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OPTIMIZATION OF OVEN-DRIED *MORINGA OLIFERA* FLOWER POWDER INCORPORATED CHAPPATHI USING RESPONSE SURFACE METHODOLOGY

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ABSTRACT

Drumstick flower has various medicinal properties like used to treat cold and anaemia and report to contain powerful antibiotic pterygospermin which has fungicidal properties. Wheat is one of the staple foods of the majority of Indian population. Whole wheat flour is mainly used for preparation of Chappathi. Hence the present study is undertaken to process drumstick flower into powder and analyzing the physiochemical properties and nutritive value of the powder and determine the optimal levels of wheat flour and oven dried drumstick flower powder (OD-DFP) using Response Surface Methodology (RSM) for acceptable Chappathi considering diameter, cooking time, weight, kneading time and overall acceptability as a response variables. Results revealed that, Response Surface Methodology (RSM) was applied for optimization, the multiple regression was used to get optimum levels and it was found that desirable values of diameter (14.87cm), cooking time (1.41min), weight (93.01gm), kneading time (4.12 min) and overall acceptability (8) was obtained for the corresponding optimum condition of wheat flour (90gm) and sun dried drumstick flower powder (5gm). Hence it is concluded that RSM was used successfully to optimize the level of wheat flour and oven dried drumstick flower powder for the development of value added chapathi.

INTRODUCTION

Among the various parts of the plant, vegetable flowers play an important role with good nutrients and therapeutic values by acting as a stimulant, tonic, diuretic and cholagogue (Jayabal, 2003). *Moringa oleifera*, commonly referred to simply as "Moringa" is the most widely cultivated species of the genus *Moringa*, which is the only genus in the family Moringaceae (Quattrocchi and Umberto, 2000). Drumstick flowers and leaves are good source of protein (Freiberger *et al.*, 1998). Drumstick flowers have been reported to be a rich source of carotene, protein, vitamin C, calcium and potassium and act as a good source of natural antioxidants; and thus enhance the shelf-life of fat containing foods due to the presence of various types of antioxidant compounds such as ascorbic acid, flavonoids, phenolics and carotenoids (Siddhuraju and Becker, 2003).

Drumstick flowers were used in treating cold and anaemia and report to contain powerful antibiotic pterygospermin which has fungicidal properties (Sreenivasan and Jyotsna, 2000). *Moringa* is free flowering. Flowering generally occurs 4–12 months after planting, depending on the type. Some selections flower 4–5 months after planting. According to Fahey, J.W. (2005), the medicinal use of *Moringa* the flowers are used to treat Throat infection, common cold, anthelmintic, anti-tumor,

rheumatism, diuretic, tonic, hysteria abortion. Drumstick flowers have seven times more vitamin C than oranges to fight many illnesses including cold and flu. Drumstick flowers are four times more vitamin A than carrots to protect against eye disease, skin disease, and heart disease. Drumstick flowers are four times more calcium than milk to build strong bones and teeth. They are three times more potassium than bananas essential for the functioning of the brain and nerves. Nearly 2 times the protein in milk and almost equal amounts of proteins as in eggs basic building blocks of all our body cells. The bark contains a gum that is used as a seasoning and a treatment for some stomach ailments (Murakami, 1998).

The word Dehydration means removing water or moisture from foods. Drying is the oldest known method of preserving food. Historically, food was dried in the sun. Nowadays, we can sundry or dry in an oven or a dehydrator that is especially designed for home drying (Singh *et al.*, 2001). Among the various types of processing techniques dehydration is considered to be an inexpensive method and imparts properties that are unmatched by any other preservation technique (Lakshmi and Radha, 2004).

Wheat is one of the staple foods of the majority of Indian population. Whole wheat flour is mainly used for preparation of chappathi and other traditional indigenous

products of wheat flour origin are poories, naans, kulchas, bathuras and so on (Sidhu and Scribel, 1998). The present study was undertaken with the objective to process drumstick flower into powder and analyzing the physiochemical properties of the powder and determine the optimal levels of wheat flour and Oven Dried Drumstick Flower Powder (OD-DFP) for acceptable Chappathi.

MATERIALS AND METHODS

SOURCES OF MATERIALS

Wheat flour and salt were purchased from the local market in Salem, Tamil Nadu, India and checked for its purity. The drumstick flowers were collected freshly. It was blanched in just enough boiling water for 2–3 minutes, removed immediately and spread on muslin cloth/trays for drying. Then the drumstick flowers were loaded on the oven trays forming one single layer of the dehydrator and were dried in the dehydrator by forced air technique. The oven was preheated to 60°C and then the loaded tray was added each time, until all the drumstick flowers were done. The temperature was maintained at 60°C and the drumstick flowers were left for 1 h for their drying. Drumstick flowers were sufficiently dried till they became crisp and brittle to touch. The drumstick flowers took four to five hours for complete drying. The Oven Dried - Drumstick Flower Powder (OD-DFP) was packed in low density polyethylene bag and stored in the refrigerator until required.

ANALYSIS OF PHYSIOCHEMICAL PROPERTIES OF SELECTED OD-DFP

Physical properties such as the drying ratio and rehydration ratio were calculated by the method of Ranganna, 1986. The water absorption capacity and oil absorption capacity was determined by the method of Sathe et al, 1982 and the bulk density of the OD-DFP as determined using Ige, 1984. The chemical properties such as moisture, total ash and fibre were determined using AOAC method. The carbohydrate was assessed using Anthrone method and the total carotene was determined using spectrophotometer. All the estimations were done in triplicates. The anti-nutritional substances suspected to be present in vegetables namely tannin was analyzed using Folin Denis Method.

PREPARATION OF OD-DFP INCORPORATED CHAPPATHI

Required amount (90-100g) of wheat flour was mixed with required amount (5-15g) of OD-DFP and made into dough by adding salt and water. Then divide it into separate balls, thin it in roll board and pin. Heat the tawa and cook till it was done.

EXPERIMENTAL DESIGN FOR OPTIMIZATION OD-DFP INCORPORATED CHAPPATHI

The Response Surface Methodology (RSM) is a widely adopted tool for the quality of optimizations processes (Nazni *et al.*, 2010). 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. Response surface methodology was applied to the experimental data using a commercial statistical package (Design expert, Trial version 6.0, State Ease Inc., Minneapolis, IN statistical software) for the generation of response surface plot and optimization of process variables. The experiments were conducted according to Central Composite Rotatable Design (CCRD) (Khuri and Cornell, 1997). A 3² factorial experiment was used to study the effects of Wheat flour (X₁) and Oven Dried Drumstick Flower Powder (X₂) on the Diameter (Y₁), Cooking time (Y₂), Weight (Y₃), Kneading time (Y₄) and Overall acceptability (Y₅) on Table 1 of the developed Chappathi.

Table 1 -Process variables, their levels and Experimental design

Variables	Symbols	Coded value		
		-1	0	+1
Wheat flour	X ₁	90	95	100
OD-DFP	X ₂	5	10	15
Design point	Uncoded	Coded		
V ₁	90	5	-1	-1
V ₂	95	5	0	-1
V ₃	100	5	+1	-1
V ₄	90	10	-1	0
V ₅	95	10	0	0
V ₆	100	10	+1	0
V ₇	90	15	-1	+1
V ₈	95	15	0	+1
V ₉	100	15	+1	+1
V ₁₀	95	10	0	0
V ₁₁	95	10	0	0
V ₁₂	95	10	0	0
V ₁₃	95	10	0	0

X₁ → Wheat flour, X₂ → Oven dried drumstick flower powder

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

$$X_1 = \frac{\text{Wheat flour} - 95}{5}$$

$$X_2 = \frac{\text{OD-DFP} - 10}{5}$$

The standard scores were fitted to a quadratic polynomial regression model for predicting individual Y responses by employing at least square technique (Wanasaundara and Shahidi, 1996; SPSS, 2007). The second order polynomial equation was fitted to the experimental data of each dependent variable as given. The model proposed to each response of Y was

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

The 3D response surface plot were generated for different interactions of any two independent variables, check holding the value of third variables as constant at the central level. The optimization of the process was aimed at finding the optimum values of independent variables (overall acceptability and omega 3 fatty acid). The optimum values of the selected variables were obtained by solving the regression equation (Parmjit, 2009).

ANALYSIS OF PHYSIOCHEMICAL PROPERTIES OF SELECTED OD-DFP INCORPORATED CHAPPATHI

Physical properties such as the drying ratio and rehydration ratio were calculated by the method of Ranganna, 1986. The water absorption capacity and oil absorption capacity was determined by the method of Sathe et al, 1982 and the bulk density of the OD-DFP as determined using Ige, 1984. The chemical properties such as moisture, total ash and fibre were determined using AOAC method. The carbohydrate was assessed using Anthrone method and the total carotene was determined using spectrophotometer. All the estimations were done in triplicates.

SENSORY EVALUATION OF OD-DFP INCORPORATED CHAPPATHI

The sensory evaluation was carried out in order to get consumer response for overall acceptability of the roasted linseed powder compared to the control chappathi. 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. Information about the ingredients used in the prepared chappathi was revealed to the panelists after conclusion of the sensory evaluation exercise in order to evaluate the influence of health awareness on food selection by the panelists

STATISTICAL ANALYSIS

The experimental data were subjected to Analysis of Variance (ANOVA) to evaluate the effect of various treatments and their interactions on the response (Sneddecor and Cochrao, 1968) using Design Expert -8.0 version. The analytical data obtained for oven dried drumstick flower powder 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. Each determination was carried out in triplate and data were then averaged.

FINDINGS

PHYSICAL CHARACTERISTICS OF OD-DFP

The Physical characteristics of OD-DFP were shown in table 2.

Table 2-Physical characteristics of OD-DFP

Physical Parameter	OD-DFP (g/100g)
Drying ratio	18
Rehydration ratio	14.97
Oil absorption capacity(ml)	5.1
Water absorption capacity (ml)	6.5
Bulk density (gm)	6.7

The final yield of OD-DFP for 100g after oven drying was found to be 18g with the moisture of 8.6%. Regarding rehydration ratio 100g of the OD-DFP was found to be 15.4g respectively. Similar results was defined by Jayaraman et al (1991) and Uadal Singh et al. (2006) who reported that oven drying (1:5) is the best when compared to sun drying (1:16.5) and shade drying respected of drying and dehydration ratio. The oil absorption capacity, water absorption capacity and bulk density of OD-DFP were 5.1ml, 6.5ml and 6.7gm respectively. Similar to our study, Fagbemi (2006) reported that the water absorption

CHEMICAL COMPOSITION OF OD-DFP

The Chemical compositions of OD-DFP were shown in table 3.

Table 3-Chemical composition of OD-DFP

Nutrients	Amount
Moisture (%)	8.66
Ash (gm)	10.5
Fiber (gm)	9.4
β carotene (µg)	1.14
Carbohydrate (gm)	33.50

The nutrient content of OD-DFP is reported as moisture 8.66%, ash 10.5gm, fibre 9.4gm, carotene 1.14µg and carbohydrate 33.50gm respectively. The moisture content of the powder was low enough for its longer shelf life.

ANTI-NUTRITIONAL FACTOR

The anti-nutritional factor in the OD-DFP such as tannin may be about 1.91g/100g respectively. According to Lakshmi and Radha (2005), the tannin content of dehydrated drumstick flower was 1.8g/100g.

OPTIMIZATION OF OD-DFP INCORPORATED CHAPPATHI

The Chappathi prepared with the help of wheat flour and OD-DFP was characterized for its physiochemical and organoleptic characteristics. The Diameter (Y_1), Cooking time (Y_2), Weight (Y_3), Kneading time (Y_4) and Overall acceptability (Y_5) were measured for response variables.

Table 4 shows that the diameter of chapatti may be ranged from 14.9 to 15.4cm, cooking time 1.42 to 1.59 minutes, weight 94.3 to 105.9gm, kneading time 4.13 to

5.09 minutes and overall acceptability may range from 4 to 8 respectively.

REGRESSION COEFFICIENT FOR THE RESPONSE VARIABLES

The regression coefficient for the response variables were shown in table 5.

DIAMETER

The diameter of OD-DFP incorporated Chappathi varied from 14.0 to 15.5cm for the samples treated under different incorporation levels. The R^2 value of the diameter of OD-DFP chappathi was 0.87 for the regression model predicting the diameter, which shows 87% variability in the data.

Table 4-Physical and sensory properties of OD-DFP incorporated Chappathi

Variables	Uncoded value		Diameter (cm)	Cooking time (min)	Weight (kg)	Kneading time (min)	Overall acceptability
	X ₁	X ₂					
S	100	-	14	1.4	95.1	4.13	7
V ₁	90	5	14.9	1.42	94.3	4.15	8
V ₂	95	5	15	1.4	94.8	4.22	7
V ₃	100	5	15.2	1.53	99.3	5.06	7
V ₄	90	10	14.9	1.44	94.5	4.34	6
V ₅	95	10	15.1	1.43	97.5	4.36	6
V ₆	100	10	15.3	1.56	105.9	5.09	6
V ₇	90	15	15.1	1.46	98.7	4.59	4
V ₈	95	15	15.2	1.47	99.6	4.54	5
V ₉	100	15	15.4	1.59	101.6	5.03	6
V ₁₀	95	10	15	1.44	98	4.36	7
V ₁₁	95	10	15.2	1.45	97.5	4.36	7
V ₁₂	95	10	15.1	1.44	98.1	4.36	6
V ₁₃	95	10	15.1	1.44	97.8	4.37	6

X₁ – Wheat flour; X₂ – Oven dried drumstick flower powder

Table 5-Regression coefficient for the response variables

Coefficients	Diameter	Cooking time	Weight	Kneading time	Overall acceptability
Model	15.11	1.44	97.94	4.37	6.31
X ₁	0.17	0.06	3.22	0.35	0.17
X ₂	0.10	0.03	1.92	0.12	-0.17
X ₁ ²	0.01	0.06	1.87	0.34	-0.09
X ₂ ²	0.01	-3.62	-1.13	4.65	-0.09
X ₁ X ₂	0.00	5.00	-0.52	-0.12	0.75
R ²	0.87	0.99	0.82	0.99	0.86
Adj R ²	0.77	0.99	0.69	0.99	0.77
Pred R ²	0.63	0.95	-0.74	0.95	0.56
Adeq R ²	11.15	0.95	8.85	44.60	11.59
Std Dev	0.07	7.99	1.71	0.03	0.49
Lack of fit	NS				

** → 1% level of significance; X₁ → Wheat flour, * → 5% level of significance; X₂ → Oven dried drumstick flower powder, NS → Not significant

COOKING TIME AND KNEADING TIME

The cooking time of the OD-DFP incorporated chappathi was 1.40 to 1.59 respectively. The kneading time of the OD-DFP incorporated chappathi was 4.13min to 5.09 respectively. The coefficient of determination, R² for the regression model predicting the cooking time and the predicting the kneading time were 99%. The data also indicated that the lack of fit is not significant.

WEIGHT

The weight of the chappathi varied from 94.3 to 105.9g. The coefficient of determination R² was 82% for the regression model predicting the weight. The lack of fit is found to be not significant.

OVERALL ACCEPTABILITY

The maximum overall acceptability is found to be 8 and it varied from 4 to 8. The coefficient of determination R² was 86% for the regression model predicting the overall acceptability.

RESPONSE SURFACE METHODOLOGY OPTIMIZATION RESULT

MATHEMATICAL MODEL

Mathematical relationship generated using Multiple Linear Regression Analysis for the response variable for coded and uncoded values are expressed in equation 1 to 5.

CODED VALUE

$$Y1=15.11+0.17X_1+0.100X_2+0.014X_1^2+0.014X_2^2-0.00X_1*X_2 \dots\dots\dots (1a)$$

$$Y2= 1.44+0.060 X_1+0.028X_2+0.061X_1^2-3.62X_2^2+5.00X_1*X_2 \dots\dots\dots (2a)$$

$$Y3= 97.94+3.22X_1+1.92 X_2+1.87 X_1^2-1.13 X_2^2-0.52X_1*X_2 \dots\dots\dots (3a)$$

$$Y4= 4.37+0.35X_1+0.12X_2+0.34X_1^2+4.65X_2^2-0.12X_1*X_2 \dots\dots\dots (4a)$$

$$Y5= 6.31+0.17X_1-1.17X_2-0.086X_1^2-0.086X_2^2+0.075X_1*X_2 \dots\dots\dots (5a)$$

The negative coefficient for X_2 in equation Y_5 indicates that the linear effect of OD-DFP.

UNCODED VALUE

$$Y1=16.778-0.0715X_1+8.965X_2+5.517X_1^2+5.517X_2^2+3.134X_1*X_2 \dots\dots\dots (1b)$$

$$Y2=22.57-0.456X_1-0.010X_2+2.455X_1^2-1.44X_2^2-2.00X_1*X_2 \dots\dots\dots (2b)$$

$$Y3=682.33-13.338X_1+3.28X_2+0.075X_1^2-0.045X_2^2-0.021X_1*X_2 \dots\dots\dots (3b)$$

$$Y4=115.64-2.46 X_1+0.467X_2 +0.013 X_1^2+1.862 X_2^2-4.700 X_1*X_2 \dots\dots\dots (4b)$$

$$Y5=2.511+0.388X_1-3.014X_2-3.448X_1^2-3.448X_2^2+0.030X_1*X_2 \dots\dots\dots (5b)$$

The negative coefficient for X_1 in equation Y_1 , Y_2 and Y_3 while X_2 in equation 2 have the negative coefficient indicates that the linear effect of OD-DFP.

The magnitude of P-value indicates that OD-DFP have significant effect on all the responses at 5% level. The quadratic terms of sugar have significant effect on overall acceptability at 5% level ($P<0.05$). The effect of X variables on the Y variable has shown in fig. The 3D response surface plot is a graphical representation of the regression equation. The graphical representation of response surface shown in fig 1-5 help to visualize the effect of wheat flour and oven dried drumstick flower powder.

CRITERIA OF OPTIMUM VALUE FOR THE RESPONSES

The optimum values of the responses were shown in table 6.

Table 6-Criteria of optimum value for the responses

Process variable	Optimum value		Response	Optimum value
	Uncoded	Coded		
Wheat flour	90	0	Diameter	14.87
OD-DFP	5	+1	Cooking time	1.41
			Weight	93.01
			Kneading Time	4.12
			Over all acceptability	8

For the optimization variables, the responses, that is Diameter, Cooking time, Weight, Kneading time and Overall acceptability were selected on the basis that these responses had direct effect on the acceptability and quality of Chappathi. To consider all the responses simultaneously for optimization, the multiple regression was used to get compromise optimum conditions and it has found that the scores were 14.87, 1.41, 93.01, 4.12 and 8 for Diameter (cm), Cooking time (min), Weight (g), Kneading time (min) and Overall acceptability respectively, corresponding to the optimum condition of wheat flour 90gm as X_1 and Oven dried drumstick flower powder 5gm as X_2 .

PHYSICAL PROPERTIES OF THE DEVELOPED OD-DFP CHAPPATHI

The physical properties of the OD-DFP incorporated chappathi is shown in table 7.

Table 7-Physical properties of the developed OD-DFP chappathi

Variables	Diameter	Cooking time	Weight	Kneading time
V ₁	14.76±0.11 ^b	1.42±0.00 ^b	94.30±0.07 ^a	4.14±0.01 ^a
V ₂	15.06±0.11 ^c	1.40±0.01 ^a	94.40±0.10 ^a	4.21±0.01 ^a
V ₃	15.18±0.08 ^{cd}	1.52±0.01 ^f	99.38±0.08 ^c	5.15±0.01 ^f
V ₄	14.60±0.19 ^a	1.43±0.00 ^c	94.70±0.07 ^a	4.37±0.01 ^b
V ₅	15.08±0.84 ^c	1.42±0.01 ^b	97.42±0.08 ^b	4.57±0.01 ^e
V ₆	15.26±0.05 ^{de}	1.55±0.01 ^g	104.50±2.79 ^e	5.29±0.24 ^g
V ₇	15.08±0.08 ^c	1.44±0.01 ^d	99.34±0.58 ^c	4.37±0.01 ^b
V ₈	15.12±0.08 ^c	1.47±0.01 ^e	98.38±0.08 ^{bc}	4.40±0.05 ^{bc}
V ₉	15.36±0.05 ^e	1.58±0.01 ^h	101.26±0.11 ^d	5.23±0.01 ^{fg}
V ₁₀	15.12±0.08 ^c	1.43±0.00 ^c	98.62±0.08 ^c	4.53±0.01 ^{de}
V ₁₁	15.10±0.07 ^c	1.44±0.01 ^d	98.66±0.05 ^c	4.47±0.06 ^{cd}
V ₁₂	15.08±0.08 ^c	1.43±0.01 ^c	98.38±0.08 ^{bc}	4.38±0.01 ^{bc}
V ₁₃	15.28±0.08 ^{de}	1.45±0.01 ^d	98.72±0.08 ^c	4.38±0.01 ^{bc}
F value	22.27	234.65	62.28	153.89
P value	0.00	0.00	0.00	0.00

Figure 1
3 D Effect of RSM on OD-DFP on Diameter

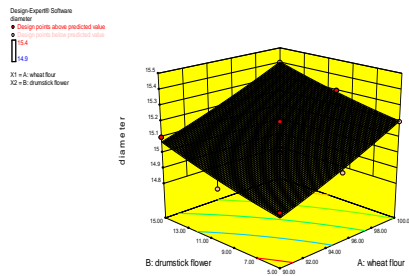


Figure 2
3 D Effect of RSM on OD-DFP on Cooking time

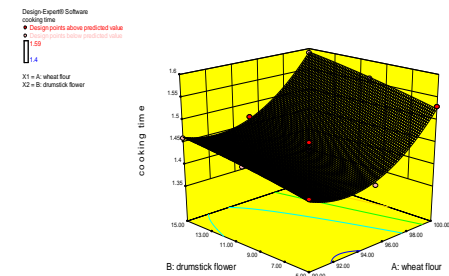


Figure 3
3 D Effect of RSM on OD-DFP on Weight

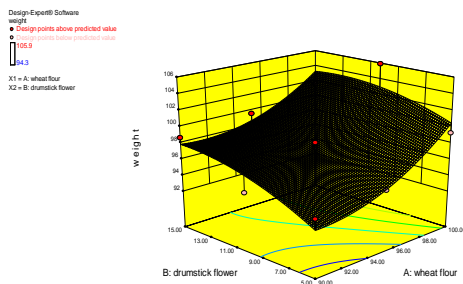


Figure 4
3 D Effect of RSM on OD-DFP on Kneading time

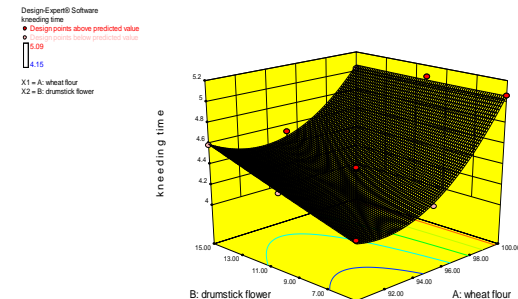
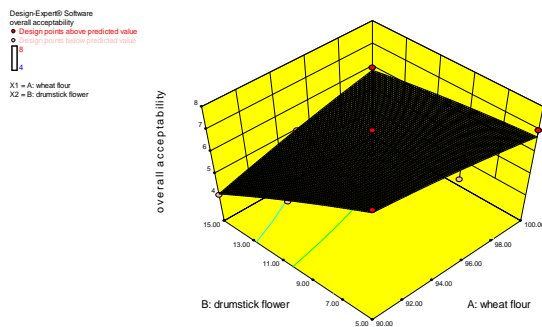


Figure 5
3 D Effect of RSM on OD-DFP on Overall acceptability



Among the thirteen variations of chappathi, V₉ has got the highest score of 15.36 and the least score 14.60 is obtained by V₄ for the diameter. For the cooking time, the highest score 1.55 is obtained by variation V₆ which is followed by V₃ with a score of 1.52 and the least score 1.40 is obtained by the variation V₂. Regarding the weight attribute, the highest score 104.50 is obtained by the variation V₆ which is followed by the variation V₉ with a score of 101.26 and the least score 94.30 is obtained by the variation V₁. For the kneading time attribute the highest score 5.23 is obtained by the variation V₉. It is followed by the variation V₃ with a score of 5.15 and the least score 4.14 is obtained by the variation V₁. Results of the Duncan's test reveal that there was significant difference for the variations.

Table 8 -Mean organoleptic evaluation of OD-DFP incorporated Chappathi using Duncan multiple range test

Variation	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability
V ₁	7.10±0.74 ^a	0.95±0.30 ^{abc}	5.90±1.19 ^a	6.80±0.63 ^{bcd}	7.10±0.74 ^c	6.90±0.74 ^{fgh}
V ₂	6.40±0.97 ^a	0.95±0.30 ^{abc}	6.00±0.82 ^{ab}	6.30±0.95 ^{abc}	6.10±0.74 ^{ab}	7.20±0.79 ^h
V ₃	6.70±1.06 ^a	0.85±0.27 ^{abc}	6.50±0.85 ^{abc}	6.00±0.82 ^{ab}	6.50±1.08 ^{abc}	6.70±0.82 ^{fgh}
V ₄	6.60±0.84 ^a	0.85±0.27 ^{abc}	6.90±0.99 ^{bc}	5.80±0.63 ^a	6.40±0.97 ^{abc}	6.10±0.74 ^{cdef}
V ₅	6.80±1.03 ^a	0.92±0.29 ^{abc}	6.50±1.08 ^{abc}	6.60±1.07 ^{abcd}	6.70±0.95 ^{abc}	5.40±0.84 ^{abc}
V ₆	7.00±0.82 ^a	0.87±0.28 ^a	6.00±0.82 ^{ab}	7.10±0.74 ^{cd}	6.80±0.92 ^{abc}	5.90±0.74 ^{cde}
V ₇	7.00±0.67 ^a	0.74±0.23 ^c	6.10±0.99 ^{abc}	6.80±0.92 ^{bcd}	6.60±0.52 ^{abc}	5.00±1.05 ^{ab}
V ₈	6.80±1.03 ^a	0.74±0.23 ^c	6.90±0.57 ^{bc}	7.20±0.79 ^d	5.90±0.99 ^a	5.60±0.97 ^{bcd}
V ₉	6.60±0.97 ^a	0.97±0.30 ^{abc}	6.80±0.78 ^{abc}	7.10±0.74 ^{cd}	6.30±0.95 ^{abc}	4.70±0.82 ^a
V ₁₀	6.40±0.97 ^a	0.84±0.27 ^{abc}	6.60±0.84 ^{abc}	6.90±0.74 ^{cd}	6.90±0.99 ^{bc}	6.20±0.63 ^{defg}
V ₁₁	6.60±0.97 ^a	0.67±0.21 ^{bc}	6.60±0.97 ^{abc}	6.60±0.84 ^{abcd}	6.60±0.97 ^{abc}	7.00±0.67 ^{gh}
V ₁₂	7.10±0.74 ^a	0.67±0.21 ^a	7.00±0.82 ^c	7.10±0.74 ^{cd}	6.70±0.95 ^{abc}	6.80±0.63 ^{fgh}

V₁₃	7.00±0.82 ^a	0.67±0.21 ^{bc}	6.40±0.84 ^{abc}	6.90±0.99 ^{cd}	7.10±0.74 ^c	6.50±0.85 ^{efgh}
F Value	0.76	2.36	1.74	2.82	1.58	9.87
P Value	0.69	0.01	0.07	0.01	0.10	0.00

Among 13 variables of chappathi, V₁ and V₁₁ have scored which is the highest for appearance attribute followed by V₂ and V₁₀ with a score of 6.40 which is the least score. For the colour attribute, the highest score 0.97 obtained by the variation V₉ which is followed by V₁ and V₂ with a score of 0.95 and the least score 0.67 is obtained by the variation V₁₁, V₁₂ and V₁₃. Regarding the flavor attribute, the highest score 7.00 is obtained by the variation V₁₂ which is followed by the variation V₈ with a score of 6.90 and the least score 5.90 is obtained by the variation V₁. For the taste attribute, the highest score 7.20 is obtained by the variation V₈ and is followed by the variation V₆, V₉ and V₁₂ with a score of 7.10 and the least score of 5.80 is obtained by the variation V₄. Regarding the texture attribute, the highest score 7.10 is obtained by the variation V₁ and V₁₃ which is followed by the variation V₁₀ with a score of 6.90 and the least score 5.90 is obtained by the variation V₈. Regarding overall acceptability attribute, the highest score 7.20 is obtained by the variation V₂ which is followed by the variation V₁ with a score of 6.90 and the least score 5.00 is obtained by the variation V₇. Results of the Duncan's test reveal that there was significant difference for the variations.

CONCLUSION

It is concluded that RSM was used successfully to optimize the level of wheat flour and OD-DFP for the development of chappathi. The overall acceptable chappathi with less kneading time, cooking time and more diameter and weight of the chappathi can be prepared using the combination of wheat flour 90g and OD-DFP 5g.

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