proteins using response surface methodology. *J. Food Sci*, Vol.61, pp. 604-607.

****