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RESEARCH ARTICLE

DEVELOPMENT AND OPTIMIZATION OF VALUE ADDED BREAD USING RESPONSE SURFACE METHODOLOGY

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ABSTRACT

Natural antioxidants or phytochemical antioxidants are secondary metabolites of plants. Ginger (*Zingiber officinale*) can be a major source of natural or phytochemical antioxidants such as beta-carotene, ascorbic acid, terpenoids, alkaloids, and polyphenols such as flavonoids, flavones glycosides, rutin etc. It is an important commercial crop which is, used both as spice and medicine and its therapeutic benefits of ginger are mainly due to the presence of volatile oils. Consumption of bakery products in the country is increasing day by day and bread is a staple food having several attractive features. In the view of health benefit of ginger it may be worthwhile to explore possibility of incorporating ginger extract in wheat flour for the development of bread to provide a convenient food to supplement the diet.. Present study was an effort to standardize the level of ginger extract in formulation for the development of value added bread. To optimize the quantity of sugar and ginger extract to be added, Response Surface Methodology (RSM) was used, while rest of the ingredient level was kept constant. The lower and upper limits for sugar and ginger extract were taken as 20-30 g and 10-20 ml, respectively. Control treatment was prepared without ginger extract addition. All thirteen combinations and control were subjected for sensory quality evaluation on a 9 point hedonic scale. From the study, it was found that the bread having composition 17.93 g sugar, and 15 ml ginger extract per 100 g of bread was found optimum and the said formulation was acceptable and recommended for value added bread. The optimized bread was found to be superior in terms of minerals, calcium and iron as compared to control bread. Since, the bread was a good source of calcium and iron, hence it can be recommended for consumption for children and old age people. The addition of ginger extract, also gave an excellent antioxidant effect on the bread compared with control. It can be recommended as one of the value added products.

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INTRODUCTION

Ginger *(Zingiber officinale)* is an important commercial crop belonging to the family Zingiberaceae grown for its aromatic rhizomes, which are used both as spice and medicine (Badreldin *et al*., 2008). It can be used fresh, dried and powdered, or as a juice or oil. Ayurvedic medicine utilizes it for the treatment of arthritis (Thomson *et al*., 2002). Other traditional uses of ginger include colic, colds, fever, menstrual cramps and appetite stimulant (Chrubasik *et al*., 2005). Ginger supplements are widely available and include liquid extract, syrup, tea and capsules. The herbal therapeutic benefits of ginger are mainly due to the presence of volatile oils and the high oleoresin content. A compound known as gingerol (Bhattarai *et al*., 2001) is an acrid chemical constituent of the ginger, and this chemical compound is the agent responsible for the hot taste of ginger and is also one of the reasons that ginger possesses stimulating properties on the body (Wang *et al*., 2003). The aroma of ginger is pleasant and spicy and its flavor is penetrating, slightly biting due to antiseptic or pungent compounds present in it, which make it indispensable in the manufacture of a number of food products like ginger bread, confectionery, ginger ale, curry powder, certain soft drinks like cordials, ginger cocktail, carbonated drinks, bitters, etc. Ginger is also used for the manufacture of ginger oil, oleoresin, essences, tinctures, etc (Francisco *et al*., 2008). Bakery products are an important source of nutrients viz. energy, protein, iron, calcium and several vitamins. Most bakery products can easily be enriched and fortified at a low cost with proteins and various vitamins and minerals to meet the specific needs of the target groups and vulnerable sections of the population, who are undernourished and malnourished. Since fortification and enrichment can be easily carried out, it is very important that more nutritious products should be produced in future (Sharma *et al*., 2013). Bread is a staple food having several attractive features mentioned above and these

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features enhance the value of producing bread from composite flours for organoleptic, economic and nutritional reasons. In places where soft wheat flour is not available or too expensive, it becomes economically necessary to produce bread from composite flours. Nutritionally, bread can be easily fortified with ginger extract to provide a convenient food to supplement the diet for better nutrition. Since consumption of bakery products in the country is increasing day by day and in the view of above health benefit of ginger, it may be worthwhile to explore possibility of incorporating ginger extract in wheat flour. Present study was an effort to standardize the level of ginger extract in formulation for the development of value added bread.

MATERIALS AND METHODS

Ginger used for this investigation were purchased from the local market. All required ingredients like as sugar, refined white flour, dry yeast, water and common salt and refined oil for greasing agent were purchased from local market of Allahabad. India. All the chemicals used in analysis were of AR (analytical reagent) grade. This work was carried out at Centre of Food Technology, University of Allahabad, Allahabad, U.P., India.

Preparation of aqueous ginger extract

The ginger was washed, drained and then grated with the help of grater and then the aqueous extract was prepared (Puranik *et al*., 2013) to incorporate it in the bread preparation.

Development and Optimization of value added bread

Bread was prepared as per the slightly modified method (Nazni and Gracia, 2014). The ingredients such as refined wheat flour, sugar and salt were mixed for 1-2min. Then, yeast dissolved in lukewarm water (30-35ºC), which is the optimum temperature for the yeast cells to be activated, and finally the extracts was added to the dry ingredients. All the ingredients were again mixed for 2min and during mixing, water was added to the mixture. After mixing, the dough was kept for fermentation for 30 min. After that, the dough was placed in aluminium baking pan for proofing at an incubation chamber at 35 ºC and 80% relative humidity for 30 min. Then, the samples were ready for baking. Baking of sample was conducted in a laboratory oven with air circulation at (150 ºC) for 30 min. The loaves were removed from the pans and cooled at room temperature. To optimize the quantity of sugar and ginger extract to be added, Response Surface Methodology (RSM) was used while rest of the ingredient like refined white flour, dry yeast, water and common salt (Girdhari Lal *et al*., 2010) level was kept constant on the basis of hit and trial method using 9-point hedonicscale. Response Surface Methodology (RSM) is a collection of statistical and mathematical technique useful for developing, improving and optimization process (Mugwiza Telesphore and He, 2009), for statistical and graphical analysis of the experimental data and also for monitoring the combined effects of variables (Philip John Kanu *et al*., 2007). The sugar (17.93 g) and ginger extract (15ml) was repeated 5 times as central points. The lower and upper limits for sugar and ginger extract were taken as 20-30g and 10-20ml, respectively. Control treatment was prepared without ginger extract addition. All 13combinations and control were subjected for sensory quality evaluation by 15 trained panelists. The process flow chart is adopted for the preparation of bread by using various ingredients like refined white flour, dry yeast, water, refined oil and common salt. The process flow chart for the preparation of bread is given in Fig. 1.

Collection of raw material
↓
Proper mixing of ingredient with ginger extract and sugar
↓
Dough was prepared with yeast, water & kneaded
For 10-15 minutes
↓
Fermentation of dough for a period of 30 min
& covered with wet cloth
↓
Loaf was moulded and rest for 5-10 minutes
↓
Preheated and baked in oven at 150^{o}C for 30 minutes
↓
Cooled and sliced

Fig. 1. Process flow chart in the preparation of value added bread

Proximate and Mineral content analysis

The moisture, crude fat, fibre and protein content of the samples were determined as per AOAC (2005) procedures; whereas minerals (Ca and Fe) were estimated as per the AOAC (1990) procedures.

Sensory Analysis

To carry out initial optimization of the ingredients of RSM design, thirteen combinations were judged by a trained panel of 15-members using a 9 point hedonic scale (9-like extremely and 1-dislike extremely) (Murray *et al*., 2001) for color, flavor, texture and mouth feel.

Determination of antioxidant activity

The antioxidant activities of native and processed raw materials were also measured by the DPPH radical scavenging method (De - Ancos *et al*., 2002). An aliquot (0.10ml) of sample extract in methanol was mixed with 2 ml of methanolic 0.1 mM DPPH solution and the volume was made up to 5 ml with distilled water. The mixture was thoroughly vortex-mixed and kept in dark for 30 min. The absorbance was measured at 515 nm. The result was expressed as percentage of inhibition of the DPPH radical. The percentage of inhibition of the DPPH radical was calculated according to the following equation:

% inhibition of DPPH = ((Abs control-Abs sample)/(Abs control)) X 100

where, Abs control is the absorbance of the DPPH solution without the extract.

Determination of Total Phenol Content

Total polyphenols were estimated as per procedure described by (Singleton *et al*., 2005) using folin ciocalteu method, where 250 mg sample was taken in 10 ml of acetone and water (70:30 v/v) solution in a graduated test tube and heated on water bath at 70^{o}C for 10 min. The sample was brought to room temperature, centrifuged at 3500 rpm for 10 min. The supernatant (0.2 ml) was made up to 10 ml with distilled water.

This solution was diluted 10 fold and sample solution (5 ml) was mixed with saturated sodium carbonate (0.5 ml) and Folin-Ciocalteaue reagent (0.2 ml) and made up to 10 ml with distilled water. The absorbance was read at 765 nm after 60 min by UV visible double beam spectrophotometer (Model Evolution 600, Thermo Electron, US).

Texture analysis of Optimized Bread

Hardness was measured by Texture analysis of control and optimized developed bread with the help of Texture analyzer by operating Force in compression, Pre test speed – 5mm/sec, Test speed – 10mm/sec, Post test speed-10mm/sec, distance - 8mm/sec and Load cell -5kg.

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 Co. Stat 6.303, CoHort software (USA).

RESULTS AND DISCUSSION

Optimization of Value added bread

For the optimization of the variables, the responses colour, flavour, texture, mouth feel and overall acceptability were selected. From the ANOVA result in Table 2 there was significant difference found for each variable of sensory attributes at $p<0.05$. All these responses have been shown to create direct effect on the quality of bread (Puranik *et al*., 2013). Interaction between sugar and ginger extract showed positive ($P < 0.05$) effect on the flavour as we increase the concentration of ginger extract (Fig. 2). Interaction between sugar and ginger extract to colour had significant negative effect on colour ($P < 0.05$) (Fig. 3). The interactive effect of ginger to sugar showed positive effect on texture of bread (Fig. 4). On increasing the amount of ginger extract and sugar, mouth feel increases (Fig.5). Interaction between sugar and ginger extract showed positive ($P < 0.05$) effect on the overall acceptability of optimized bread (Fig 6). The overall effect of ginger extract and sugar was maximum on all sensory

Table 1. Effect of variables on the sensory attributes of developed ginger bread

Variables		Sensory Responses				
Ginger exract (ml)	Sugar(g)	Colour	Texture	Flavour	Mouth feel	Overall Acceptability
10.00	20.00	7.9	7.4	7.3	7.5	7.6
20.00	20.00	8.1	8.3	8.3	8.2	8.2
10.00	30.00	8.3	5.3	5.2	5.4	5.5
20.00	30.00	8.2	8.3	8.3	8.1	8.2
7.93	25.00	6.9	8.1	8.1	8.2	8.2
22.07	25.00	8.3	8.4	8.3	8.3	8.4
15.00	17.93	7.1	8.3	7.9	8.5	7.4
15.00	32.07	7.9	5.9	5.4	5.8	5.7
15.00	25.00	8.2	7.8	7.6	7.9	7.9
15.00	25.00	7.6	6.7	6.6	6.9	6.8
15.00	25.00	7.8	7.6	7.5	7.5	7.6
15.00	25.00	8.1	8.3	8.4	8.1	8.2
15.00	25.00	8.2	7.8	7.7	7.9	7.7
Control		7.2	7.9	8.5	8.4	8.6

Table 2. ANOVA results for value added bread

Source	Color	Texture	Flavour	Mouthfeel	Overall acceptability
Model SS	0.69	8.46	10.04	8.03	8.48
Model DF	5	5	5	5	5
Mean MS	0.14	1.69	2.01	1.61	1.70
Pure Error	0.29	1.37	1.65	0.91	1.09
Mean	7.95	7.48	7.38	7.45	7.49
F cal.	0.90	4.08	4.00	4.91	5.29
F tab.	0.5289	0.0470	0.0493	0.0301	0.025
R square	0.3918	0.7444	0.7406	0.7781	0.7906

Table 3. Nutritional composition of Control and Optimized value added bread

Bread sample	Moisture (%)	Energy (kcal)	Protein (gm/100g)	CHO (gm/100g)	Fat (gm/100g)	Ash (gm/100g)	Ca (mg/100g)	Fe (mg/100g)	Fibre (gm/100)
Control N	34.5±0.28	258±0.57	6.4±0.05	56.49± 0.04	0.58±0.00	1.47±0.23	12.1±0.05	2.5±0.05	0.2±0.03
Optimised A	23.5±0.23	304±2.30	7.6±0.11	66±0.04	1.0±0.23	1.9±0.42	23±0.57	3.0±0.04	2.0±0.05

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responses followed by control. To consider all the responses simultaneously for optimization, the RSM was used to compromise optimum conditions and it was found that the sensory scores were 7.1, 8.3, 7.9, 8.5 & 7.4 for colour, texture, flavor, mouth feel and overall acceptability corresponding to optimum conditions (Table 1).

Bread having composition 17.93 g sugar, & 15 ml ginger extract per 100 g bread was found optimum. Triplicate samples were prepared using the optimum conditions and were evaluated for all the responses. Corresponding values for color, texture, flavor, mouth feel and overall acceptability were 7.1, 8.3, 7.9, 8.5 & 7.4 respectively which were comparatively higher than the predicted value (Table 2). Therefore, bread having composition 17.93 g sugar, 15 ml ginger extract per 100 g of bread was found optimum and the said formulation was recommended for value added bread.

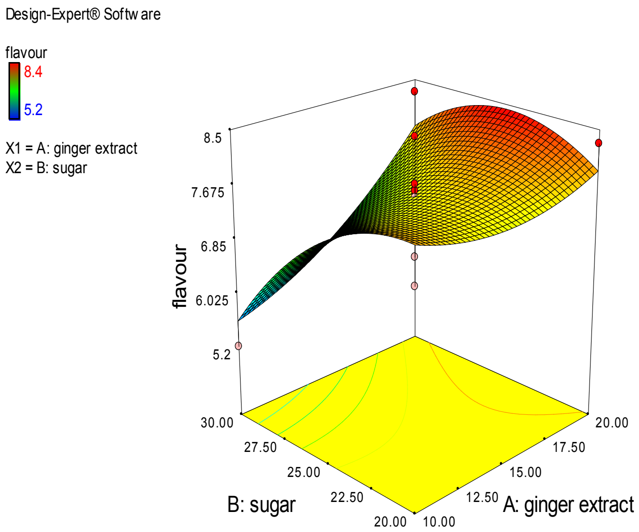


Fig. 2. Response surface and counter plots showing effects of variable on the flavor of value added bread

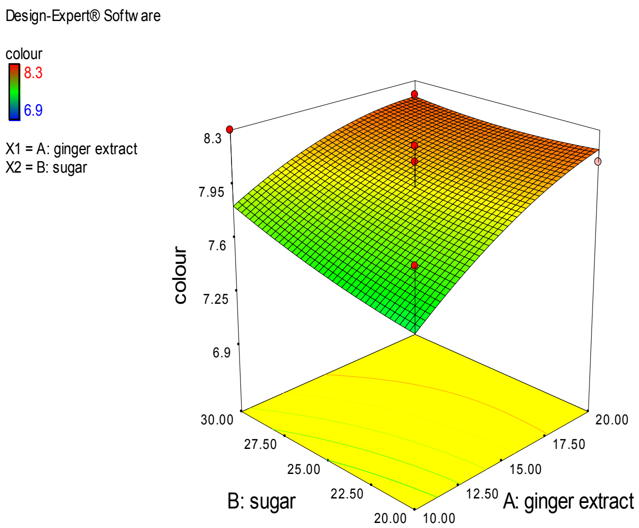


Fig. 3. Response surface and counter plots showing effects of variable on the colour of value added bread

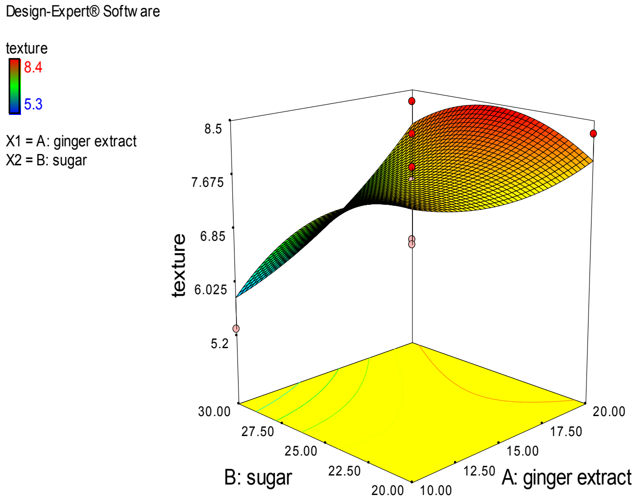


Fig. 4. Response surface and counter plots showing effects of variable on the texture of value added bread

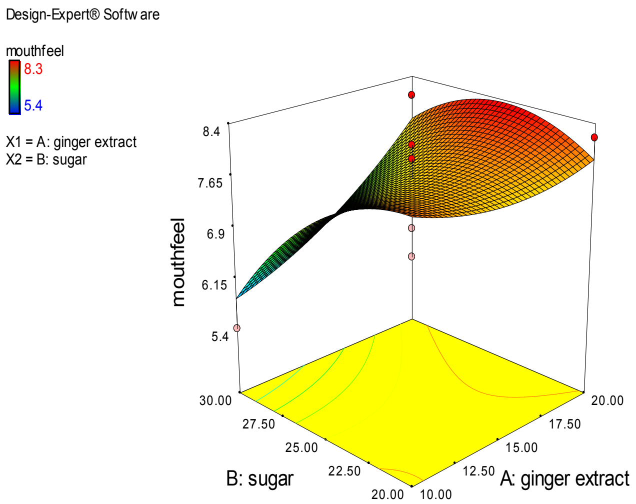


Fig. 5. Response surface and counter plots showing effects of variable on the mouth feel of value added bread

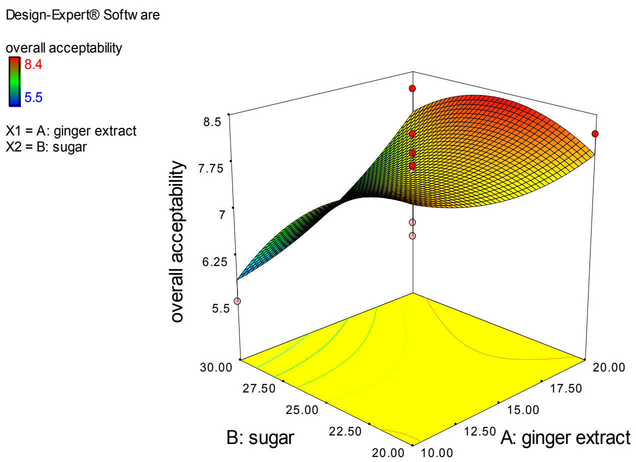
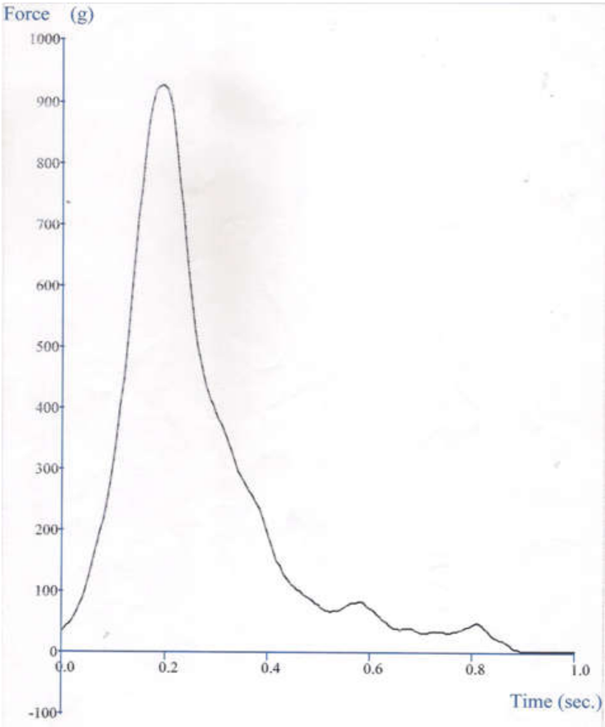
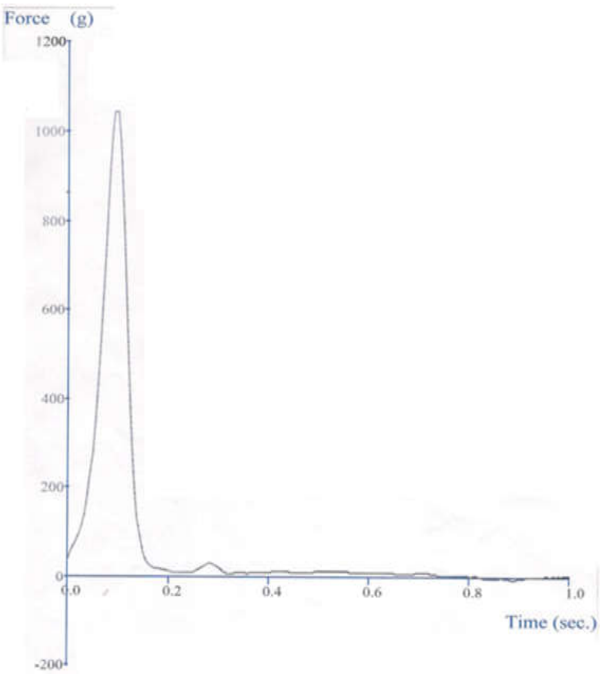


Fig. 6. Response surface and counter plots showing effects of variable on the overall acceptability of value added bread



(a)



(b)

Fig. 6 Effects of variables on the texture of bread: (a) Control bread and (b) Optimized bread

Texture analysis of Optimized Bread

From the results of texture analysis, the hardness of control bread and optimized bread was found to be comparatively near to each other i.e. 915 g and 1015 g respectively (Fig. 6). This result can be correlated with the acceptable sensory scores of control and optimized bread (texture score of 7.9 & 8.3 respectively).

Nutritional Evaluation of Optimized Bread

The nutritional composition of optimized bread regarding moisture, ash, crude fat, crude protein, crude fiber, carbohydrate and mineral contents are presented in (Table 3). The nutritive value of ginger extract incorporated bread was significantly higher than that of control. By incorporation of ginger extract, the ash content was increased from 1.47% to 2.94%. The optimized bread was found to be superior in terms of minerals, calcium, iron and fibre, 23.6, 3.0mg/100g and 2% respectively as compared to control bread (12.1 & 2.5 mg/100g and 0.2%). The moisture content was decreased from 39.5% to 23.5% which may be also helpful for the improvement of shelf-life of optimized bread. Since, the bread was a good source of calcium, iron and fibre (Table 3), hence it can be recommended for consumption for children and old age people.

Evaluation of antioxidant activity

Antioxidant activity in terms of total phenol content and DPPH % radical scavenging activity was found to be 310.54mgGAE / 100g and 93.2% respectively, for ginger extract incorporated optimized bread which was higher than control bread (212.65mg GAE / 100g & 90.1%) (Table 4). The addition of ginger extract, gave an excellent antioxidant effect on the bread compared with control. The same results were obtained in study in which, in bread, addition of purified extracts of marjoram, mint and basil is reported to have an excellent antioxidant effect compared with the effect of BHA (Bassiouny *et al*., 1990). The higher efficiency of the ginger extract could be due to the stability of this natural antioxidant during baking. Results of sensory evaluation reveal that the ginger extract at concentrations of 15% may be used in place of synthetic antioxidants in bread. Addition of natural antioxidants can increase shelf-life of food products containing fats and oils. In addition, natural antioxidants are safe and impart health benefits to the consumer.

Conclusion

Consumption of bakery products in the country is increasing day by day and bread is commonly consumed food like bread, have several attractive features. Nutritionally, bread can be easily fortified with ginger extract to provide a convenient food to supplement the diet's nutrition. The herbal therapeutic benefits of ginger are mainly due to the presence of volatile oils and in the view of health benefit of ginger it may be worthwhile to explore possibility of incorporating ginger extract in wheat flour. Present study was an effort to standardize the level of ginger extract in formulation for the development of value added bread. From the study, it was found that the bread having composition 17.93 g sugar, 15 ml ginger extract per 100 g of bread was found optimum and the said formulation was acceptable and recommended for value added bread. Ginger extract bread provide concentrated form of nutrients along with vitamins and minerals. The nutritive value of ginger extract incorporated bread was significantly higher than that of control. The optimized bread was found to be superior in terms of minerals, calcium and iron as compared to control bread. Since, the bread was a good source of calcium and iron, hence it can be recommended for consumption for children and old age people. The addition of ginger extract, also gave an excellent antioxidant effect on the bread compared with control. Addition of natural antioxidants can increase shelf-life of food products containing fats and oils. In addition, natural antioxidants are safe and impart health benefits to the consumer. It can be recommended as one of the value added products.

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