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RESEARCH ARTICLE

OPTIMIZATION OF SUN-DRIED *Moringa olifera* FLOWER POWDER INCORPORATED CHAPPATHI USING RESPONSE SURFACE METHODOLOGY

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ABSTRACT

Wheat is one of the staple foods of the majority of Indian population. Whole wheat flour is mainly used for preparation of Chappathi. Drumstick flower has various medicinal properties like used to treat cold and anaemia and report to contain powerful antibiotic pterygospermin which has fungicidal properties. 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 sun dried drumstick flower powder (SD-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 (15.24cm), cooking time (1.45min), weight (95.49gm), kneading time (4.20 min) and overall acceptability (7.72) was obtained for the corresponding optimum condition of wheat flour (95gm) and sun dried drumstick flower powder (5gm). Hence it is concluded that RSM was used successfully to optimize the level of wheat flour and sun dried drumstick flower powder for the development of value added chapathi.

INTRODUCTION

Wheat is one of the staple foods of the majority of Indian population. Of the total wheat produced, 75% get processed into whole wheat flour in the Chakki mill and the remaining 8-12% is processed in the roller mill for suji/rawa and refined wheat flour/ maida. Whole wheat flour is mainly used for preparation of chappathi and other traditional indigenous products of wheat floue origin are poories, naans, kulchas, bathuras and so on (Sidhu and Scribel, 1998). Plant foods play an important role in the diet as they provide essential micronutrients and minerals. 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, Umberto, 2000). Drumstick is world widely famous for its medicinal properties. Drumstick plants grow very rapidly and are loaded with number of nutritional benefits.Regular consumption of drumstick tonic helps in providing important nutrients like calcium, vitamins and iron to expectant mothers (dietihub.com, 2010). Drumstick flowers were used in treating cold and anaemia and report to contain powerful antibiotic pterygospermin which has fungicidal properties (Sreenivasan and Jyotsna, 2000).

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Vegetable flowers are highly perishable and some of them are usually available in particular season of the year. Vegetable flowers come in plenty during glut seasons and excess get spoilt. Inorder to minimize wastage, vegetables can be processed and preserved by simple traditional methods like sun drying, salting, smoking, pickling and advanced method like canning, dehydration and freeze drying. 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). 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 sun dried drumstick flower powder(SD-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 dried for 2 days under the sunlight until they were fully dried or crisp. The drumstick flowers were turned frequently to ensure uniform drying. The daytime temperature ranges from 36 to 38ºC. The Sun Dried –Drumstick Flower Powder (SD-DFP) was packed in low density polyethylene bag and stored in the refrigerator until required.

Analysis of physiochemical properties of selected SD-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 SD-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.

Experimental design for optimization SD-DFP incorporated Chappathi

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 3^2 factorial experiment was used to study the effects of wheat flour (X) and sun dried drumstick flower powder (X_2) 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 level		
		–1	0	+1
Wheat flour	X_1	90	95	100
SD-DFP	X_2	5	10	15
Design point	Uncoded		Coded	
	X_1	X_2	x_1	x_2
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

$X_1 \rightarrow$ Wheat flour
x → Coded value
$X_2 \rightarrow$ Sun dried drumstick flower powder
X→ Uncoded value

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.

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

$$X_2 = \frac{\text{Sun dried drumstick flower powder} - 10}{5}$$

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

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

Where, β_0, β_i, β_{ij} are intercepts, quadratic regression coefficient terms. X_i and X_j are independent variables.

The model permitted evaluation of quadratic terms of the independent variables on the dependent variable. The response surface and contour 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 (diameter, cooking time, weight and kneading time) to achieve the maximum (appearance, colour, flavour, taste, texture and overall acceptability). The optimum values of the selected variables were obtained by solving the regression equation (Parmjit, 2009).

Sensory Evaluation

The sensory quality is the different senses of preparation and eating food. All the developed products were evaluated for their acceptability by a semi trained panel of ten judges. Chappathi was evaluated for sensory quality on the basis of appearance, colour, flavour, taste, texture and overall acceptability using a 9 point Hedonic scale score card with scores ranging from 9 to 1, where score 9 and 1 represented like extremely respectively used for evaluating the development products and analyzed statistically using Duncan's multiple range test.

Analysis of physical properties of SD-DFP incorporated Chappathi

The variable parameters like diameter, cooking time, weight and kneading time were assessed for the determination of physical properties of Chappathi. Weight of the products was measured in grams using weighing balance. The time taken for complete cooking of the product was noted in minutes. Diameter and width of the products was measured in cm using scale.

Chemical analysis of SD-DFP incorporated chappathi

The moisture and fibre were determined using AOAC method. Carbohydrate content was assessed using Anthrone method and the total carotene was determined using spectrophotometer.

Statistical Analysis

The statistical significance of the regression coefficients was determined by student's t test and second order model equation was determined by Fisher's test. The relative effect of each process parameter on individual response was compared from the value corresponding of those parameters by ANOVA and Duncan's Multiple Range Tests.

FINDINGS

Physical characteristics
Drying ratio and rehydration ratio of SD-DFP

Table 2. Drying ratio and rehydration of SD-DFP

Physical Parameters	Quantity(g/100g)
Drying ratio	21
Rehydration ratio	15.40

Table 2 shows that the final yield of SD-DFP for 100g after 2 days drying was found to be 21g with the moisture of 8.5%. Regarding rehydration ratio 5g of the SD-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.

Bulk density, water absorption and oil absorption ratio of SD-DFP

The oil absorption and bulk density of SD-DFP is 5.3 and 6.7 ml respectively. The bulk density of SD-DFP is 6.7gm. Similar to our study, Fagbemi (2006) reported that the water absorption capacity of the flour is increased when compared to that of fresh product. Healso (2001) reported that boiling enhanced oil absorption capacity. Similar observations were reported by Padmashree et al. (1987) and Abby and Ibeh (1988) for cowpea, Giami and Bekebain (1992) for fluted pumpkin and Del Rosarrio and Flores (1981) for mung bean.

Table. 3 Bulk density, water absorption and oil absorption ratio of SD-DFP

Parameters	SD-DFP		
	Initial	Final	Difference
Oil absorption(ml)	10	4.7	5.3
Water absorption(ml)	10	3.6	6.4
Bulk density(gm)	10	3.3	6.7

Chemical analysis of SD-DFP

The nutrient content of SD-DFP is reported as moisture 8.50%, ash 5.8gm, fibre 9.7gm, carotene 0.83µg and carbohydrate 35.50gm respectively. The moisture content of the powder was low enough for its longer shelf life. Similar to our study, Lakshmi (2005) reported that the nutrient content of SD-DFP were 4.5g moisture, 9.0g ash, 28.4g carbohydrate and 4.12mg of carotene (Table 4).

Table 4. Nutrient composition of SD-DFP

Nutrient	Amount (100gm)
Moisture (%)	8.50
Ash(gm)	5.8
Fibre(gm)	9.7
ß carotene(µg)	0.83
Carbohydrate(gm)	35.50
protein(gm)	10.28
Fat(gm)	1.3
Energy(kcal)	280

Anti-nutritional factor

The anti-nutritional factor in the SD-DFP such as tannin may be about 1.175g/100g respectively. According to Lakshmi and Radha (2005), the tannin content of dehydrated drumstick flower was 1.8g/100g.

Optimization of Sun Dried Drumstick Flower Chappathi

The Chappathi prepared with the help of wheat flour and SD-DFP was characterized for its physiochemical and organoleptic characteristics. The diameter (Y1), cooking time (Y2), weight (Y3), kneading time (Y4) and overall acceptability (Y5) were measured for response variables. Table 5 shows that the diameter of chapatti may be ranged from 14. 9 to 15.4cm, cooking time 1.42 to 1.54 minutes, weight 95.2 to 97.8gm, kneading time 4.15 to 4.50 minutes and overall acceptability may range from 4 to 8 respectively.

Diagnostic checking of fitted model and surface plot for various responses

Regression analysis indicated that the fitted quadratic model accounted for more than 80% for weight and overall acceptability (significant at P>0.05) and 68% for diameter, 70% for cooking time, 42% for kneeding time (significant at P>0.05) respectively. Multiple regression equation was generated relating responses to both coded and uncoded form (levels) of process variables. The values of regression coefficients, sum of squares, F values and P values for coded form of process variables are presented in Table 6.

Diameter

The diameter of sun dried drumstick flower incorporated chappathi varied from 14. 9 to 15.4cm for the samples treated under different incorporation levels. The coefficient of determination R^2 was 0.686 for the regression model predicting the diameter, which shows 68% variability in the data. Adequate precision of 5.644 indicated about the adequacy of the model (Table 6). The F value for the model as 3.07 and the lack of fit is not found to be significant.

Cooking time and Kneading time

The cooking time and kneading time of the sun dried drumstick flower incorporated chappathi was 1.42 to 1.54 and 4.15 to 4.50 respectively. The minimum kneading time of 4.15min was obtained when the cooking time is 1.42min respectively. The coefficient of determination, R^2 was 70% for the regression model predicting the cooking time and 42% predicting the kneading time. The data also indicated that the lack of fit is not significant.

Weight

The weight of the chappathi varied from 95.2 to 97.8g. The coefficient of determination R^2 was 99% for the regression model predicting the weight. The F value of the model is 114 and 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 R^2 was 82% for the regression model predicting the overall acceptability. The F value of the model is 6.37 and lack of fit is not significant.

Effect of variables on responses

Wheat flour affects the diameter and cooking time at linear level in 5% level of significance. SD-DFP affects the cooking time which is significant at 5% level. The weight and overall acceptability are at 1% level of significant difference, but the kneading time and overall acceptability of wheat flour does not contain any significant difference in their responses.

Table 5. Physical and sensory properties of SD-DFP incorporated Chappathi

Variables	Uncoded value		Diameter (cm)	Cooking time (minutes)	Weight (kg)	Kneading time (minutes)	Overall acceptability
	X_1	X_2					
V_1	90	5	15	1.42	95.2	4.15	7
V_2	95	5	15.2	1.44	95.5	4.18	8
V_3	100	5	15.4	1.46	95.8	4.19	7
V_4	90	10	14.9	1.43	96.1	4.17	6
V_5	95	10	15	1.47	96.6	4.19	5
V_6	100	10	15.2	1.5	96.9	4.26	6
V_7	90	15	14. 9	1.48	97.2	4.28	4
V_8	95	15	15.1	1.5	97.5	4.22	5
V_9	100	15	15.3	1.52	97.8	4.5	4
V_{10}	95	10	15.1	1.54	96.3	4.32	6
V_{11}	95	10	15.1	1.48	96.5	4.33	7
V_{12}	95	10	15.2	1.47	96.4	4.5	7
V_{13}	95	10	15.4	1.48	96.6	4.5	6

X_1 – Wheat flour; X_2 – Sun dried drumstick flower powder

Table.6. Regression coefficient for the response variables

Coefficients	Diameter	Cooking time	Weight	Kneading time	Overall acceptability
Model	15.14	1.48	96.48	4.34	6.31
X1	0.18**	0.025*	0.33**	0.058	0.00
X2	-0.050	0.030*	1.00**	0.080	-1.50**
$X1^2$	-0.057	-0.012	0.010	-0.041	-0.59
$X2^2$	0. 043	-6.89	0.010	-0.056	-0.086
$X1^2*X2^2$	0.00	0.00	0.00	0.045	0.00
F value	3.07	3.37	114.38	1.03	6.37
R^2	0. 686	0. 706	0. 987	0.424	0.819
Adj R^2	0.462	0. 496	0. 979	0.013	0.691
Pred R^2	0.319	0.247	0.964	-1.288	0.606
Adeq precision					
Lack of fit	5.644 NS	6.654 NS	36.355 NS	3.123 NS	7.757 NS

** → 1% level of significance; X_1 → Wheat flour
* → 5% level of significance; X_2 → Sun dried drumstick flower powder
NS → Not significant

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

$$Y1=15.14+0.18X_1-0050X_2-0.057X_1^2+0.043X_2^2+0.00X_1*X_2 \quad \ldots\ldots\ldots\ldots \text{(1a)}$$

$$Y2=1.48+0.025X_1+0.030X_2-0.012X_1^2-6.897X_2^2+0.00X_1*X_2 \quad \ldots\ldots\ldots\ldots \text{(2a)}$$

$$Y3=96.48+0.33X_1+1.00X_2+0.010X_1^2+0.010X_2^2+0.00X_1*X_2 \quad \ldots\ldots\ldots\ldots \text{(3a)}$$

$$Y4=4.34+0.058X_1+0.080X_2-0.041X_1^2-0.056X_2^2+0.045X_1*X_2 \quad \ldots\ldots\ldots\ldots \text{(4a)}$$

$$Y5=6.31+0.00AX_1-1.50X_2-0.591X_1^2-0.086X_2^2-0.00X_1*X_2 \quad \ldots\ldots\ldots\ldots \text{(5a)}$$

The negative coefficient for X_1 in equation 4a and 5a indicates that linear effect of SD-DFP decreases the diameter, kneading time and overall acceptability

Uncoded value

$Y1=8.607+0.469X_1-0.044X_2-2.26X_1^2+1.724X_2^2+4.54X_1*X_2$ …… (1b)

$Y2=-3.372+0.095X_1+0.011X_2-4.759X_1^2-2.758X_2^2+1.138X_1*X_2$ ……..… (2b)

$Y3= 91.925-0.0119X_1+0.192X_2+4.138X_1^2+4.138X_2^2+8.648X_1*X_2$ ……. (3b)

$Y4=-10.071+0.302X_1-0.111X_2-1.621X_1^2-2.221X_2^2+1.80X_1*X_2$ …… (4b)

$Y5=-202.65+4.455X_1-0.231X_2-0.023X_1^2-3.448X_2^2+6.661X_1*X_2$ …… (5b)

$X_1 \rightarrow$ Wheat flour

$X_2 \rightarrow$ Sun dried drumstick flower powder

The negative coefficient for X_1 in equation 3b (weight) and for X_2 in equation 1b, 4b and 5b indicates that linear effect of SD-DFP decreases the diameter, kneading time and overall acceptability.

Diagnostic checking of fitted model and surface plot for various responses

The diameter and cooking time decreased with decreased wheat flour and drumstick flower powder. The minimum diameter and cooking time were observed with 90gm wheat flour and 5gm SD-DFP incorporated chappathi however with further increase in wheat flour, increased drumstick flower powder also increased cooking time of the developed chappathi (Fig.1and 2).

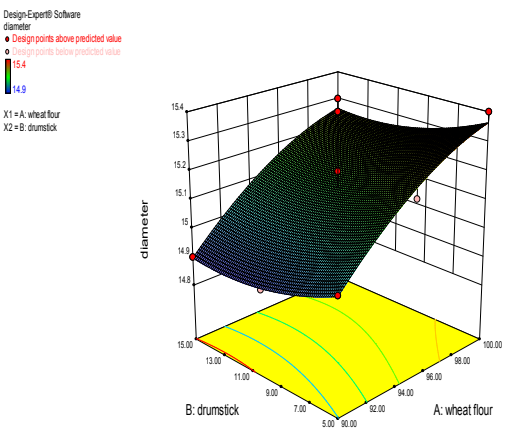

Fig.1. Effect of wheat flour and SD-DFP on diameter

The effect of maximum amount of SD-DFP (15gm) indicated that the increase in weight up to maximum amount that 97.2 to 97.8gm. The minimum amount of SD-DFP range of 5 to 10gm showed minimum time for kneading the dough and also maximum levels of overall acceptability which is shown in Fig 3, 4 & 5

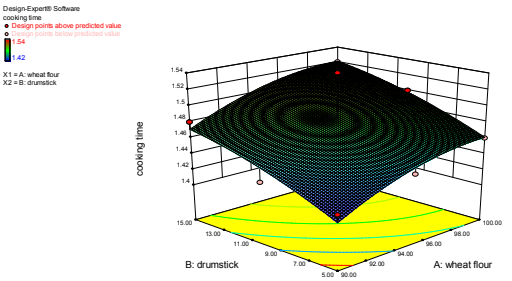

Fig. 2. Effect of wheat flour and SD-DFP on cooking time

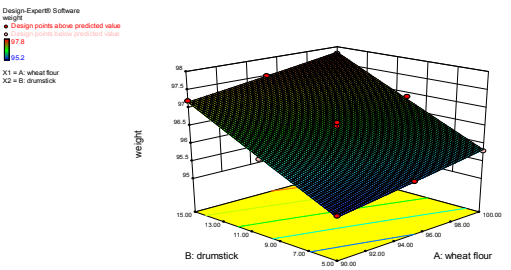

Fig.3. Effect of wheat flour and SD-DFP on weight

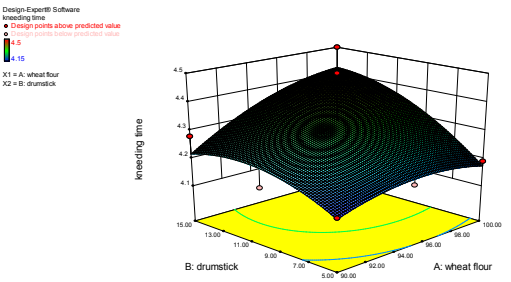

Fig.4. Effect of wheat flour and SD-DFP on kneading time

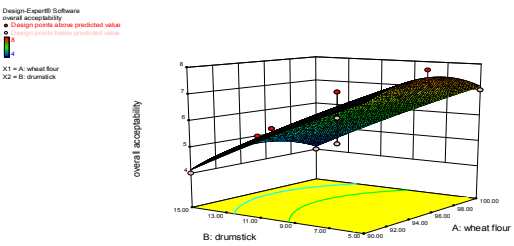

Fig.5. Effect of wheat flour and SD-DFP on weight overall acceptability

Criteria of optimum value for the responses

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 15.237, 1.448, 95.493, 4.200 and 7.724 for diameter (cm), cooking time (min), weight (g), kneading time (min) and overall acceptability respectively, corresponding to the optimum condition of wheat flour 95gm as X_1 and sun dried drumstick flower powder 5gm as X_2.

Table 7. Criteria of optimum value for the responses

Process variable	Optimum value		Response	Optimum value
	Uncoded	Coded		
Wheat flour	95	-1	Diameter	15.237
			Cooking time	1.448
	5	+1	Weight	5.493
SD-DFP			Kneading Time	4.200
			Over all acceptability	7.724

Table 8. Physical properties of the developed SD-DFP chappathi

Variables	Diameter (cms)	Cooking time (minutes)	Weight (kg)	Kneading time (minutes)
V_1	15.02±0.083^{b}	1.412±0.008^{a}	95.140±0.089^{a}	4.14±0.008^{a}
V_2	15.12±0.083^{bc}	1.432±0.008^{b}	95.420±0.084^{b}	4.17±0.009^{b}
V_3	^{d}	1.452±0.008^{c}	95.70±0.071^{c}	4.18±0.010^{b}
V_4	15.36±0.547^{g}	1.426±0.005^{b}	96.12±0.084^{d}	4.17±0.008^{b}
V_5	14.90±0.707^{a}	1.460±0.100^{cd}	96.52±0.837^{f}	4.18±0.008^{b}
V_6	15.08±0.083^{bc}	1.500±0.007^{f}	96.82±0.837^{g}	4.25±0.010^{d}
V_7	15.16±0.055^{cd}	1.478±0.084^{e}	97.12±0.084^{h}	4.28±0.008^{e}
V_8	14.82±0.084^{a}	1.502±0.008^{fg}	97.50±0.071^{i}	4.21±0.011^{c}
V_9	15.10±0.071^{bc}	1.512±0.008^{g}	97.78±0.084^{j}	4.49±0.012^{g}
V_{10}	^{d}	1.532±0.008^{h}	96.32±0.084^{e}	4.32±0.008^{f}
V_{11}	15.26±0.055^{ef}	1.478±0.008^{e}	96.44±0.089^{f}	4.33±0.013^{f}
V_{12}	15.06±0.055^{bc}	1.470±0.007^{e}	96.32±0.083^{e}	4.50±0.010^{gh}
V_{13}	15.02±0.084^{b}	1.472±0.008^{de}	96.50±0.083^{f}	4.50±0.011^{h}
F value	15.20±0.071^{de}	93.295	408.909	882.473
P value	15.32±0.084^{fg}	0.00**	0.00**	0.00**
	22.585			
	0.00**			

**-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)

which is followed by V_9 with a score of 0.512 and the least score 1.412 is obtained by the variation V_1. Regarding the weight attribute, the highest score 97.78 is obtained by the variation V_9 which is followed by the variation V_8 with a score of 97.50 and the least score 95.14 is obtained by the variation V_1. For the kneading time attribute the highest score 4.50 is obtained by the

Table 9. Mean organoleptic evaluation of SD-DFP incorporated Chappathi

Variation	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability
V_1	7.100±0.738^{a}	6.30±0.948^{abc}	5.90±1.197^{a}	6.80±0.632^{bcd}	7.10±0.738^{c}	6.90±0.738^{fgh}
V_2	6.400±0.966^{a}	6.70±0.948^{abc}	6.00±0.816^{ab}	6.30±0.948^{abc}	6.10±0.738^{ab}	7.20±0.788^{h}
V_3	6.700±1.059^{a}	6.50±0.849^{abc}	6.50±0.849^{abc}	6.00±0.816^{ab}	6.50±1.08^{abc}	6.70±0.823^{fgh}
V_4	6.60±0.843^{a}	6.50±0.849^{abc}	6.90±0.994^{bc}	5.80±0.632^{a}	6.40±0.966^{abc}	6.10±0.738^{cdef}
V_5	6.80±1.033^{a}	6.20±9.189^{ab}	6.50±1.080^{abc}	6.60±1.075^{abcd}	6.70±0.948^{abc}	5.40±0.843^{abc}
V_6	7.00±0.816^{a}	5.90±0.876^{a}	6.00±0.816^{ab}	7.10±0.738^{cd}	6.80±0.919^{abc}	5.90±0.738^{cde}
V_7	7.00±0.667^{a}	7.10±0.738^{c}	6.10±0.994^{abc}	6.80±0.919^{bcd}	6.60±0.516^{abc}	5.00±1.054^{ab}
V_8	6.80±1.033^{a}	7.10±0.738^{c}	6.90±0.567^{bc}	7.20±0.788^{d}	5.90±0.994^{a}	5.60±0.966^{bcd}
V_9	6.60±0.966^{a}	6.60±0.966^{abc}	6.80±0.788^{abc}	7.10±0.738^{cd}	6.30±0.948^{abc}	4.70±0.823^{a}
V_{10}	6.40±0.966^{a}	6.60±0.843^{abc}	6.60±0.843^{abc}	6.90±0.738^{cd}	6.90±0.994^{bc}	6.20±0.632^{defg}
V_{11}	6.60±0.966^{a}	7.00±0.667^{bc}	6.60±0.966^{abc}	6.60±0.843^{abcd}	6.60±0.966^{abc}	7.00±0.666^{gh}
V_{12}	7.10±0.738^{a}	6.00±0.667^{a}	7.00±0.816^{c}	7.10±0.738^{cd}	6.70±0.948^{abc}	6.80±0.632^{fgh}
V_{13}	7.00±0.816^{a}	7.00±0.667^{bc}	6.40±0.843^{abc}	6.90±0.994^{cd}	7.10±0.738^{c}	6.50±0.849^{efgh}
F Value	0.762	2.359	1.741	2.821	1.584	9.870
P Value	0.688	0.009	0.067	0.02	0.105	0.00

**-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

Physical evaluation of the SD-DFP incorporated Chappathi

Among the thirteen variations of chappathi, V_3 has got the highest score of 15.36 and the least score 14.82 is obtained by V_7 for the diameter. For the cooking time, the highest score V_{10} is obtained by variation 1.532 variation V_{12} and V_{13}. It is followed by the variation V_9 with a score of 4.49 and the least score 4.14 is obtained by the variation V_1. Results of the Duncan's test reveal that there was significant difference for the variations.

Organoleptic evaluation of SD-DFP chappathi using Duncan's multiple range test

Among 13 variables of chappathi, V_1 and V_2 have scored which is the highest for appearance attribute followed by V_2 and V_{11} with a score of 6.40 which is the least score. For the colour attribute, the highest score 7.10 obtained by the variation V_7 and V_8 which is followed by V_{11} and V_{13} with a score of 7.00 and the least score 6.00 is obtained by the variation V_{12}. Regarding he flavor attribute, the highest score 7.00 is obtained by the variation V_{12} which is followed by the variation V_9 with a score of 6.80 and the least score 6.40 is obtained by the variation V_{13}. For the taste attribute, the height score 7.20 is obtained by the variation V_8 and is followed by the variation V_6, V_9 and V_{12} with a score of 7.10 and the least score of 6.00 is obtained by the variation V_3. Regarding the texture attribute, the highest score 7.10 is obtained by the variation V_1 and V_{13} which is followed by the variation V_{10} with a score of 6.90 and the least score 6.10 is obtained by the variation V_2. Regarding overall acceptability attribute, the highest score 7.20 is obtained by the variation V_{11} which is followed by the variation V_1 with a score of 6.90 and the least score 5.40 is obtained by the variation V5. Results of the Duncan's test revealed that there was significant difference for all the variations V_3, V_{13}, V_9, and V_{12} for diameter.

Conclusion

It is concluded that RSM was used successfully to optimize the level of wheat flour and SD-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 95g and SD-DFP 5g.

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