



Enhancing the quality of chapatti by brahmi using response surface methodology

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Abstract

The Brahmi (*Centella asiatica*) is the second most important herb which is used widely as therapeutically and in ayurvedic treatments. It is effective in the role of high antioxidant activity in brain and nerve regeneration. Chapatti is a prominent food used in developed and developing countries. In this current study, the optimization was carried out using central composite rotatable design (CCRD) of Response Surface Methodology. And over 15 different formulations, sensory scores of prepared product for appearance, color, texture, flavour, taste and overall acceptability was ranged from 8.10 to 8.83, 8.14 to 8.74, 7.75 to 8.79, 7.93 to 8.76, 7.87 to 8.74 and 7.89 to 8.74 respectively. Based on sensorial attributes, the optimized product had significant influenced on all sensory parameters indicates quadratic response surface model with the best fit desirability of 1.000.

Keywords: *Centella asiatica*, response surface methodology, central composite rotatable design (CCRD), antioxidant, brain & nerve regeneration effect

Introduction

According to World Health Organisation, consuming a healthy diet throughout the life-course helps to protect against malnutrition in all its form as well as a range of non-communicable diseases (NCD's). The dietary change in the lifestyle is the first basic step to treat deficiency or excesses in nutrient intake, imbalance of essential nutrients or impaired nutrient utilization.

Green leafy vegetables play a major component in the healthy diet ^[1]. To improve the nutritional value and to include therapeutic uses by adopting traditional medicinal herbs has an essential part of the healthy diet, herbs consists of phytochemical rich components and enormous antioxidants to boost up the individual's metabolism ^[2,3].

Centella asiatica (Linn.) belongs to the family Apiaceae (Umbelliferae) commonly known as Indian Pennywort ^[4]. This herb was found throughout tropical and subtropical regions in India up to an altitude of 600m ^[5]. It grows by lying flat on the ground with faintly aromatic, creeper herb that attains height up to 15cm (6 inches), the stem is glabrous, striated, with nodes at rooting and it exists all the time ^[6]. It composed of many compounds including asiatic acid, madecassic acid, asiaticoside, madecassoside, brahmoside, brahmic acid, brahminoside, thankinaside, isothankuniside, centelloside, madasiatic acid, centic acid, and cenellicacid ^[7]. Even among these triterpenes, the most important biologically active compounds are the Asiatic acid, madecassic acid, asiaticoside, madecassoside ^[8]. The vitamins which are involved are vitamin C, vitamin B1, vitamin B2, niacin, carotene, and vitamin

A. Total ash contains chloride, sulfate, phosphate, iron, calcium, magnesium, sodium, and potassium ^[5,9].

In today's world, the most often facing challenges with all age group people are absentmindedness, slow recollection,

and lower holding capacity of memory. It is an independent ability to encode, hold and subsequently recall information with past experiences in the brain of the individual. It gives an individual the capability to learn and adapt from previous experiences and the power of recognizing the learned facts, skills, and habits ^[10].

By incorporating these herbs in our diet can beneficially protect the cells from oxidative damage, destroys excess free radicals, and maintains a balance oxidative state. As a potent antioxidant, it exerted significant neuro-protective effects and proved efficacious in protecting rat brains against age-related oxidative damage ^[11]. And as one of the chief herbs for treating skin problems, healing wounds, for revitalizing the nerves and brain cells, hence primarily known as a "Brain food" in India⁴. Due to its biological active components of triterpenes and saponins, it shows a significant role in medicinal and nutraceutical applications ^[12].

However, the enriching of brahmi can improve the quality of the chapatti. The nature of brahmi is slightly bitter in taste. So, to mask the herb's bitter taste researchers identified groundnut- incorporated chapatti to satisfy the consumer's demands and also healthy food.

Chapatti is generally consumed in fresh forms in households as well as in restaurants. It is a cheap and primary source of protein and energy ^[13]. A chapatti consists mainly of a crust; with little crumbs ^[14]. The desired quality characteristics in a chapatti are greater pliability, puffability, soft texture, and light creamish brown color, and slight chewiness with a baked wheat aroma ^[15]. Ideally, the chapatti is creamy in color when baked with the minimum of small brown spots and fully puffed so that two distinct layers are present.

In the present study, brahmi was utilized to enrich the quality of chapatti by investigate the effect of Brahmi on different nutritional and sensory attributes and to achieve the best quality product with optimized proportion of wheat flour, Brahmi, and groundnut, using the Response surface methodology (RSM)

Material and Methods

Sample collection

All regularly consumed good quality raw material i.e. wheat flour (multigrain), groundnut, common salt (Brand Tata), oil (sunflower oil) and Centella asiatica fresh leaves were procured from market of Mysuru, Karnataka, India.

Chapati preparation

Dry roast the groundnuts of required amount for 8-10 min in low flame.

Remove the skin of ground nut and powder it coarsely to reduce its size.

Mix all the pre-weighed ingredients (refined wheat flour, powdered groundnut, chopped brahmi, salt and oil)

Make dough of chapatti consistency with required amount of water. Keep aside for 30 minutes.

Roll the dough into chapatti size and cook it both sides with 1 tsp of oil.

Experimental design

Central composite rotatable design was adopted to set up the experimental design in chapatti development. A statistical software design expert® version 7.1.5 from Statease Inc; USA, was used to construct, to analyze the design for product optimization as well as to elucidate the effect of these ingredients on the sensory attributes [16, 17, 18]. From response surface methodology, 15 runs were obtained in which 4 factorial points, 6 axial points and 5 central points showed in Table 1. The ranges of ingredient for chapatti - Brahmi (A), Groundnut (B), Wheat flour (C) were 1.46-8.54g, 2.93-17.07g and 70.86-99.14g respectively. The experimental design of 15 formulations were prepared and evaluated for sensory score are summarized in Table 2. The data were analyzed and prediction equation was generated for each response given below;

Table 1: Experimental design for chapatti with process variables and their levels

Process variables	A point (-1.414)	Factorial point (-1)	Centre point (0)	Factorial point (+1)	A point (+1.414)
Brahmi (gm)	1.46	2.50	5.00	7.50	8.54
Groundnut (gm)	2.93	5.00	10.00	15.00	17.07
Wheat flour (gm)	70.86	75.00	85.00	95.00	99.14

Table 2: Experiment design for chapatti

RUNS	VARIABLES			RESPONSES					
	Levels uncoded			Y1	Y2	Y3	Y4	Y5	Y6
	X1	X2	X3	Appearance	Colour	Texture	Flavour	Taste	OAA
	Brahmi (gm)	Groundnut (gm)	Wheat flour (gm)	(score)	(score)	(score)	(score)	(score)	(score)
1	5.00	10.00	99.14	8.55±0.47	8.60±0.44	8.22±0.64	8.48±0.45	8.15±0.45	8.57±0.45
2	5.00	10.00	85.00	8.81±0.26	8.68±0.39	8.69±0.41	8.46±0.64	8.58±0.44	8.62±0.40
3	2.50	05.00	75.00	8.19±0.32	8.21±0.55	8.03±0.38	7.95±0.33	7.87±0.45	7.89±0.47
4	7.50	05.00	95.00	8.65±0.39	8.35±0.59	8.25±0.49	8.23±0.42	8.32±0.45	8.40±0.44
5	8.54	10.00	85.00	8.54±0.40	8.48±0.43	8.38±0.41	8.44±0.48	8.57±0.45	8.67±0.42
6	7.50	15.00	75.00	8.70±0.32	8.58±0.43	8.79±0.34	8.57±0.48	8.59±0.38	8.74±0.34
7	5.00	17.07	85.00	8.83±0.35	8.69±0.41	8.79±0.40	8.67±0.42	8.70±0.46	8.65±0.45
8	5.00	02.93	85.00	8.79±0.34	8.74±0.41	8.20±0.60	8.76±0.33	8.74±0.34	8.69±0.41
9	5.00	10.00	85.00	8.65±0.45	8.64±0.40	8.35±0.74	8.62±0.41	8.40±0.62	8.50±0.63
10	1.46	10.00	85.00	8.36±0.38	8.29±0.41	8.14±0.68	8.19±0.41	8.32±0.42	8.32±0.42
11	5.00	10.00	85.00	8.30±0.46	8.15±0.55	8.15±0.55	8.20±0.40	8.25±0.40	8.20±0.40
12	5.00	10.00	85.00	8.60±0.49	8.55±0.47	8.55±0.47	8.45±0.47	8.55±0.47	8.50±0.50
13	2.50	15.00	95.00	8.30±0.77	8.25±0.77	8.20±0.40	8.25±0.60	8.25±0.51	8.42±0.42
14	5.00	10.00	85.00	8.10±0.75	8.20±0.84	8.35±1.14	8.20±1.00	8.54±0.89	8.54±0.82
15	5.00	10.00	70.86	8.15±0.74	8.14±0.75	7.75±0.72	7.93±0.65	7.95±0.47	8.01±0.67

*OAA-overall acceptability

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

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

where,
 β₀ - the value of the fitted response at the center point of the design, i.e., point (0, 0, 0);
 β_i, β_{ii} and β_{ij} - the linear, quadratic and cross product (interaction effect) regression terms respectively; n - Number of independent variables.

Organoleptic evaluation of chapatti

The final point of product quality viewed by consumers from sensorial attributes. These samples were evaluated by various sensory properties in the appraisal of food¹⁵. Sensory evaluation on the produced chapatti was served among 25 semi-trained panellists drawn from the Department of Food Science, Yuvaraja’s college, Mysuru. The same-trained panellists using 9-point hedonic scale with 1-dislike extremely, 5-neither like nor dislike, and 9-like extremely for various characteristics such as appearance, color, flavor, taste, texture and overall acceptability [16, 17].

Results and Discussion

The central composite rotatable design was used in experiment with independent variables and responses is given in Table 2. Along with sensorial properties, overall acceptability is also one of the most important criteria as response for the product acceptance. Among 15 combinations the scores for different sensory parameters ranged from 8.1-8.83 for appearance, colour 8.14-8.74, texture 7.75-8.79, flavour 7.93-8.76, taste 7.7-8.74 and overall acceptability 7.89-8.74.

At different level of ingredients, the sensory scores were observed and analysis of variance was calculated for each selected model. The effects of the independent variables using wheat flour, groundnut and Centella asiatica leaves on the response showed in Table 3. The sign and magnitude of the coefficients indicate the effect of the variable on the

responses. Negative sign of a coefficient at linear level indicates decrease in response with an increase in level of the variable where as at interactive levels; level of one variable in Table 3 could be increased while that of the other decreased to obtain the same response. For each model all the three linear, quadratic and interactive effects were calculated. The selected model for all the responses was the quadratic response surface models. The adequacy was calculated by F-ratio, mean, standard deviation, coefficient correlation and lack of fit test. R^2 value was more than 90% showed fitness of the polynomial regression models for describing the effect of variables and lack of fit was highly non-significant. The regression coefficient, correlation coefficients for the responses were 0.99 for flavor and overall acceptability, 0.97 for taste and texture,

Table 3: Coefficient of second order polynomial regression models of chapatti

Coefficient	Appearance	Color	Texture	Flavor	Taste	OAA
β_0	8.42	8.36	8.42	8.41	8.51	8.51
β_1	0.06	0.07	0.08	0.09 ^c	0.09 ^d	0.12 ^a
β_2	0.01	-0.02	0.19 ^c	0.16 ^b	-0.01	-0.01
β_3	0.14 ^d	0.16 ^d	0.17 ^c	0.19 ^b	0.20 ^c	0.20 ^a
β_{11}	-0.01	-0.03	-0.05	0.05 ^d	-0.07 ^d	0.03 ^c
β_{22}	0.17 ^c	0.14 ^c	0.06	0.02	0.07 ^d	0.06 ^b
β_{33}	-0.06	-0.04	-0.18 ^c	-0.11 ^b	-0.18 ^b	-0.13 ^a
β_{12}	0.16	0.22 ^d	0.25 ^c	0.20 ^b	0.17 ^d	0.15 ^b
β_{13}	-0.03	-0.08	0.03	-0.01	-0.18 ^d	-0.23 ^a
β_{23}	-0.19 ^d	-0.05	-0.11	-0.06	-0.11	-0.08 ^c
R^2 %	0.92	0.91	0.97	0.99	0.97	0.99
p%	<0.05	<0.05	<0.01	<0.001	<0.01	<0.0001
Mean	8.47	8.40	8.33	8.42	8.42	8.46
SD	0.10	0.09	0.04	0.06	0.06	0.02
F-value	6.57	5.73	17.65	36.80	21.52	211.60

* β_0 - the value of the fitted response at the center point of the design, i.e., point (0, 0, 0);

* β_i , β_{ij} - the linear, quadratic and cross product (interaction effect) regression terms respectively;

*n - Number of independent variables.

*The superscripts values indicate significant at the level; a: $p < 0.0001$, b: $p < 0.001$, c: $p < 0.01$, d: $p < 0.05$

*OAA – Overall acceptability

The closer the value of R^2 to unity, the better the empirical models fits the actual data. On the other hand, the smaller the value of R^2 the less relevance the dependent variables in the models have in explaining the behavior of variations^[18]. The fitted models are represented by the following equations:

$$\text{Appearance} = 8.42 + 0.06X_1 + 0.01X_2 + 0.14X_3 - 0.01X_2^2 + 0.17X_2 - 0.06X_2^2 + 0.16X_1X_2 - 0.03X_1X_3 - 0.19X_2X_3 \quad R^2 = 0.92$$

$$\text{Color} = 8.36 + 0.07X_1 - 0.02X_2 + 0.16X_3 - 0.03X_2^2 + 0.14X_2^2 - 0.04X_2^2 + 0.22X_1X_2 - 0.08X_1X_3 - 0.05X_2X_3 \quad R^2 = 0.91$$

$$\text{Texture} = 8.42 + 0.08X_1 + 0.19X_2 + 0.17X_3 - 0.05X_2^2 + 0.06X_2^2 - 0.18X_2^2 + 0.25X_1X_2 + 0.03X_1X_3 - 0.11X_2X_3 \quad R^2 = 0.97$$

$$\text{Flavor} = 8.41 + 0.09X_1 + 0.16X_2 + 0.19X_3 + 0.05X_2^2 + 0.02X_2^2 - 0.11X_2^2 + 0.20X_1X_2 - 0.01X_1X_3 - 0.06X_2X_3$$

$$\text{Taste} = 8.51 + 0.09X_1 - 0.01X_2 + 0.20X_3 - 0.07X_2^2 + 0.07X_2^2 - 0.18X_2^2 + 0.17X_1X_2 - 0.18X_1X_3 - 0.11X_2X_3 \quad R^2 = 0.97$$

$$\text{OAA} = 8.51 + 0.12X_1 - 0.01X_2 + 0.20X_3 + 0.03X_2^2 + 0.06X_2^2 - 0.13X_2^2 + 0.15X_1X_2 - 0.23X_1X_3 - 0.08X_2X_3 \quad R^2 = 0.99$$

From the above equation, it can be concluded that at linear level, Centella asiatica was positively significant at the level of $p < 0.01$ for flavor, $p < 0.05$ for taste and $p < 0.0001$ for overall acceptable and insignificant for appearance, color and texture. Groundnut was positively significant at the level of $p < 0.01$ for texture, $p < 0.001$ for flavor, while insignificant for appearance, color, taste and overall

acceptability. Wheat flour was positively significant at the level of $p < 0.05$ for appearance and color, $p < 0.01$ for texture and taste, $p < 0.001$ for flavor and $p < 0.0001$ for overall acceptability.

At quadratic level, Centella asiatica was positively significant at the level of $p < 0.05$ for flavor and taste, $p < 0.001$ for overall acceptable, while insignificant for appearance, color and texture. Groundnut was positively significant at the level of $p < 0.01$ for appearance and color, $p < 0.05$ for taste and overall acceptability, while insignificant for texture and flavor. Wheat flour was negatively significant at the level of $p < 0.001$ for flavor and taste, $p < 0.01$ for texture, $p < 0.0001$ for overall acceptability, while insignificant for appearance and color.

At interactive level, Centella asiatica and groundnut had positive significant effect at the level of $p < 0.05$ for color and taste, $p < 0.01$ for texture, $p < 0.001$ for flavor and overall acceptability, while insignificant for appearance. Centella asiatica and wheat flour had negative significant effect at the level of $p < 0.05$ for taste, $p < 0.0001$ for overall acceptable and was insignificant for appearance, color, texture and flavor. Groundnut and wheat flour had negative significant at the level of $p < 0.05$ for appearance, $p < 0.01$ for overall acceptability and was insignificant for color, texture, flavor and taste.

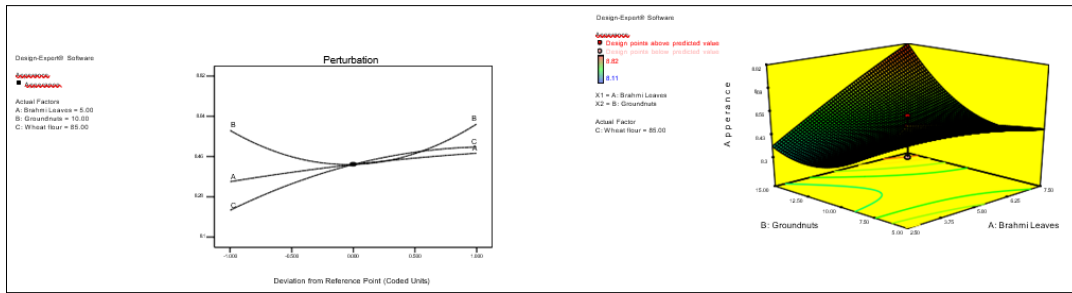


Fig 1a: Appearance

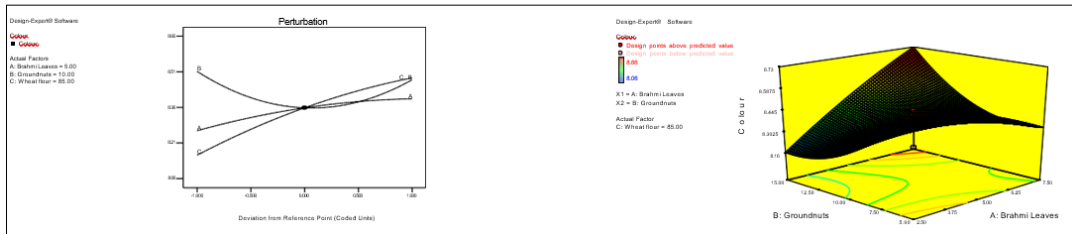


Fig 1b: Color

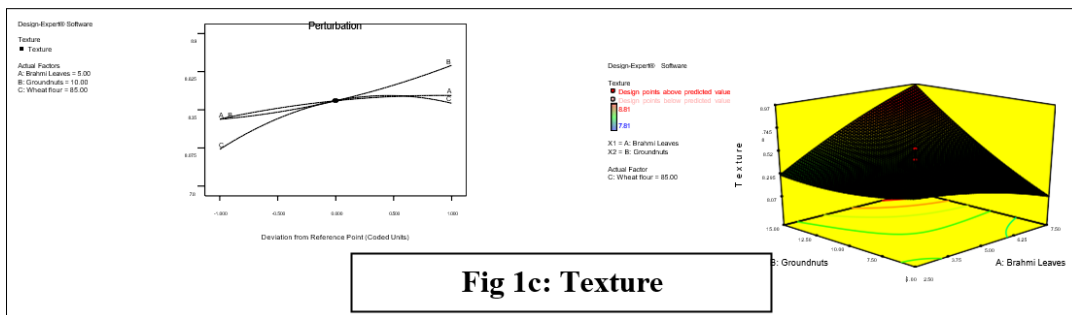


Fig 1c: Texture

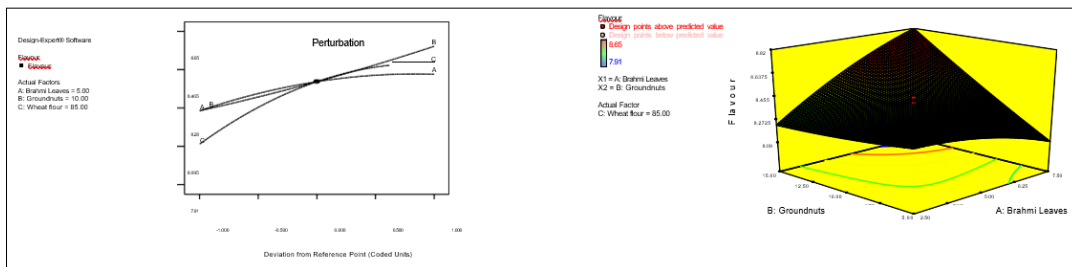


Fig 1d: Flavor

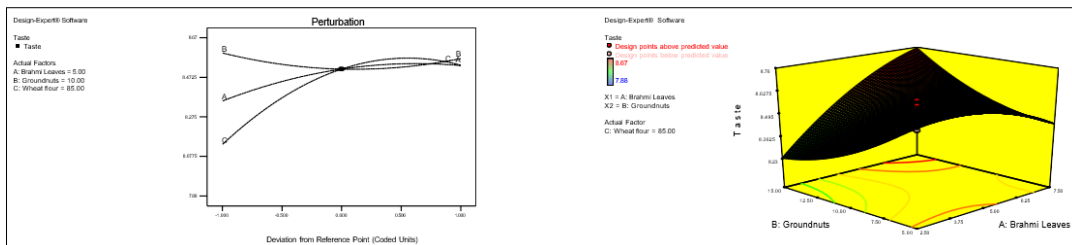


Fig 1e: Taste

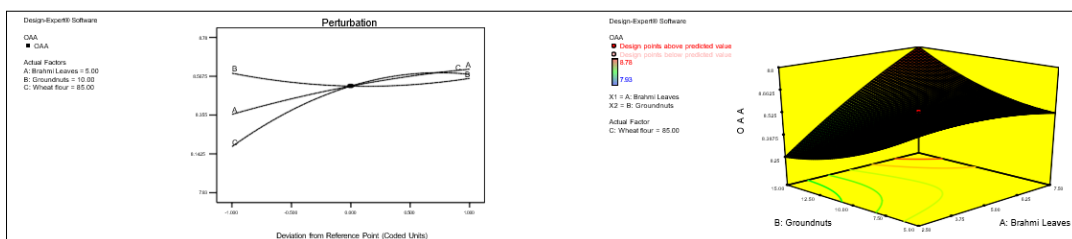


Fig 1f: OAA

It is clear from Fig 1a and 1f that all the three variables had effect on sensory scores. As there was increase in *Centella asiatica* concentration there was increase in all sensory parameters. Scores of texture and flavor though were increased with increasing the concentration of *Centella asiatica*, but it was very negligible increase when compared with other parameters.

In increase in the groundnut concentration, it was observed that increased the scores of texture and flavor, as it decreases then appearance, color, taste and overall acceptability. As wheat flour concentration increases then there was increased in appearance, color, flavor and overall acceptability. But there was slightly increase in texture and taste. In the present study, all the three variables which are *Centella asiatica*, groundnut and wheat flour had great influence on sensory parameters.

Optimization of independent variables

Numerical optimization of independent variables *Centella asiatica*, groundnut and wheat flour were achieved using design expert software shown in Table 4. The aim of the experiment was increases sensory scores. The obtained optimized solution was 7.38g *Centella asiatica*, 14.99g groundnut and 79.50g refined wheat flour with best fit desirability of 1.000 (Fig 1). The optimized results were 8.83 appearance, 8.69 color, 8.84 texture, 8.70 flavor, 8.73 taste and 8.81 for over all acceptability. Both the predicted and actual value for responses were shown in Table 4 were in concurrence with each response, hence the fitted models are suitable for predicting the responses. RSM showed that quadratic response surface models were fitted. F values were significant in all selected responses and a high R² value showed fitness of the polynomial regression models for describing the effect of variables.

Table 4: Predicted and actual response values for the optimized composition of Chapatti

Responses	Predicted	Actual (n=3)
Brahmi (gm)	7.38	-
Groundnut (gm)	14.99	-
Wheat flour (gm)	79.50	-
Appearance (Score)	8.83	8.35±0.15
Color (Score)	8.69	8.40±0.19
Texture (Score)	8.84	8.39±0.22
Flavor (Score)	8.70	8.43±0.19
Taste (Score)	8.74	8.55±0.25
OAA (Score)	8.81	8.52±0.22

Conclusion

The present study indicated that Response surface methodology was successfully suited for evaluating the individual and interaction effect of variables on different parameters and to optimize brahmi, groundnut and wheat flour to improve the quality of chapatti seems to be justified based on sensory properties. The 3 variables employed in the study had slightly difference on the quality of chapatti. Until for some extent the addition of brahmi increases all sensory attributes. The optimized solution suggested that the combination of ingredients level achieved a very good desirable result with 7.38g of brahmi, 14.99g of groundnut ad 79.50g of wheat flour with the best fit desirability of 1.000 for the chapatti.

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