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Original article

Wheatgrass incorporation as a viable strategy to enhance nutritional quality of an edible formulation

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Abstract

Wheatgrass is highly valuable due to its medicinal properties. Despite the medicinal properties, wheatgrass could not be part of daily diet, as it is not a regular part of diet so there is requirement to prepare food product supplemented with wheatgrass. In this study, we have prepared edible formulation based on wheatgrass (EFWG). The optimum combination of ingredients for the preparation of wheatgrass incorporated edible formulation was determined using response surface methodology (RSM). RSM is used to analyse the effect of wheatgrass flakes, refined wheat flour, and frying time on sensory and objective (total phenolic and fiber levels) attributes of formulated food product. A central composite rotatable design was used to develop models for the sensory and objective responses. Responses were mostly affected by the changes in wheatgrass flakes level and frying time and to a lesser extent by the refined wheat flour. Responses individual graph plots of different responses were superimposed and regions meeting the maximum sensory score (7.85), total phenolic content (81.85 mg/100 g) and fiber (2.43 g) were identified at 7.00 g wheatgrass flakes, 90.98 g refined wheat flour and 3:50 min. frying time. Optimized formulation was analyzed for its nutritional composition, antinutritional factors and antioxidant properties. The optimized formulation could be recommended to all the age group but especially for children, lactating mothers and geriatric population due to its high calcium, iron and fiber content.

Key words: Wheatgrass, response surface methodology, product formulation, nutritional analysis, antioxidant properties, antinutritional factors

1. Introduction

Wheatgrass is widely used in the Indian traditional system of medicine for various ailments (Rajesh *et al.*, 2011). The young grass of common wheat plant, known as wheatgrass *(Triticum aestivum*), belongs to family poaceae. Wheatgrass is rich in vitamins (A, C, and E), minerals (Ca, Mg, Iron, Zinc), fiber and bioactive compounds (chlorophyllin, quercetin, rutin). Chlorophyll constitutes about 70% of total chemical constituents of wheatgrass (Swati *et al.*, 2010). Several biological properties have been attributed to wheatgrass including blood building activity (Marwaha *et al.*, 2004), anticancer **(**Dey *et al.*, 2006**)**, antiulcerative (Kothari *et al.*, 2008**)**, antidiabetic (Chauhan *et al.*, 2014**)**, antiarthritic (Nenonen *et al.*, 1998), anti-inflammatory and antiageing (Smith *et al.*, 2006). It is believed that pharmacological potential of wheatgrass is due to its high nutrient content and presence of bioactive compounds, which makes it a medicinal plant for the treatment of various diseases and life threatening conditions (Walters *et al.*, 1992).

Ready to eat snacks are an important source of nutrients (energy, protein, iron, calcium and several vitamins). Most ready to eat snacks can easily be enriched and fortified at a low cost with proteins, vitamins and minerals to meet the specific needs of the target groups and vulnerable sections of the population, who are malnourished. Use of fortification and enrichment plays an important role in creating food products (Sharma *et al.*, 1998).

Wheatgrass flakes could be used for preparing value added ready to eat products for organoleptic, economic and nutritional reasons. Value added edible formulation of wheatgrass (EFWG) could be easily fortified with wheatgrass flakes to provide a convenient food to supplement daily nutrition. Since consumption of ready to eat snacks is increasing day-by-day and wheatgrass on the other hand is full of functional ingredients. It may be worthwhile to explore the possibility of incorporating wheatgrass in edible formulations. The present study is an effort to standardize the level of wheatgrass flakes for the development of value added edible formulation of wheatgrass (EFWG).

2. Materials and Methods

2.1 Procurement of the raw material

Wheatgrass seeds for the research were purchased from local market of Allahabad, and grown in controlled conditions at the laboratory of Centre of Food Technology, University of Allahabad, Uttar Pradesh, India. All the other required ingredients like refined wheat flour, common salt, refined oil and spices were purchased from local market of Allahabad. All the chemicals used in analyses were of AR grade.

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2.2 Cultivation of wheatgrass

Wheatgrass was grown in 2 inch deep plastic trays filled with one part organic fertilizer/peat moss and three parts planting soil. Wheat grains were soaked in water for 24 h then rinsed. Wheat was evenly spread over the moist soil. It was covered with a paper towel and placed near a window to ensure proper ventilation for three days. Around the ninth or 10th day, the wheatgrass having grown to 10-12 inches were harvested. At this stage, the wheatgrass is at its nutritional peak. Fresh leaves of the grass were cut and dried in hot air oven (50-55^0 C) for 6 h. Dried samples were stored in airtight containers for further processing.

2.3 Experimental design

Response surface methodology (RSM) was used to determine the experimental design and optimal ingredient level in preparation of EFWG. RSM is an important tool for optimization, which reduces the number of experimental runs needed to provide sufficient information for statistically acceptable results. A three factor central composite design (CCD) was used to design the experiments, comprising of three independent variables including the wheatgrass flakes (6-8%), refined wheat flour (92-95%) and frying time (2-5 min) Table 1. The effects of these variables were seen on the responses variables total phenolic content, fiber and overall acceptability. The experimental sheets of 20 variants with different ratio of independent variables were generated (Table 2). The response variables to be estimated were entered in the sheet. This data were subjected to analysis of variance (ANOVA) one-way analysis and regression coefficients (R^2) to get the optimum response. Coefficient of determination (R^2) values should be close to 1. The predicted R^2 value should be in reasonable agreement with adjusted R^2 (Bunkar *et al.*, 2012). R^2 can be defined as the ratio of explained variation to the total variation, which was a measure of the degree of fit (Chan *et al.*, 2009).

Table 1: Levels of dependent factors to optimized EFWG

Name	Units	(-1) Low level	(+1) High level	(-) Alpha	(+) Alpha
Wheatgrass flakes	(g)	6	8	5.31821	8.68179
Refined wheat flour	(g)	92	95	90.9773	96.0227
Frying time	(Minutes)	2	5	0.977311	6.02269

Table 2: Experimental design generated levels of independent variables in estimated responses

Generated			Estimated		
Wheatgrass flakes (g)	Refined wheat flour (g)	Frying time (minutes)	TPC (mg/100g) Acceptability	Fiber (g)	Overall
6.00	92.00	2.00	80.89	1.65	6.89
8.00	92.00	2.00	81.12	2.26	7.12
6.00	95.00	2.00	81.66	2.15	7.66
8.00	95.00	2.00	80.22	1.96	6.22
6.00	92.00	5.00	79.86	2.42	5.86
8.00	92.00	5.00	81.56	3.15	7.56
6.00	95.00	5.00	80.89	1.85	6.89
8.00	95.00	5.00	81.88	2.66	7.88
5.32	93.50	3.50	80.69	1.89	6.69
8.68	93.50	3.50	80.54	2.42	6.54
7.00	**90.98**	**3.50**	**81.85**	**2.43**	**7.85**
7.00	96.02	3.50	81.56	2.76	7.56
7.00	93.50	0.98	80.89	1.89	6.89
7.00	93.50	6.02	81.65	2.21	7.65
7.00	93.50	3.50	81.12	2.52	7.12
7.00	93.50	3.50	81.12	2.36	7.12
7.00	93.50	3.50	81.12	2.65	7.12
7.00	93.50	3.50	81.45	2.21	7.45
7.00	93.50	3.50	81.25	2.36	7.25
7.00	93.50	3.50	81.52	2.41	7.52

2.4 Formulation of the product

Preparation of the EFWG: Wheatgrass flakes, refined wheat flour and refined oil were mixed in the proportions as obtained in the experimental design to form different formulations. These formulated mixes were further mixed with fixed ingredients, *i.e.*, common salt (2.8 gm), and ajwain (3.5 gm). The dry powder was thoroughly mixed, followed by the addition of refined oil and cold water (25-35 ml), to make a pliable dough. Refined oil was used during the dough preparation to enhance the stability of the product as well as improve the texture of the end product. Small round balls were made from the dough, rolled and flattened into circular shape (20 cm diameter) and cut into desirable shapes. These pieces were fried (according to the combinations) in refined sunflower oil and heated up to 150 ± 5°C to a golden brown colour. The control samples were prepared following the same procedure, without incorporation of wheatgrass flakes. The EFWG were packed in paper/ foil/ polyethylene (PFP) pouches prior to sensory, proximate, antioxidant and antinutritional analysis. The data for formulations along with responses were analyzed using statistical software (Design-Expert 7.0.0) of the best-fit design to obtain the optimized compositions.

2.5 Determination of responses

2.5.1 Total phenolic content (TPC)

Phenolic compound concentration in the EFWG methanolic extract was estimated by a colorimetric assay, based on procedures described by Singleton and Rossi (1965) with some modifications (Singleton and Rossi, 1965). Briefly, 1 ml of sample was mixed with 1 ml of Folin-Ciocalteu's phenol reagent. After 3 min, 1 ml of saturated sodium carbonate solution was added to the mixture and adjusted to 10 ml with distilled water. The reaction tube was kept in the dark for 60 min after which the absorbance was measured at 765 nm (Thermo Scientific, model-Evolution 600). Gallic acid was used to calculate the standard curve (0.01- 0.4 mM). The results are expressed as mg of gallic acid equivalents/g of extract (GAEs).

2.5.2 Estimation of crude fiber

Crude fiber was estimated using acid and alkaline digestion method (Ranganna, 2005). Digestion of 2 g sample (W) was done with 200 ml H_2SO_4 (0.25N) for 30 min. Residue was washed with hot distill water. Then digestion was done with 250 ml of NaOH (0.25N) for 30 min. Again washed with hot distill water. Then residue was washed with 15 ml ethanol. This residue was kept in hot air oven untill constant weight (W1) was obtained. Kept the residue in muffle furnace at 450°C for 4-5 h. Weight (W2) was taken after it get cooled.

$$\text{Crude fiber content (\%)} = (W1-W2)/(W) \times 100$$

2.5.3 Overall acceptability

Sensory evaluation of EFWG (20 combinations) resulting from the experimental design was evaluated in relation to the sensory preference using 9-point hedonic scale with anchor points, 1 (dislike very much) and 9 (like very much). A semi-trained panel of 10 judges evaluated the samples, which were randomly presented for overall acceptability. All panelists were between the ages of 25 to 40 years. The order of presentation of samples was randomized and different 2-digit number codes were used for the sample sets. The coded samples were served at room temperature (25°C) and water was provided for rinsing. The results were presented as mean of 10 evaluations.

2.5.4 Nutritional analysis

The nutritional analysis of the optimum formulation was conducted to evaluate the nutritional adequacy of the formulated food product. Moisture and ash were estimated by using standard (AOAC, 2005) method. Protein was estimated using micro-kjeldhal method using kel plus. Fat was determined by the soxhlet extraction method (Ranganna, 2005). The carbohydrate content was calculated by difference from the levels of nutrients analyzed. Iron and phosphorus were determined according to standard method of AOAC using spectrophotometer while calcium and vitamin C were determined by titrimetric method (Ranganna, 2005). The total caloric value was calculated by using the equation:

$$TCV = [(\text{carbohydrates} + \text{protein})\ 4 + (\text{lipids})\ 9]\ \text{kcal.g}^{-1}$$

2.6 Antinutritional analysis

2.6.1 Tannin

Tannin content in wheatgrass and optimized EFWG was determined by Folin-Denis method (Sadasivum and Manickam, 2005). Color intensity was measured at 700 nm after 30 min of incubation period. Standard graph was prepared using 0-100 µg tannic acid. Tannin content of the samples was calculated as per cent (%) tannic acid from the standard graph.

2.6.2 Phytate

Phytate content was determined by colorimetric method as described by Sadasivam and Manickam (2005). 3% TCA was used for extracting phytate and was precipitated as ferric phytate, which was then converted into ferric hydroxide, and soluble sodium phytate by adding sodium hydroxide in boiling condition. Hot nitric acid was added to it and solution was diluted. Colour of solution was developed using potassium thiocyanate and its intensity was read immediately at 480 nm. The absorbance of iron content so determined was used for calculating phytate phosphorus content assuming a constant 4 Fe: 6 P molecular ratio in the precipitate. Ferric nitrate was used to make standard curve.

2.6.3 Trypsin inhibitor

Trypsin inhibitor (TI) content of sample was determined according to the method of (Kakade *et al.,* 1974) as modified by Rackis *et al.* (1981) using BAPNA (N-a-Benzoyl-DL-Arginine p-nitroanilide) as a substrate.

2.7 Antioxidant analysis

2.7.1 Radical scavenging activity

The free radical scavenging activity of the extract was measured using DPPH (1, 1- diphenyl 2-picryl hydrazyl) method of (Mansouri *et al.,* 2005) with slight modification. 10 mg of grounded optimized product was mixed with 10 ml acidified methanol and heated at 40°C in water bath for 30 min. 100 µl of sample extract thus prepared was kept in a test tube and diluted with 2.9 ml of pure methanol. Sample was mixed with 150 µl of DPPH solution, incubated for 15 min. in dark and absorbance was measured in UV visible spectrophotometer at 515 nm. The % radical scavenging activity was calculated using following formula:

$$\text{Control Absorbance - Sample Absorbance/Control Absorbance} \times 100$$

2.7.2 Ferric reducing antioxidant power (FRAP)

Ferric reducing antioxidant power was determined by the method described by Benzie and Strain (1996). 200 µl of methanolic extract of sample was mixed with 1.3 ml of freshly prepared FRAP reagent and kept for incubation at 37°C for 30 min. Absorbance was measured at 595 nm by using spectrophotometer. The absorbance change in the test mixture was compared with standard mixture of heptahydrate ferrous sulphate (0.1 mM/l - 1.0 mM/l). FRAP values are expressed as mMol of Fe (II) equivalent/ g sample.

2.7.3 Reducing capacity

The reducing power was determined according to the method of Oyaizu (1986). EFWG methanolic extract (2.5 ml) was mixed with 2.5 ml of sodium phosphate buffer (pH 6.6) and 2.5 ml of 1% potassium ferricyanide. The mixture was incubated at 50°C for 20 min. After that, 2.5 ml of 10% trichloroacetic acid (w/v) was added in the mixture and centrifuged at 650 rpm for 10 min. The upper layer (5 ml) was mixed with 5 ml deionised water and 1 ml 0.1% ferric chloride, and the absorbance was measured at 700 nm, higher absorbance indicates higher reducing power. Ascorbic acid was used as standard.

2.7.4 Total flavonoid content

Aluminum chloride colorimetric method was used for flavonoid determination (Bahorun *et al.*, 1996). 1 ml of EFWG methanolic extract was mixed with 1 ml of 2% aluminum chloride. The absorbance of the reaction mixture was measured at 430 nm with a spectrophotometer (Thermo Scientific, model-Evolution 600). A calibration curve was prepared using a standard solution of quercetin (0.05-0.5 mg/ml). Final results are expressed as mg quercetin equivalents/g (QE) of sample.

2.8 Statistical Analysis

The data obtained were analyzed statistically for analysis of variance (ANOVA) using completely randomized design with least significant difference (LSD) at $p < 0.05$ using Design-Expert 7.0.0 statistical software package.

3. Results

In this study, wheatgrass fiber and minerals rich snack food was prepared from natural ingredients to yield products with specific functional properties. The proximate composition of EFWG clearly showed that optimized formulation is rich in calcium (117.33 mg/ 100 g), iron (5.36 mg/100 g), dietary fiber (2.43%) and energy (496.59 kcal), respectively (Table 3). The optimized edible product of wheatgrass (EFWG) was developed using central composite design with minimum possible number of points. The experimental design with different independent variables and respective responses along with the coded variables for the product is given in (Table 2).

3.1 Response surface model

The best formulation was optimized using central composite design (CCD). Three factors were studied to get the optimum values. The experimental sheet of different independent variables; amount of wheatgrass flakes and refined wheat flour with frying time was generated and the responses; estimated total phenolic content, crude fiber and overall acceptability were entered in the sheet (Table 2). The data were analyzed on the basis of ANOVA and regression coefficients. The effects of different independent variables were studied on different responses to obtain an optimum solution. The results of ANOVA and regression coefficient (R^2) for the effect of independent variables on dependent variables, known as responses, were analyzed. For each model, the probability (p value) was less than F value ($p \geq 0.05$), revealing that the terms in each model had a significant effect on the responses-total phenolic content, fiber and overall acceptability. The R^2 values were 0.8408, 0.8079, and 0.8504 for TPC, fiber, and overall acceptability, suggesting a good fit of each model.

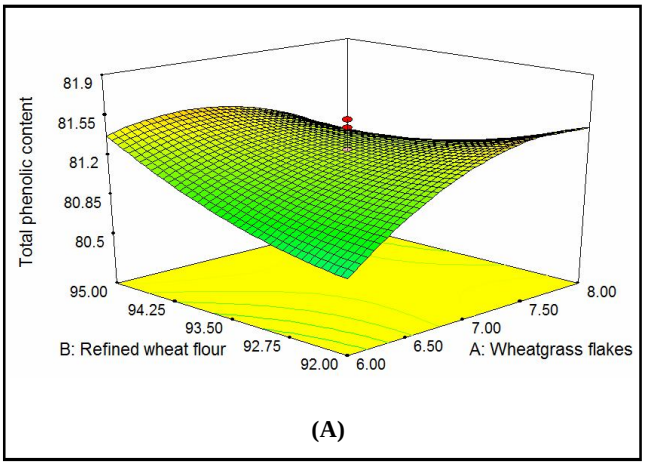
Table 3 : Proximate analysis

Parameters	Control	Optimised EFWG
Moisture (g)	13.00±1.00	11.00±1.00
Protein (g)	6.50±0.78	7.89±0.68
Fat (g)	30.30±2.14	27.85±1.12
Ash (g)	2.00±0.85	2.15±0.65
Carbohydrate (g)	48.2±1.00	49.11±1.15
Energy (kcal/100g)	491.5±0.56	496.59±0.86
Phosphorus (mg)	53.00±1.00	72.33±2.21
Calcium (mg)	100.00±2.00	117.34±2.45
Iron (mg)	2.70±0.20	5.36±1.36
Ascorbic acid (mg)	0.78±0.02	7.00±0.50

EFWG = Edible formulation of wheatgrass

3.2 Effect of independent variables on total phenolic content

Total phenolic content of EFWG (TPC) is one of the important antioxidant properties of the formulated snacks. In the present study, TPC was found to be in the range of 79.86-81.88 mg/100 g (Table 2). Response surface plot for TPC as function of wheatgrass flakes, refined wheat flour and frying time is given in Figure 1 (a, b, c). Increase in the values of wheatgrass flakes, refined wheat flour and frying time increases the TPC. Regression analysis showed a significant ($p \leq 0.05$) positive effect of wheatgrass flakes, refined wheat flour and frying time on total phenolic content.



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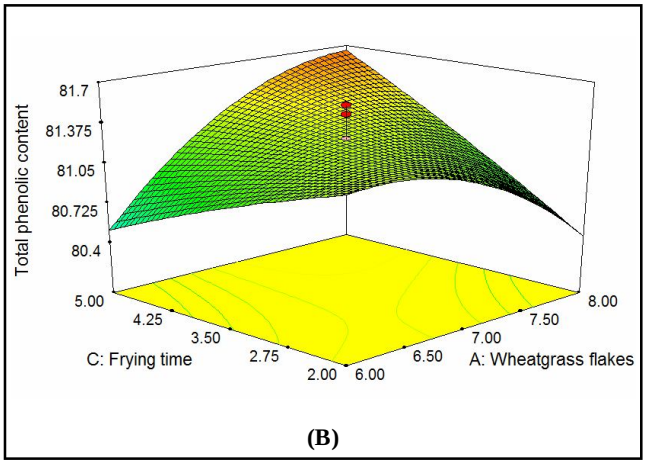

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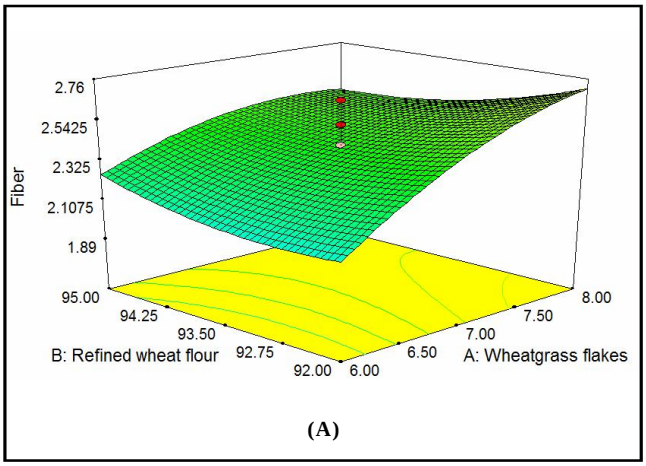
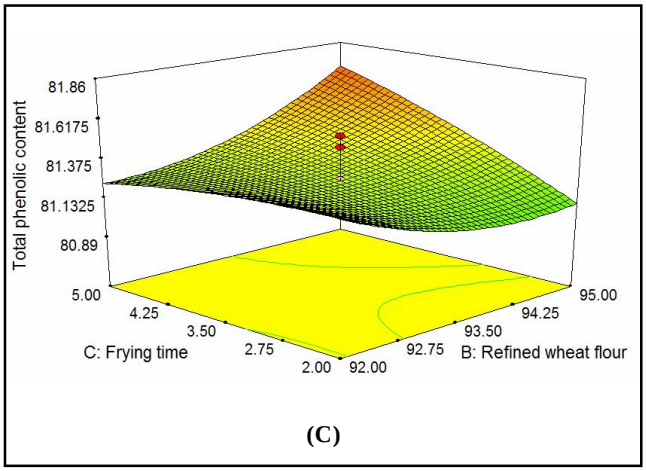


(A)



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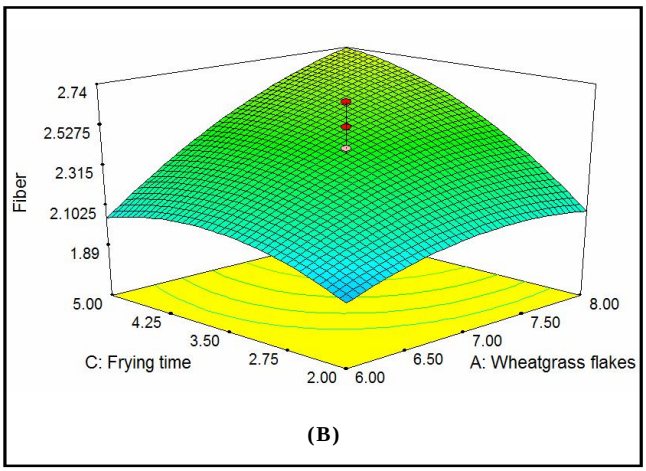


(B)

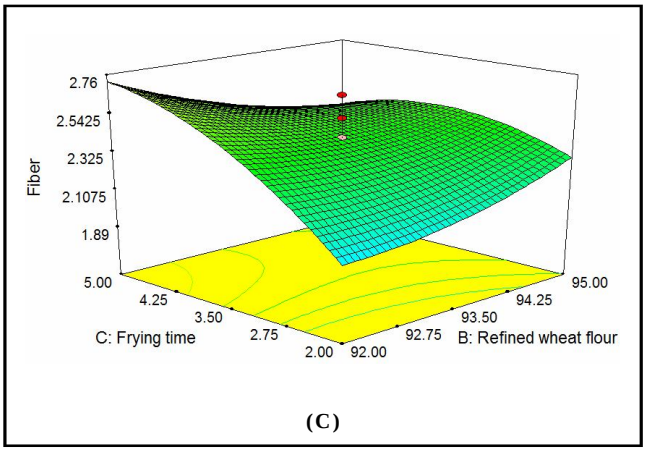
Figure1: Response surface and counter plots showing effects of variable on the total phenolic content of EFWG, (A) wheatgrass flakes vs. refined wheat flour, (B) wheatgrass flakes vs. frying time, (C) refined wheat flour vs. frying time.

3.3 Effect of independent variables on crude fiber content

In this experiment, the fiber content ranged from 1.65 to 3.15 g/ 100 g (Table 2). Regression model fitted well with the experimental results. Fiber content showed a significant ($p \leq 0.05$) positive effect with both the variables; wheatgrass flakes and refined wheat flour however frying time showed ($p \leq 0.05$) negative effect on fiber content. From the response surface plot Figure 2 (a, b, c), it was observed that increase in wheatgrass flakes and refined wheat flour content increases significantly ($p \leq 0.05$) the value of fiber of the optimized formulation.

3.4 Effect of independent variables on overall acceptability

Overall acceptability of EFWG was found to be in the range of 5.86 to 7.85 (Table 2). As per regression coefficient for overall acceptability, it was noticed that overall acceptability of the optimized product (EFWG) showed a positive ($p \leq 0.05$) effect with wheatgrass flakes, refined wheat flour and frying time. Response surface plot Figure 3 (a, b, c) showed that overall acceptability of the optimized product increases with increase in the value of wheatgrass flakes, refined wheat flour and frying time.



(C)

Figure 2: Response surface and counter plots showing effects of variable on the fiber content of EFWG, (A) wheatgrass flakes vs. refined wheat flour, (B) wheatgrass flakes vs. frying time, (C) refined wheat flour vs. frying time.

3.5 Optimization and characterization

The response optimization was achieved as per the desired criteria based on the acceptance of the product. The solutions could be achieved from the software with the maximum desirability as well as the acceptance and the optimum variable levels by being at random starting points and proceeding on the path of the steepest

slope to a maximum. The best among them was taken as the optimum. Wheatgrass flakes 7.00 g, refined wheat flour 90.98 g with 3:50 min frying time achieving the desirability of 1 and OAA of 7.85 on nine point hedonic scale was the optimized ingredient composition with the best fit. The predicted response value of acceptability, TPC and fiber content scores were 7.26, 8.26, 2.41 as against actual values 7.85, 81.85, 2.43, respectively, which were in concurrence with each other.

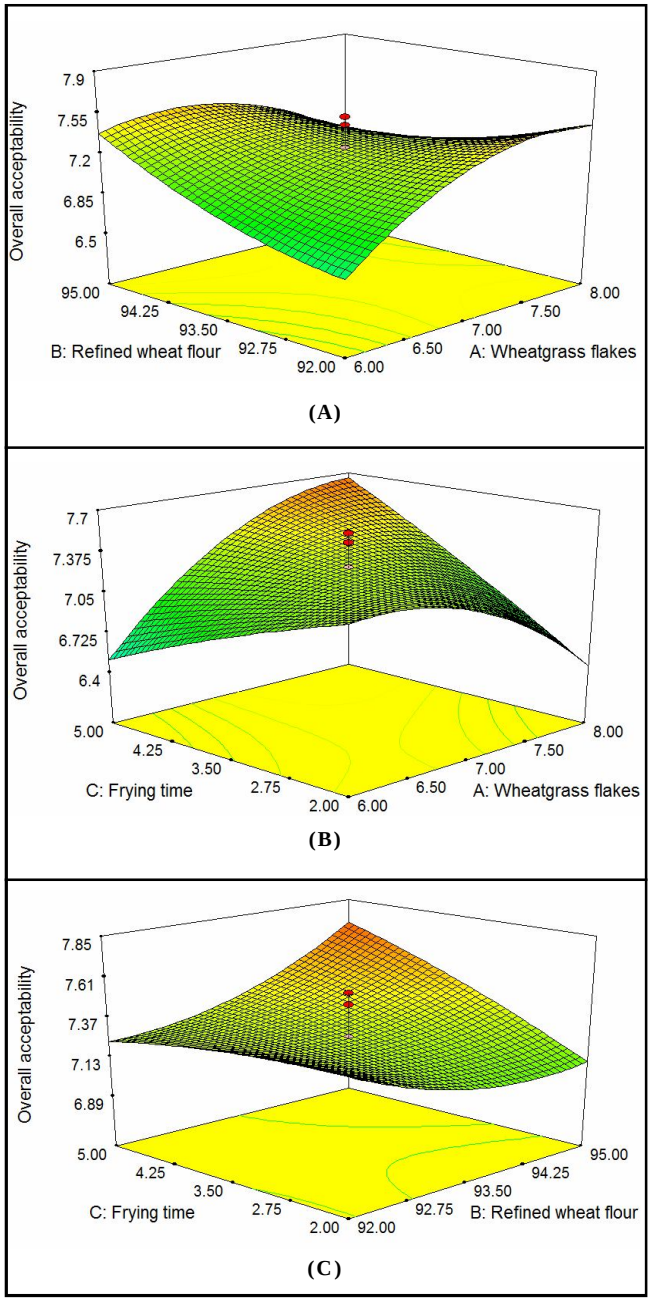


Figure 3: Response surface and counter plots showing effects of variable on the overall acceptability of EFWG, (A) wheatgrass flakes vs. refined wheat flour, (B) wheatgrass flakes vs. frying time, (C) refined wheat flour vs. frying time.

3.6 Proximate composition

The proximate composition of the optimized EFWG is shown in (Table 3). By incorporation of wheatgrass flakes, the protein, ash and carbohydrate was increased from 6.50% to 7.89%, 2% to 2.15%, and 48.2% to 49.11%, respectively. The fat and moisture content was decreased from 13% to 11%, 30.30% to 27.85% with incorporation of wheatgrass flakes. The optimized formulation was found to be superior in terms of 117.34% calcium, 72.33% phosphorus, 5.36% iron, and 7% ascorbic acid as compared to control, 100% calcium, 53% phosphorus, 2.70% iron, and 0.78% ascorbic acid, respectively.

3.7 Antinutritional analysis

The antinutritional factors of optimized product are summarized in (Table 4). Highest tannin, trypsin inhibitor and phytate content was found in optimized EFWG (0.56%, 20%, 38.67%), respectively, and lowest was in case of control (0.43%, 18%, 34.33%), respectively.

Table 4: Antinutritional analysis

Treatments	Tannin (mg/100g)	Phytate (%)	Trypsin inhibitor (%)
Control	0.43±0.11	34.33±1.52	18.00±1.25
Optimised EFWG	0.56±0.21	38.67±1.52	20.00±1.41

EFWG = edible formulation of wheatgrass

3.8 Antioxidant analysis

Antioxidant potential of optimized formulation EFWG was shown in (Table 5). Wheatgrass flakes supplemented optimized formulation contained higher antioxidant potential including 98.67 mgQE/g total flavonoid content, 78.33% DPPH radical scavenging activity, 0.42 mmol Fe(II)Eq/g FRAP value, 0.41 % reducing capacity, and 46.67 umolAAE/g metal chelating activity than control (40 mg QE/g, total flavonoid content, 47.67% DPPH radical scavenging activity, 0.21 mmol Fe(II)Eq/g FRAP value, 0.26 % reducing capacity, 17 umolAAE/g Metal chelating activity, respectively.

Table 5 : Antioxidant analysis

Treatment	TFC (mg QE/g)	DPPH (%)	FRAP (mmolFe(II)Eq/g)	Metal chelating (µmol/AAE/g)	Reducing powder (%)
Control	40.00±2.54	47.67±2.5	0.21±0.23	17.00±0.77	0.26±0.23
Optimised EFWG	98.67±7.5	78.33±1.5	0.42±0.15	46.67±0.88	0.41±0.06

4. Discussion

In this study, response surface methodology was used for the optimization of independent variables, *i.e.*, amount of wheatgrass flakes, amount of refined wheat flour and frying time and their effect on responses, *i.e.*, total phenolic content, fiber and overall acceptability. It reveals that the terms in each model had a significant effect on the responses-total phenolic content, fiber and overall acceptability, suggesting a good fit of each model. Jackson *et al.* (1996) used RSM to predict that maximum crispness of banana chips could be produced by blanching at 69°C and 22 min, while Shyu and Hwang (2001) optimized the conditions for vacuum frying

of apple chips at temperature of 100-110°C for 20-25 min. and immersing in fructose solution of 30-40%.

The increased effect of independent variables on TPC may be due to the higher antioxidant content of wheatgrass flakes and incorporation of refined wheat flour may also have increased TPC content. In some conditions, heat-processing treatments (frying, roasting) may also be helpful for increasing antioxidant content. Heat treatments (frying and roasting) leads to chemical oxidation of phenol and non-enzymatic browning reaction associated with strong antioxidant potential (Manzocco *et al.,* 2000).

Formulated product has increased value of fiber content with incorporation of wheatgrass flakes and refined wheat flour could be due to the high fiber content of wheatgrass. Wheatgrass powder was found to be a rich source of dietary fiber. Mogra and Chouhan (2014) reported higher amounts of dietary fiber content (23.26%) in wheatgrass powder.

For the evaluation of sensory attribute of formulated product, overall acceptability was considered as response variable. In this study the hedonic ratings of sensory attribute, *i.e.*, overall acceptability was observed 7.85 (like moderately) by the panelists (Table 2). Overall acceptability of the optimized product was found increase with increase in the amount of wheatgrass flakes, refined wheat flour and frying time. Crispiness and other sensory attributes were increased with the increased incorporation of wheatgrass flakes in the formulated product.

The nutritive value of wheatgrass flakes supplemented formulation was found higher than that of control product. It is clear that supplementation of the basic formula with the wheatgrass flakes resulted in higher dietary fiber, and mineral matter content. This fulfills approximately one third nutritional requirement of school going children (Table 3). The fiber content was relatively high in this product, which indicates that incorporation of natural plant fibers, and their minerals in food products thus increasing the mineral and fiber consumption in daily diet.

It must be noted that antinutritional factors (tannin, trypsin inhibitor and phytate content) of EFWG was found higher than control product. The results are closer to that of Udensi *et al.* (2007). Studies suggest that antinutritional factors can be reduced by various food processing techniques.

Incorporation of wheatgrass flakes, gave an excellent antioxidant effect on the EFWG as compared with control. Addition of wheat grass enhanced the antioxidant effect of the optimized formulated product. The higher efficiency of the wheatgrass flakes could be due to the persistence of this natural antioxidant during processing. In addition, natural antioxidants are safe and impart health benefits to the consumer.

5. Conclusion

The EFWG formulation can serve as a good source of dietary fiber, minerals and is a novel approach for increasing the mineral and fiber consumption in daily diet. Hence, it can be recommended for consumption by children and old age people for partial fulfillment of nutritional requirements. Wheatgrass may be good source of natural antioxidants and has the potential to enhance the health benefits to the consumer.

Conflict of interest

We declare that we have no conflict of interest.

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