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Evaluation of wheat breads supplemented with Teff (*Eragrostis tef* (ZUCC.) Trotter) Grain flour

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Abstract

The aim of this study was to evaluate the effect of Supplementations of teff (*Eragrostis teff* (ZUCC.) Trotter) grain flour to wheat flour at 0, 5, 10, 15 and 20% levels on organoleptic and nutritional evaluation of the supplemented bread. Protein, moisture, ash and falling number as well as rheological evaluation were estimated for prepared flour blends and dough. Besides, organoleptic assessment tests for their breads were carried out. Substitution of wheat flour by teff flour caused significant increases in ash and substantial reduction in protein content. Falling Number increased significantly as the percentage of teff flour was increased. However, the results indicated that addition of teff flour caused non-significant increase in water absorption and also, with exception of 15% and 20% substitution of teff flour, no significant change was observed in development time. Data on the gluten quality of flour blends indicated that the gluten contents decreased significantly as the percentage of teff flour substitution increased. Nevertheless, additions of 5% teff flour to wheat flour substitution; gives parameter values at least as good as the control sample and produce acceptable bread, in terms of weight, volume, specific weight, taste and texture. However, high level of teff flour resulted in higher negative changes in organoleptic characteristics. It may be concluded that breads supplemented with teff flour, up to a 5% level, are organoleptically and nutritionally acceptable.

Key words: Teff flour; wheat flour; bread; gluten; loaf.

Introduction

In recent years, with the increasing urbanization as well as the advancement in baking technology and changing food habits, the bakery food products such as bread are now becoming popular in urban and semi urban areas of the most developing countries (Agrawal, 1990). Wheat flour of both hard and soft wheat classes has been the major ingredient of bakery products for many years because of its functional proteins. However, Recognition of the beneficial nutritional attributes of some crop grains due to the complementarily of their essential amino acids with those of wheat has led to world-wide attempts to fortify traditional wheat bakery products, such as bread with locally grown unexploited grains (Patel and Rao,1995) Several studies about the influence of the addition of cereal flours such as sorghum, maize and barely, as well as rich lysine legumes, on the physico-chemical properties of bread dough and its final products quality have been reported in the last three decades. (Gayle, *et al.,* 1986; Rastogi and Singh, 1989; Shfali and Sudesh, 2001; McWatter, *et al.,* 2004).

Teff [*Eragrostis tef* (ZUCC.) Trotter] is one of the major and indigenous cereal crops in Ethiopia, where it is believed to have originated, with largest share of area (Bultosa, 2007). Teff is a fine stemmed, tufted annual grass characterized by a large crown, many shoots and a shallow, diverse root system. Its inflorescence is a loose or compact panicle. (Stallknecht *et al.,* 1993) Teff is the smallest grain in the world, taking 150 grains to weigh as much as one grain of wheat. The extremely small grains are 1 - 1.5

Table 1. Chemical characteristics of bread wheat flour and wheat-teff flour blends

Flour blends	Moisture content	Ash content	Protein content	Falling Number
Bread flour	11.10 (±0.10)[a]	0.802 (±0.001)[e]	11.80 (±0.17)[a]	536.33(±15.05)[e]
5 % teff flour substitute of bread flour	10.73 (±0.12)[b]	0.993 (±0.001)[d]	11.67 (±0.12)[a]	588.00 (±4.60)[d]
10 % teff flour substitute of bread flour	9.83 (±0.12)[d]	1.153 (±0.002)[c]	11.77 (±0.0)[a]	624.33 (±12.66)[c]
15 % teff flour substitute of bread flour	10.10 (±0.10)[c]	1.280 (±0.001)[b]	11.43 (±0.12)[b]	750.67 (±10.6o)[b]
20 % teff flour substitute of bread flour	10.03 (±0.11)[c]	1.470 (±0.001)[a]	11.10 (±0.10)[c]	943.33 (±11.93)[a]

Means in column followed with the same letter are not significantly different ($P \leq 0{\cdot}05$).

mm long and there are 2,500 - 3,000 seeds to the gram. Because the grains are so small, the bulk of the flour consists of the bran and germ (Ketema, 1987). Teff is considered to have an excellent amino acid composition, with lysine levels higher than wheat or barley, as well as very high calcium, phosphorous, iron, copper, aluminum, barium, and thiamine (Mengesha, 1965). The principal use of teff grain for human food is the Ethiopian bread (injera). Injera is a major food staple, and provides approximately two-thirds of the diet in Ethiopia (Stewart and Getachew, 1962). While the reported high iron content (0.05%) of teff seed has been refuted the lack of anemia in Ethiopia, is considered to be due to the available iron from injera (Ketema, *et al.*, 1997). Teff protein is essentially lack of gluten, the type found in wheat, so it is alternative foods for consumers suffer from wheat gluten allergies (Hopman *et al.*, 2007). The grain proteins are also presumed easily digestible because prolamins are very small (Twidwell *et al.*, 2002) In this study, as teff grain flour was characterized by its high level of lysine as compared to other cereal flours ((Piccinin, 2002), the effects of the substitution of wheat flour with different levels of teff grain flour on the physico-chemical, bread making properties of the flour were investigated.

Materials and methods

Plant Materials

Teff seeds (*Eragrastis tef* (ZUCC.) Trotter) used in this study were purchased from local market in Kassala town, Eastern Sudan, which were originally obtained from Ethiopia. Wheat flour was obtained from commercial mills in Khartoum North, Sudan. Baking materials were obtained from the local market.

Preparation of teff and wheat flour blends

The purchased teff seeds were manually cleaned by siftings and winnowing and freed carefully from chaffs, dust and other impurities. They were then ground into fine flour (0.4 mm) by micro Hammer mill C.480 (please provide details of make and company with country name). The teff flour was added to bread flour as percentages 0, 5, 10, 15 and 20 % and kept for subsequent chemical analysis, rheological and baking tests.

Chemical composition of flour blends

Crude protein, moisture, and ash content, of the flour blends, were determined as outlined by AOAC (1990). Protein content was measured using the Kjeldahl method (AACC Method No 46-11), to determine its total nitrogen content. A factor of 5.75 was used to convert the nitrogen content (%) into protein content (%). For the moisture content determination, the samples were dried in a 105^0 C oven for 24 h. For ash content samples were burnt for 4 h, at 500 ^{0} C. The weight of the remaining residue was used to calculate the ash content (%).

Falling number

The falling number of the flour blends was estimated according to AACC (2000) method No 56-81B); Seven grams of flour were added to 25 ml water in a special glass tube and shaken to aid dispersion. The tube and its contents were heated in boiling water for 60 seconds. The viscosity of the gel at the end of the heating time was assessed. At the end of the test the time was recorded in seconds. The total heating time (60 s) plus the time the plunger took to fall the set distance through the gel is called the falling number. Falling Number is defined as time in sec required to stir and allow stirrer to fall a measured distance

Table 2. Rheological characteristics of bread wheat flour dough as affected by blending of teff flours

Flour blends	Water absorption (%)	Development Time (min.)	Stability time(min.)	Softening time after12 min. (F.U.)	Farinograph Quality Number
Bread flour	63.0 [a]	5.3 [a]	8.8 [a]	72 [c]	98 [a]
5 % teff flour substitute of bread flour	65.1 [a]	5.3 [a]	5.9 [b]	131 [b]	77 [b]
10 % teff flour substitute of bread flour	65.9 [a]	5.3 [a]	5.5 [b]	138 [b]	74 [c]
15 % teff flour substitute of bread flour	64.9 [a]	4.3 [b]	5.2 [c]	146 [b]	68 [c]
20 % teff flour substitute of bread flour	64.4 [a]	3.8 [c]	4.8 [c]	169 [a]	59 [d]

Means in column followed with the same letter are not significantly different ($P\leq 0{\cdot}05$).

Table 3. Gluten quantity and quality of bread wheat flour dough as affected by teff flours

Flour blends	Wet Gluten	Dry Gluten	Gluten index
Bread flour	28.60 (±0.763)[a]	10.83 (±0.058)[a]	82.50 (±2.014)[a]
5 % teff flour substitute of bread flour	21.63 (±0.611)[c]	10.58 (±0.416)[b]	64.38 (±1.393)[c]
10 % teff flour substitute of bread flour	23.63 (±0.513)[b]	10.30+(±0.1)[c]	71.26 (±1.798)[b]
15 % teff flour substitute of bread flour	21.80 (±0.4)[c]	10.02 (0.029)[d]	67.00 (±1.410)[bc]
20 % teff flour substitute of bread flour	16.27 (±1.50)[d]	9.73 (±0.058)[e]	52.04 (±4.243)[d]

Means in column followed with the same letter are not significantly different ($P\leq 0{\cdot}05$).

through a hot aqueous flour or meal gel undergoing liquefaction,

Rheological analysis of flour blends dough

Properties of dough of the flour blends, water absorption, dough development time, dough stability, and degree of softening, were obtained using a farinograph (Brabender OHG, Kulture, 51-55, d-47055, Duisburg, Germany) according to approved AACC method (1986) .Dough extensibility and maximum resistance to a extension were determined using an extensometer (model 8 600, Brabender OHG, Duisburg, Germany) using AACC method (1986).

Gluten quality

The gluten quality was evaluated by the standard methods of AACC test procedure (AACC 2000) Method No 38-10 (please mention the numbers of AACC methods). Where ten grams of flour samples were weighed and placed into the glutomatic washing chamber on top of polyester screen, then every sample of flour was mixed and washed with 2% salt (NaCl) solution for 5 minutes. Then the wet gluten was removed from the washing placed in the centrifuge holder and centrifuged to stop automatically. The passed gluten through the sieve was weighed. The residue retained inside the screen and the through was weighed and then dried in a Glutrok 2020 heater to give dry gluten. The dry gluten was then weighed.

Bread making

Breads were prepared by a straight-dough method and by the chemical-dough development method according to AACC (1986). Control sample (all-purpose wheat flour) and blend flours were prepared by adding teff flour in ratios of 0, 5, 10, 15 and 20% (w/w) each to bread flour.

Loaf bread volume

The loaf volume expressed in cubic centimeters was determined by the seed displacement method according to Pyler (1973). The loaf was placed in a container of known volume into which millet seeds were run until the container is full. The volume of seeds displaced by the loaf was considered as the loaf volume.

Table 4. Physical characteristics of breads made from wheat flour and Teff flours blends

Flour blends	Weight (g.)	Volume(cm^3)	Specific volume(Cm^3/g)
Bread flour	107.50 (±0.26)^{b}	391.67 (±2.87)$^{c\ d}$	3.65 (±0.03)$^{c\ d}$
5 % teff flour substitute of bread flour	106.70 (±0.44)^{d}	430.00(±13.4)^{a}	4.03 (±0.13)^{a}
10 % teff flour substitute of bread flour	108.73 (±0.60)^{c}	415.00 (±5.00)^{b}	3.82 (±0.07)^{b}
15 % teff flour substitute of bread flour	110.23 (±0.25)^{a}	400.00 (±8.66)^{c}	3.63 (±0.11)$^{c\ d}$
20 % teff flour substitute of bread flour	108.93 (±0.76)^{b}	383.33 (±2.89)^{d}	3.52 (±0.02)^{d}

Means in column followed with the same letter are not significantly different ($P \leq 0{\cdot}05$).

Table 5. Sensory characteristics of biscuits made from wheat flour and teff flours blends

Flour blends	Color	Aroma	Taste	Texture	Mouth feel	Over all acceptance
Bread flour	8.9 ^{a}	7.8 ^{a}	6.5 $^{a\ b}$	8.2^{a}	8.8 ^{a}	8.1 ^{a}
5 % teff flour substitute of bread flour	7.0 ^{b}	6.9 ^{b}	7.2 ^{a}	8.9 ^{a}	7.9 ^{b}	6.7 ^{b}
10 % teff flour substitute of bread flour	4.3 ^{c}	4.1 ^{c}	6.7 ^{ab}	6.0 ^{b}	3.9 ^{c}	4.3 ^{c}
15 % teff flour substitute of bread flour	2.0 ^{d}	2.9 ^{d}	4.9 ^{b}	3.0 ^{d}	2.4 ^{d}	2.4 ^{d}
20 % teff flour substitute of bread flour	1.6 ^{d}	1.0 ^{e}	4.5 ^{b}	3.8 ^{c}	1.5^{d}	1.0 ^{e}

Means in column followed with the same letter are not significantly different ($P \leq 0{\cdot}05$).

Loaf bread specific volume: The specific volume of the loaf was calculated according to the AACC (1986) by dividing volume of the loaf (cm^3.) by its weight (g).

Organoleptic assessment

The breads samples were evaluated for colour, aroma, taste, texture, mouth feel and overall acceptability, by a panel of 15 trained judges according to the method of Hooda and Jood (2005)

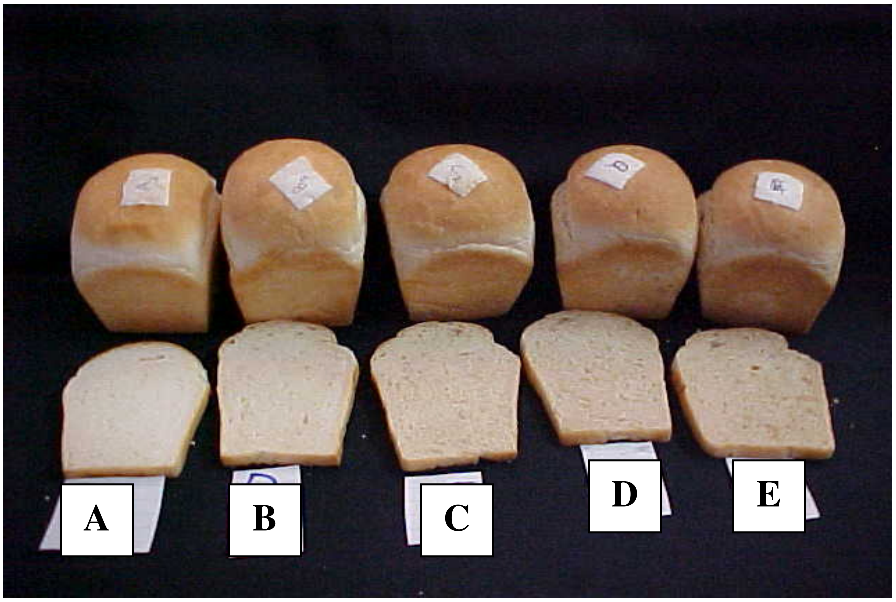
Statistical analysis

All parameters were performed in triplicate. The statistical analyses were conducted using the analysis of variance procedure. Duncan's multiple range test was used to separate the means. (Gomez and Gomez, 1984)

Results and discussion

The moisture, ash and protein content as well as the falling number of the flour blends are detailed in Table 1. The results revealed that the ash content increased from 0.802 (w/w) for wheat flour alone to 0.993%, 1·153%, 1.28% and 1.47 on substitution of wheat flour with 5%, 10%, 15% and 20% teff flour, respectively. However, the protein content decreased from 11.87% to 11.67%, 10.77%, 10.43% and 10.10. These findings indicated that the supplementation of wheat flour with teff flour caused substantial increases in the ash and insignificant reduction in protein content. This may be due to the fact that teff flour is higher in ash and lower in protein as compared to wheat flour. Bultosa (2007) reported that teff grain protein ranged from 11.1 to 8.7% with mean of 10.4%, and the ash content had ranged from 3.16 to 1.99% with mean of 2.45%.

The Falling Number is an indication of amylase enzyme activity. Substitution of wheat flour by teff flour caused significant increase in Falling Number, indicating less amylase activity (Khalil *et al.*, 2000). Table 2 shows the results of water absorption, development time, dough stability, softening time and Farinograph Quality Number of wheat bread flour as affected by addition of teff flour. The results indicated that addition of teff flour caused non-significant increase in water absorption. The observed higher water absorption of flour blends may be due to



the increased hydration capacity of teff flour. These results are similar with that reported by Aldawey (1997) who found that the water absorption increased significantly ($P < 0.05$) due to the addition of sesame products to wheat flour. Also, with exception of 15% and 20% substitution of wheat flour, no significant change was observed in development time as influenced by the addition of teff flour. Khalil *et al.* (2000) reported that addition of cassava flour to wheat flour reduced water absorption and increased development time. This might suggest that the effect of supplementation on wheat flour is crop dependent.

The dough stability time and Farinograph Quality Number of wheat flour blends decreased as the level of teff flour increased. Similar results were obtained by Khalil *et al*., (2000) who found that the mixing times and dough stability time of wheat flour substituted with cassava flour markedly increased at 50 % level of substitution. On the other hand the results revealed that the softening time increase as the percentage of teff flour increased. Dough development time and stability value are indicators of the flour strength, where higher values suggesting stronger dough (Wang *et al.*, 2002).

As shown in Table 3 the addition of teff flour to wheat flour resulted in a significant reduction in gluten values. The gluten contents decreased significantly as the percentage of teff flour substitution increased, this might be attributed to the fact that the teff flour is essentially considered as gluten free grain (Hopman *et al*, 2007).

Physical characteristics data of breads made from wheat flour and teff flours blends are presented in Table 4. The results showed that weight, volume and specific volume of the loaf increased significantly ($P \leq 0.05$) and then decreased as the level of teff flour increased, it has been observed that 5% teff flour bread gave the highest volume, while the control and 20% teff flour gave the lowest volume of loaf bread. These results are in a partial agreement with those reported by Talley *et al.* (1972) who found that 17% and 30% substitution of sunflower meal in wheat flour produced dense, compact loaves; however, 3% enrichment gave an attractive loaf.

Organoleptic evaluation of breads, as shown in Table 5, revealed that, as the level of teff flour was increased, the score of colour, aroma, mouth feel and overall acceptability of the breads decreased significantly. However, among the bread blends maximum score of taste and texture was observed in breads containing 5% of teff flour bread. Matthews *et al.* (1970) mentioned that substituting high levels of sunflower flour resulted in deterioration of crumb colour and texture of the bread. The low loaf volume and firm crumb texture may be attributed to gluten dilution (Dubois, 1978)

Conclusion

The use of teff flour up to 5% develops the chemical and physical properties of the parent flour, and its bread is considered as the most acceptable organoleptically and nutritionally as they contained appreciable amount of nutrients. However, high level of teff flour resulted in inferior changes in organoleptic characteristics.

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