

# Evaluation of composite blends of fermented fenugreek and wheat flour to assess its suitability for bread and biscuit

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**Abstract:** Flour of fenugreek supplemented at 5, 10, and 15% levels with wheat flour was assessed for the production of bread and biscuit to improve nutritional profile. Germinated fenugreek flour samples had 29.89% crude protein, 7.91% crude fat, 11.35% crude fiber and 2.94% ash on dry weight basis. The wet gluten, falling number, and water activity of wheat flour reduced on incorporation of germinated fenugreek flour while the foaming capacity, water and oil absorption increased for bread and biscuit blended wheat flours. The farinograph water absorption values were 66.3, 63.9 and 61.8%, while the dough stability values were 7.0, 9.0 and 10.5 min at 5, 10 and 15% supplementation levels, respectively. The dough development times were 4.5, 6.1, and 7.5 min and farinograph quality numbers were 76, 100 and 123 Brabender units, respectively. The microbiological analysis of value added products for coliforms, *E.coli*, and yeast was absent, and TPC and mould counts were lower than control. The nutritive values in terms of protein, fiber, ash as well as calcium, magnesium, iron and zinc content of bread and biscuit increased as a result of the supplementation of germinated fenugreek flour to wheat flour. The sensory evaluation of the bread samples made by supplementation at 5 and 10% and 5% levels for biscuit were rated acceptable.

**Keywords:** Composite Blends, Germinated Fenugreek Flour, Functional Properties, Farinograph Values, Nutritional Profile, Sensory Characteristics

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## 1. Introduction

In developing countries with the increasing urbanization, the demand of processed food is increasing rapidly. There is urgent need for cheaper foods rich in protein for individuals, taking into consideration their age, sex, physical activity and physiological needs. Therefore, the need for strategic use of inexpensive high protein resources that complement the balanced amino acid profile of the staple diet in order to enhance their nutritive value and overcome malnutrition problem in developing countries (Addisu 2011). Among the processed foods, bakery products have wide popularity in rural as well as urban areas among all the age groups (Agrawal, 1990).

To augment the protein quality, the concept of cereal-legume complementation by blending cereal and legume

flours can be applied. Fortification with high protein legume flours could provide a good opportunity to improve the nutritional quality of protein consumed by many people. Therefore, fortification of wheat flour with non-wheat flour increasing the nutritional quality of wheat products by improving its amino acid profiles (Stark and Madar 1993).

Fenugreek (*Trigonella foenum-graecum* L.) is an annual legume mainly used as a spice crop in many parts of the world. This crop is native to an area extending from Iran to northern India, but is now widely cultivated in China, North and East Africa, Ukraine and Greece (Petropoulos 2002). It is locally used as a pulse, spice and medicinal plant, and has a long history in Ethiopia (Gall and Zerihun 2009).

Fenugreek seed can be utilized for value addition of

cereals based food products to attain multiple benefits. It is used as a condiment and as a supplement to wheat and maize flour for bread making and as a constituent of the daily diet of general population in Indian subcontinent. It can be incorporated in to food products, such as cookies, cereals, crackers, doughnuts, bagels, biscuits, pizza dough, pasta, bread, juices, salads, sauces, and candies. Its leaves are consumed widely in India as a green leafy vegetable and are a rich source of calcium, iron,  $\beta$ -carotene and other vitamins (Sharma et al 1996).

In view of above, the present study has been planned to evaluate blends of fermented fenugreek and wheat flour and perform the physico-chemical, functional and nutritional characteristics to assess its suitability for bread and biscuit production.

## 2. Materials and Methods

Fenugreek seeds were obtained from Sinana Agricultural Research Center, Bale Robe, and Ethiopia. Both soft and hard wheat flour and ingredients were obtained from Kaliti Food Share Company, Ethiopia, currently producing bakery products at commercial scale.

*Preparation of fenugreek flour:* Fenugreek seeds were cleaned, graded, sorted and washed three times using potable water. Then, the seeds were soaked in potable water for 24 h at room temperature with seeds: water ratio of 1:5 (w/v). The unimpeded water was discarded and the soaked seeds were rinsed twice by boiled cooled water to avoid post contamination during germination. The soaked seeds were germinated in plastic sieves covered with sterilized cloth for 72 h at room temp with frequent watering. The germinated fenugreek seeds were dried in a drying oven (Beschickung-Loading, Model 100-800, Memmert, Germany) at 60°C for 24 h (Shalini & Sudesh 2004) and ground to pass through 710 micron sieve (Endecotts LTD., London, UK) to obtain fine powder.

*Blend formulation:* The wheat flour was supplemented at 5, 10, and 15% of dried germinated fenugreek flour. The flour blends were mixed using laboratory mixing machine (Model: R100C, CAT, Chicago, 1970). The flour mixtures were individually blended, homogenized, packed in polyethylene bags and stored at room temperature till further use. All formulated blends were analyzed for proximate composition (Moisture, total ash, fat, protein and fiber), physico-chemical analysis (Color grade value, falling number, wet gluten, water activity and farinograph values such as water absorption, stability, development time, degree of softening and farinograph quality number), functional properties (Bulk density, water absorption capacity, dispersibility, oil absorption capacity, foaming capacity) using standard methods Etana *et al* (2013).

*Bread preparation:* The bread samples made from three blend formulations and control flour were baked using straight dough method. The baking formula with 63% flour blend, 0.3% yeast, 0.3% bread improver, 0.6 % salt and 35.8 % water (Etana *et al.*, 2013). All ingredients were mixed in a dough mixer (Model G.P.A. Orlandi mixer, Italy) for 15 min.

The dough was fermented in a bowl covered with low density polyethylene for 30 min at room temp. It was then knocked back, molded and the dough pieces were then allowed to ferment for 60 min in a proofer at 35°C and 80% relative humidity. The fermented dough was baked at 213 °C for 20 min according to Shalini and Sudesh (2005).

*Biscuit preparation:* 65.1% flour blend with other ingredients (18.49% sugar, 9.3% shortening, 0.93% skimmed milk powder, 1.86% high fructose, 0.37 % sodium bicarbonate, 1.02% ammonium bicarbonate, 0.58% salt, 0.02% vanilla) were mixed with 2.33% water in to a mixing bowl for 15 min at high speed using a mixer (Model G.P.A. Orlandi mixer, Italy) (Hegazy and Ibrahim, 2009). The dough was removed from the mixer and allowed to keep at a normal room temperature for about 5-10 min to allow proper fermentation. Then fermented dough was placed in sheeting rollers so that it attains the proper thickness. The formed biscuits were baked in an electric convection oven (model G.P.A. Orlandi oven, Italy) at 170°C for 7 min (Hegazy and Ibrahim 2009).

*Proximate composition analysis:* Moisture content, total ash, crude fat, crude protein and crude fiber were determined by the methods described in AOAC (2000). Total carbohydrates of the samples including crude fiber were determined by difference. The minerals were determined by flame atomic absorption spectrometry and flame photometry as mentioned in AOAC (2000).

*Functional properties analysis:* Bulk density and Water absorbing capacity were determined by the methods used by Narayana and Narasinga-Rao (1984) and Helen (2011), respectively. Dispersibility, oil absorption capacity and foaming capacity were determined by the method used by Coffman and Gracia (1977).

*Physico-chemical analysis:* Color grade value, falling number (Hag berg falling number apparatus, model 1500, Sweden, 2005), wet gluten content, water activity and farinograph values (water absorption, stability, development time, degree of softening and farinograph quality number) of control wheat flour and blends were measured by standard methods as described by Etana *et al* (2013).

*Microbiological analysis:* Total plate counts, yeast and mould, Coliforms and *E. coli* counts were enumerated in control, bread and biscuit samples supplemented with fenugreek flour by standard methods as described by Neilsen (2003).

*Sensory evaluation of products:* The sensory characteristics of biscuit and bread were evaluated by 20 trained sensory panels. The panelists were asked to evaluate color, appearance, taste, flavor, texture and overall acceptability of the samples on a 9-point hedonic scale, ranging from 9 as like extremely to 1 as dislike extremely (Meilgaard et al 2007).

*Data analysis:* The quality characteristics of flours, as well as the baking test results of products made with fenugreek flour supplementation were analyzed by one way ANOVA (Analysis of Variance) using statistical tools of JMP version 5 (SAS Institute Inc., Cary, NC, USA). Significance was accepted at 0.05 level of probability ( $p \leq 0.05$ ). Mean separation was performed by "Each pair student's t-test" for multiple comparison of means.

### 3. Results and Discussion

**Raw material analysis:** The fenugreek flour had 29.89% crude protein, 7.91% crude fat, 11.34% crude fiber, 51.55% carbohydrate and 2.94% ash content on dry weight basis. Fenugreek Seeds are a good source of minerals and had 168.88 mg/100g Ca, 153.10 mg/100g Mg, 11.51 g/100g Fe and 4.43 mg/100g Zn. It is revealed that hard wheat flour had 10.84% protein, 1.68% fat, 0.5% fiber and 1.84% ash content whereas soft wheat flour had 9.61% protein, 1.15% fat, 0.4% fiber and 1.06 % ash content, used for bread and biscuit preparation in this investigation, respectively. Generally, fenugreek flour is highly nutritious as compared with wheat flour in terms of proximate composition and mineral content (Sharma et al 1996). Therefore, fenugreek seeds offer a logical means to upgrade the quantity and quality of protein and dietary fiber of wheat flours.

Physico-chemical properties of wheat flour and blended flours are shown in table 1. The color grade values for the blended flours of both bread and biscuit were higher in comparison to control wheat flour which showed less bright flours. The highest color values (4.36 and 6.33) were observed for bread and biscuit flour samples supplemented with 15% germinated fenugreek flour, respectively. Low values of color grade are preferred value in producing white bread and biscuit. Hence, flour samples with 5% for biscuit and up to 10% for bread production were most preferable. Both bread and biscuit wheat flour exhibited wet gluten contents of 32.9 and 23.5%; respectively, which reduced upon supplementation with fenugreek flours at all levels where as on mean basis a non significant difference was observed among the blends. Shalini and Sudesh (2003) also reported that the wet gluten decreased in increasing the levels of non-wheat flour in wheat flour. The falling numbers of the blended flours were lower than the control wheat flour because fenugreek flour had higher amylase activity. The results showed significant variations among the treatments due to different level of supplementation which ranged from 222.0 to 293.7 sec for bread production and 188.0 to 221.3 for biscuit production.

The water activity of blended flours used for bread and biscuit preparation ranged from 0.42 to 0.59 and 0.41 to 0.58, respectively which were suitable for good condition storage by restricting the access to water and reducing the chemical change in the flour. As the supplementation level of fenugreek flour increased, the water activity decreased. The presenting findings are in confirmation with Bolandi et al (2008) who reported that the actual water activity of flours during storage ranged from 0.3 to 0.6.

Table 2 depicts the functional properties of fenugreek-wheat composite flour of biscuit and bread production. The bulk density of the flour samples ranged from 0.77-0.82 g/cm<sup>3</sup> for biscuit and 0.81-0.83 g/cm<sup>3</sup> for bread. The bulk density is generally affected by the particle size and the density of flour and important in determining the packaging requirement, raw material handling and application in wet processing in the food industry (Ajanaku *et al.*, 2012).

**Nutritional profile of biscuits:** The protein, ash, carbohydrate, fiber and mineral percent of biscuit samples increased as the supplementation level of germinated fenugreek flour increased in the blend. Highest protein (12.67%) was recorded for biscuit prepared from wheat supplemented with 15% germinated fenugreek flour while the lowest (9.66%) for control (Table 5). The crude fat content of samples ranged from 13.64 to 17.02 %. Biscuit with 15% fenugreek flour had higher ash content (3.78%) where as lowest in the control. Similar results were reported by Hegazy and Ibrahim (2009) that incorporation of fenugreek flour to biscuits formula increased protein, fat, fiber, ash and amino acids contents. It is apparent that the supplementation of fenugreek flour to wheat flour significantly ( $p < 0.05$ ) increased calcium, iron, zinc and magnesium percent in the bread and biscuit samples.

Physical characteristics of bread samples prepared from wheat and different fenugreek composite flours are presented in Table 6. Loaf volume is one of the major quality indicators for bread and is influenced by many factors including wheat flour compositions, additives and dough fermentation conditions (Rosell et al 2001). Significant reduction in loaf volume was observed at all the levels of supplementation. Maximum reduction in loaf volume (334 ml) of the bread was observed in case of germinated fenugreek flour at 15 % supplementation level. This may be due to the dilution effect on gluten content with the addition of non wheat flour to wheat flour that has been reported to be associated with loaf volume depression effect of composite flours as also reported by Sharma and Chauhan (2000). Other workers have also reported similar decrease in loaf volume of bread supplemented with non-wheat flours (Sharma and Chauhan, 2000). Loaf weight increased with the increase in the level of fenugreek flour in wheat flour. Loaf weight of control bread was 86.6 g. Supplementation of wheat flour with fenugreek flour at 15 % level, a significant increase in loaf weight (94.73g) was observed, indicating that an extra amount of water was retained in breads after baking (Rao and Hemamalini 1991). The present results are in conformation with the findings of Sharma and Chauhan, (2000) that showed increase in loaf weight in fenugreek flour supplemented breads. Loaf weight increased with the increase in the level of fenugreek flour in wheat flour. Loaf weight of control bread was 86.6 g. Supplementation of wheat flour with fenugreek flour at 15 % level, a significant increase in loaf weight (94.73g) was observed, indicating that an extra amount of water was retained in breads after baking (Rao and Hemamalini 1991). The present results are in conformation with the findings of Sharma and Chauhan (2000) that showed increase in loaf weight in fenugreek flour supplemented breads.

The physical characteristics of fenugreek based biscuits and control are shown in Table 6. Physical characteristics showed significant increase among the different blends compared to control accept spread ratio. Spread ratio of biscuits supplemented with different level of fenugreek flour and control samples ranged from 98.95 to 74.54 being highest in

the control. Similarly other research worker also reported that incorporation of oat bran, soy flour, and black gram flour decreased the spread ratio (Mc Watters *et al.*, 2003).

**Sensory characteristics of bread:** The crumb color of fenugreek flour supplemented bread, scored maximum points (7.97) for 5:95 followed by 10:90 (7.77) and lowest (5.04) being for 15: 85 blend as against 8.13 for the control sample. Color variations in bread crumb color due to supplementation of fenugreek flour at 5 and 10% were significant (Table 7). A decrease in crumb color intensity with the increase in the level of substitution of fenugreek flour also reported by Sharma and Chauhan (2000).

Aroma, the quality perceived by the sense of smell plays a primary role in creating consumer appeal. The aroma of fenugreek flour supplemented bread samples scored maximum (7.87) in 5:95 (bread with 5% fenugreek flour) followed by 10:90 (7.53) and lowest (5.1) being for 15:85 blend and 7.76 in the control bread. Our findings are in support of Shalini and Sudesh (2004) who also observed better flavor in germinated fenugreek flour supplemented bread. Control bread samples rated significantly at par with the bread samples made from 5 and 10% supplemented fenugreek flour. The bread samples supplemented with fenugreek flour at 5 and 10% levels exhibited non-significant difference in taste and rated at par with control by sensory panels but noticed significant difference at 15% supplementation level. Appearance, Texture and Overall

acceptability of bread samples made from blends of 5:95 and 10:90 are within acceptable limits. No significant differences were noticed with respect to control bread samples.

**Sensory characterizes of biscuits:** Biscuits supplemented by different levels of fenugreek flour and the control (wheat biscuit) samples were evaluated sensory characteristics. The mean scores of sensory attributes ranged between 4.40 and 8.46. Biscuit prepared with 100% of wheat flour scored maximum than the rest of the blends. The mean scores decreased as the proportion of fenugreek flour increased in the blends. The highest value was recorded for biscuit made with 5% fenugreek flour while the lowest value was for 15% fenugreek flour with wheat flour. There were no significant difference among control sample and biscuits containing 5% germinated fenugreek flour with respect to sensory characteristics.

**Microbial profile:** The microbial profile of fenugreek based bread and biscuit had lower counts than control samples (Table 8). This was due to fenugreek is reported to have anti-microbial and hypocholesterolemic activity (Al-Habori and Raman 2002). According to WHO Standard (1994) the maximum permissible limits in baked products (cake, bread and biscuit) for Total plate count (TPC) is  $2.0 \times 10^5$  cfu g<sup>-1</sup>, coliforms bacteria <20 cfu g<sup>-1</sup>, *E. coli* absent, yeast and mold is <  $1.0 \times 10^4$  cfu g<sup>-1</sup>. Thus, developed fenugreek based bread and biscuit had lower microbial profile (Table 8) compared to WHO Standards (1994).

**Table 1.** Physico-chemical properties of wheat flour and blended flours.

Parameters	Blends (FF:WF) for bread production			
	0:100	5:95	10:90	15:85
Color grade	0.58 ± 0.18 <sup>a</sup>	1.41 ± 0.08 <sup>b</sup>	2.40 ± 0.10 <sup>c</sup>	4.36 ± 0.21 <sup>d</sup>
Wet gluten (%)	32.9 ± 0.44 <sup>a</sup>	30.37 ± 0.40 <sup>a</sup>	28.3 ± 0.20 <sup>a</sup>	26.6 ± 0.25 <sup>a</sup>
Falling number (sec.)	293.7 ± 0.58 <sup>a</sup>	288.0 ± 1.00 <sup>b</sup>	257.7 ± 1.53 <sup>c</sup>	222.0 ± 1.00 <sup>d</sup>
Water activity (a <sub>w</sub> )	0.59 ± 0.01 <sup>a</sup>	0.56 ± 0.00 <sup>b</sup>	0.54 ± 0.00 <sup>c</sup>	0.42 ± 0.00 <sup>d</sup>
Parameters	Blends (FF:WF) for biscuit production			
	0:100	5:95	10:90	15:85
Color grade	2.60 ± 0.10 <sup>a</sup>	3.53 ± 0.15 <sup>b</sup>	5.67 ± 0.21 <sup>c</sup>	6.33 ± 0.35 <sup>d</sup>
Wet gluten (%)	23.5 ± 0.72 <sup>a</sup>	21.2 ± 0.21 <sup>a</sup>	20.2 ± 0.10 <sup>a</sup>	19.2 ± 0.15 <sup>a</sup>
Falling number (sec.)	221.3 ± 1.53 <sup>a</sup>	212.0 ± 1.00 <sup>b</sup>	205.0 ± 1.00 <sup>c</sup>	188.0 ± 1.00 <sup>d</sup>
Water activity (a <sub>w</sub> )	0.58 ± 0.01 <sup>a</sup>	0.56 ± 0.00 <sup>b</sup>	0.53 ± 0.00 <sup>c</sup>	0.41 ± 0.01 <sup>d</sup>

All values are means of triplicates ± SD, FF - fenugreek flour, WF- wheat flour, Levels not connected by same letter under the same rows are differed significant

**Table 2.** Functional properties of Wheat and blended flours for bread and biscuit production.

FF:WF for Bread	Bulk density (g/cm <sup>3</sup> )	Water absorption (%)	Oil absorption(ml/g)	Dispersibility (%)	Foaming capacity
Control	0.82 ± 0.01 <sup>a</sup>	56.7 ± 0.15 <sup>a</sup>	84.37 ± 0.12 <sup>a</sup>	73.93 ± 0.11 <sup>a</sup>	13.20 ± 0.20 <sup>c</sup>
5:95	0.81 ± 0.00 <sup>b</sup>	71.63 ± 0.32 <sup>b</sup>	109.3 ± 0.30 <sup>b</sup>	74.47 ± 0.15 <sup>b</sup>	14.63 ± 1.1 <sup>b</sup>
10:90	0.81 ± 0.00 <sup>c</sup>	86.23 ± 0.23 <sup>c</sup>	110.6 ± 0.21 <sup>c</sup>	78.30 ± 0.26 <sup>c</sup>	17.27 ± 0.06 <sup>a</sup>
15:85	0.83 ± 0.00 <sup>c</sup>	96.63 ± 0.21 <sup>d</sup>	112.1 ± 0.23 <sup>d</sup>	75.23 ± 0.21 <sup>d</sup>	18.03 ± 0.32 <sup>a</sup>
FF:WF for Biscuit	Bulk density (g/cm <sup>3</sup> )	Water absorption (%)	Oil absorption (ml/g)	Dispersibility (%)	Foaming capacity
Control	0.82 ± 0.01 <sup>a</sup>	58.00 ± 0.30 <sup>a</sup>	85.47 ± 0.11 <sup>a</sup>	73.93 ± 0.11 <sup>a</sup>	12.04 ± 0.64 <sup>a</sup>
5:95	0.77 ± 0.01 <sup>b</sup>	74.03 ± 0.25 <sup>b</sup>	110.5 ± 0.10 <sup>b</sup>	78.77 ± 0.25 <sup>b</sup>	14.13 ± 0.15 <sup>b</sup>
10:90	0.78 ± 0.00 <sup>b</sup>	81.93 ± 0.11 <sup>c</sup>	111.5 ± 0.50 <sup>c</sup>	75.33 ± 0.15 <sup>c</sup>	15.40 ± 0.36 <sup>c</sup>
15:85	0.79 ± 0.00 <sup>c</sup>	96.23 ± 0.50 <sup>d</sup>	112.73 ± 0.12 <sup>d</sup>	76.00 ± 0.00 <sup>d</sup>	17.52 ± 0.19 <sup>d</sup>

All values are means of triplicates ± SD; FF: fenugreek flour; WF: wheat flour; Levels not connected by same letter under the same rows differed significantly

**Table 3.** *Farinograph values of blended flours for bread production.*

Parameters	Blends (FF:WF)			
	Wheat flour	5:95	10:90	15:85
Consistency, FU	455	447	431	418
Water absorption(corrected for 500 FU)	56.9	67.4	65.1	63.0
Water absorption (corrected to 14.0%)	55.8	66.3	63.9	61.8
Dough stability (min.)	5.9	7.0	9.0	10.5
Dough development time (min)	4.2	4.5	6.1	7.5
Degree of softening (FU)	18	31	47	55
Degree of softening (ICC),FU	55	65	76	84
Farinograph Quality Number	66	76	100	123

Where: FF-Fenugreek flour, WF-wheat flour Farinograph quality number

**Table 4.** *Nutritional profile of bread made from different blends of fenugreek and wheat flour.*

Components	Blends (FF:WF)			
	0:100	5:95	10:90	15:85
Moisture, %	30.09±0.01 <sup>a</sup>	30.20±0.005 <sup>a</sup>	31.57±0.568 <sup>b</sup>	35.54±0.006 <sup>c</sup>
Protein,%	10.85±0.006 <sup>d</sup>	11.78±0.015 <sup>c</sup>	12.76±0.021 <sup>b</sup>	13.66±0.025 <sup>a</sup>
Fiber,%	0.65±0.02 <sup>a</sup>	1.90±0.115 <sup>b</sup>	2.93±0.071 <sup>c</sup>	3.08±0.021 <sup>d</sup>
Ash,%	1.85±0.01 <sup>a</sup>	2.06±0.042 <sup>b</sup>	2.56±0.105 <sup>c</sup>	2.97±0.072 <sup>d</sup>
Fat,%	1.61±0.076 <sup>a</sup>	1.94±0.01a	1.97±0.01a	2.11±0.182 <sup>b</sup>
Carbohydrate,%	65.59±0.078 <sup>a</sup>	64.02±0.049 <sup>b</sup>	61.48±0.125 <sup>c</sup>	55.72±0.135 <sup>d</sup>
Energy (Kcal/100gm)	320.32±0.379 <sup>a</sup>	320.66±0.221 <sup>a</sup>	314.66±0.510 <sup>b</sup>	296.510±1.133 <sup>c</sup>
Minerals (mg/100g)				
Calcium	64.13±0.007 <sup>d</sup>	68.47±0.007 <sup>c</sup>	73.99±0.014 <sup>b</sup>	78.04±0.021 <sup>a</sup>
Magnesium	21.22±0.007 <sup>a</sup>	29.68±0.007 <sup>b</sup>	35.44±0.007 <sup>c</sup>	41.99±0.021 <sup>d</sup>
Iron	7.79±0.014 <sup>d</sup>	7.84±0.007 <sup>c</sup>	7.99±0.014 <sup>b</sup>	8.03±0.007 <sup>a</sup>
Zinc	2.15±0.007 <sup>a</sup>	2.24±0.007 <sup>b</sup>	2.36±0.007 <sup>c</sup>	2.44±0.007 <sup>d</sup>

All values are means of triplicates ± SD; FF: fenugreek flour; WF: wheat flour; Levels not connected by same letter under the same row differed significantly

**Table 5.** *Nutritional profile of biscuit made from different blends of fenugreek and wheat flour.*

Components	Blends (FF:WF)			
	0:100	5:95	10:90	15:85
Moisture,%	3.98±0.01 <sup>a</sup>	4.13±0.01 <sup>b</sup>	4.18±0.02 <sup>c</sup>	4.37±0.01 <sup>d</sup>
Protein,%	9.66±0.05 <sup>d</sup>	11.84±0.01 <sup>c</sup>	11.92±0.02 <sup>b</sup>	12.67±0.01 <sup>a</sup>
Fiber,%	0.52±0.02 <sup>c</sup>	1.83±0.11 <sup>b</sup>	1.94±0.08 <sup>b</sup>	2.31±0.28 <sup>a</sup>
Ash,%	1.25±0.01 <sup>c</sup>	2.40±0.20 <sup>b</sup>	3.59±0.12 <sup>a</sup>	3.78±0.18 <sup>a</sup>
Fat,%	17.02±0.02 <sup>a</sup>	16.07±0.03 <sup>b</sup>	15.67±0.22 <sup>c</sup>	13.64±0.28 <sup>d</sup>
Carbohydrate,%	68.09±0.06 <sup>a</sup>	65.56±0.17 <sup>b</sup>	64.65±0.11 <sup>c</sup>	65.54±0.13 <sup>b</sup>
Energy (Kcal/100gm)	464.21±0.11 <sup>a</sup>	454.23±0.99 <sup>b</sup>	447.25±1.59 <sup>c</sup>	435.58±2.11 <sup>d</sup>
Minerals (mg/100g)				
Calcium	56.82±0.304 <sup>a</sup>	62.40±0.141 <sup>b</sup>	66.31±0.141 <sup>c</sup>	70.71±0.396 <sup>d</sup>
Magnesium	19.78±0.689 <sup>d</sup>	26.18±0.262 <sup>c</sup>	31.61±0.066 <sup>b</sup>	38.66±0.169 <sup>a</sup>
Iron	5.71±0.134 <sup>c</sup>	6.15±0.071 <sup>b</sup>	6.80±0.028 <sup>a</sup>	6.81±0.00 <sup>a</sup>
Zinc	1.65±0.00 <sup>a</sup>	1.87±0.007 <sup>b</sup>	1.85±0.00 <sup>c</sup>	2.01±0.007 <sup>d</sup>

All values are means of triplicates ± SD; FF - fenugreek flour, WF- wheat flour. Levels not connected by same letter under the same row are significantly different

**Table 6.** *Physical characteristics of bread and biscuit supplemented with fenugreek flour.*

Bread samples (FF:WF)	Loaf volume (ml)	Loaf weight (g)	Specific loaf volume (ml/g)
Control	428.00 ± 2.00 <sup>a</sup>	86.66 ± 0.14 <sup>a</sup>	4.94±0.03 <sup>a</sup>
5:95	408.33 ± 2.08 <sup>b</sup>	90.98 ± 0.77 <sup>b</sup>	4.49±0.04 <sup>b</sup>
10:90	391.67 ± 3.79 <sup>c</sup>	93.29 ± 0.61 <sup>c</sup>	4.18±0.03 <sup>c</sup>
15:95	334.67 ± 1.53 <sup>d</sup>	94.73 ± 0.11 <sup>d</sup>	3.53±0.02 <sup>d</sup>
Biscuit samples (FF:WF)	Width(diameter),(mm)	Thickness, (mm)	Spread Ratio (D/T)
Control	66.40±0.10 <sup>a</sup>	6.71±0.05 <sup>d</sup>	98.95±2.0 <sup>a</sup>
5:95	65.47±0.06 <sup>b</sup>	7.10±0.06 <sup>c</sup>	92.21±1.00 <sup>b</sup>
10:90	65.00±0.00 <sup>c</sup>	7.84±0.12 <sup>b</sup>	82.90±0.01 <sup>c</sup>
15:85	64.40±0.14 <sup>d</sup>	8.64±0.01 <sup>a</sup>	74.54±0.12 <sup>d</sup>

All values are means of triplicates ± SD, FF: fenugreek flour, WF: wheat flour. Levels not connected by same letter under the same column differed significantly

**Table 7.** Sensory characteristics of breads supplemented with germinated fenugreek flour.

Sensory attributes	Blends (FF:WF)			
	Control	5:95	10:90	15:85
Crust Color	8.13 ± 0.32 <sup>a</sup>	7.97 ± 0.06 <sup>a</sup>	7.77 ± 0.35 <sup>a</sup>	5.04 ± 0.36 <sup>b</sup>
Aroma (odor)	7.76 ± 0.32 <sup>a</sup>	7.87 ± 0.11 <sup>a</sup>	7.53 ± 0.06 <sup>a</sup>	5.1 ± 0.10 <sup>b</sup>
Taste	7.80 ± 0.20 <sup>a</sup>	7.23 ± 0.23 <sup>ab</sup>	7.03 ± 0.64 <sup>b</sup>	4.46 ± 0.15 <sup>c</sup>
Appearance	7.70 ± 0.36 <sup>a</sup>	7.27 ± 0.47 <sup>a</sup>	7.23 ± 0.21 <sup>a</sup>	5.40 ± 0.53 <sup>b</sup>
Texture	8.30 ± 0.10 <sup>a</sup>	7.89 ± 0.11 <sup>a</sup>	7.83 ± 0.40 <sup>a</sup>	6.53 ± 0.32 <sup>b</sup>
Overall acceptability (OAA)	8.10 ± 0.10 <sup>a</sup>	7.93 ± 0.23 <sup>a</sup>	7.73 ± 0.38 <sup>a</sup>	4.46 ± 0.15 <sup>b</sup>

W: wheat flour, FF: germinated fenugreek flour; Levels not connected by same letter under the same rows are significantly different.

**Table 8.** Microbiological analysis of bread and biscuit supplemented with fenugreek flour.

Microbial counts	Microbial load of samples (cfu/g)			
	FB <sub>C</sub>	FB <sub>r10</sub>	FBi <sub>C</sub>	FBi <sub>5</sub>
TPC	1.3x10 <sup>3</sup>	1.8x10 <sup>2</sup>	9.5x10 <sup>2</sup>	1.2x10 <sup>3</sup>
Coliforms count	ND	ND	ND	ND
<i>E.coli</i> count	ND	ND	ND	ND
Yeast count	ND	ND	ND	ND

TPC: Total plate count; FB<sub>C</sub>: bread control; FB<sub>r10</sub>: bread with 10%fenugreek flour; FBi<sub>C</sub>: biscuit control, FBi<sub>5</sub>:biscuit with 5% fenugreek flour; ND-Not detected.

## 4. Conclusion

Composite blends of germinated fenugreek seed flour supplemented with wheat flour exhibited desirable physico-chemical and functional characteristics which resulted acceptable bread and biscuit. The farinograph analysis showed that the supplementation of wheat flour with fenugreek flour was satisfactory in producing better flour for bread production. However, the gluten content decreased with increasing proportion of fenugreek flour. The protein, fiber and ash as well as minerals content of products increased as a result of the addition of fermented fenugreek flour. The research work has explored the utilization of fenugreek flour by supplementing with wheat flour for the preparation of bread and biscuit. The sensory evaluation of products has exhibited that 5 and 10% for bread and 5% for biscuit, fermented fenugreek flour supplemented with wheat flour resulted highly acceptable bread and biscuit at par with control samples.

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