academicresearchJournals

Vol. 7(6), pp. 372-379, September 2019
DOI: 10.14662/ARJASR2019.110

ISSN: 2360-7874
http://www.academicresearchjournals.org/ARJASR/Index.htm

Academic Research Journal of Agricultural Science and Research

Full Length Research

Comparative analysis of proximate and mineral composition of released Tef (*Eragrostis tef (Zucc.) Trotter)* varieties in Ethiopia

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Accepted 27 August 2019

In Ethiopia, more than 35 improved tef varieties have been realised and disseminated to farmers However, so far the focus of the improvement areas were better yield and good agronomic traits giving little emphasis to quality parameters. This study was, therefore conducted to generate base line information on proximate and mineral composition of released tef varieties and to determine their nutritional quality. All the released tef varieties and local check were grown in Debre ziet research station site under uniform agronomic condition and their proximate composition (moisture, ash, crude protein, fat, fiber, and carbohydrate), energy value and mineral content (Ca, Fe, and Zn) were analyzed and compared. The result showed that different variety had significant effect (p>0.05) on almost all the proximate and mineral contents of the 35 cultivars. However, this study was limited on the grain qualities and single planting season. Therefore, further studies on the grain nutritional and anti-nutritional grain contents; suitability making and development new tef based food products should be studied.

Keywords: Tef cultivars, genotypic difference, grain nutritional quality

Cite this article as: Lamesgen Y., Mohammed Y., Tamerat K., Workineh A (2019). Comparative analysis of proximate and mineral composition of released Tef (*Eragrostis tef (Zucc.)* Trotter) varieties in Ethiopia. Acad. Res. J. Agri. Sci. Res. 7(6): 372-379

INTRODUCTION

Tef (Eragrostis tef (Zucc.) Trotter) is a major staple food for over two third of the 100 million people in Ethiopia FAO (2015). According to Ethiopian central statistical agency, 2016/17 report, tef cultivation takes up the largest amount of land under cereal cultivation (24.49%, 3.014 million hectares). It is the second largest crop after maize in terms of grain production 17.29%, 50.20 million quintals) in Ethiopia. Tef is mostly cultivated in the central, eastern and north highlands of Ethiopian (Birara, 2017). Its grain flour is mainly used for preparing injera, which is the favorite national dish of most Ethiopians. Tef's international popularity is also rapidly growing as a gluten free healthier alternative to wheat and become one of the latest super foods, like the ancient Andean grain quinoa. Because of its gluten-free diets, it is suitable for diabetic and celiac disease affected people in the world (Gujral, Freeman, and Thomson 2012). In connection to its medicinal values interests are growing in many countries to utilize tef for production of gluten free foods (Gebremariam et al, 2014)

In terms of its nutritional values, tef stands at least at a comparable level with those of other major cereals like wheat, maize, barley and sorghum that have globally significant; while it is 'rich in iron content as compared to other cereals (Asrat and Frew, 2001). It is consists of about 8 to 11 % protein, 80 % carbohydrates, 73 % starch, 3 % crude fiber and 2.5 % fat (Bultosa & Taylor 2004). It is composed of complex carbohydrates with slowly digestible starch (Baye, 2014). The Minerals content of tef such as calcium (165 mg/100 g), iron (15.7

mg/100 g) and Zinc (4.8 mg/100 g) are present in appreciable amount (Bultosa, 2007). Despite having a very good nutrient, the studies on the nutritional composition of newly released tef varieties and there's processing quality and development of new tef based food products are not sufficient**.** The chemical composition also widely depends on the environmental conditions, soil, variety and fertilizer (Gebremariam et al, 2014). For that reason, the comparison of the released and improved tef varieties is very important to determining their nutritional worth, and advising farmers and consumers in Ethiopia as well as international market.

In the last decades, more than 35 improved tef varieties have been released and disseminated to the farmers for improve productivity. However, mainly focus to release crop verities with better yield and good agronomic traits with little emphasis on some quality parameters. Lack of knowledge on the nutritional quality of each tef varieties might have contributed to affect the processing quality of different tef based food products. The general objective of this activity is therefore, to generate base line information and robust quality data base for released tef varieties. The specific objective is to evaluate the proximate and mineral composition of the released tef varieties as an index of their nutritional worth. We hope this information will help for development of different tef based products and further researchers in tef breading.

MATERIALS AND METHODS

Materials

A total of 35 released tef varieties and a local check were grown in Debre Zeit Agricultural Research Center (DZARC) with three replications. As per recommendation of the site, similar agronomic practices were conducted for all varieties. At maturity, the grain yield was harvested and brought in to the laboratory for quality parameter analysis. The grain samples were manually cleaned by sieving and sorting with handing picking to remove the stones, foreign materials (large chaff, dusts and soils) and other cereals. Then and there were milled using a laboratory scale mill and the flours were packed and sealed with polyethylene bags and stored at $4^{o}C$ until analysis.

Proximate composition and mineral content analysis

The Proximate compositions (Moisture, Ash, Crude Protein, crude Fat, crude Fiber and carbohydrate) of the samples were determined using the AOAC (2000) method. Moisture content was determined by drying to a constant weight at $105^{o}c$ and calculating moisture as the loss in weight of the dried tef grain samples. Total ash was determined by Furnace using gravimetric method as percentage loss in weight on ignition. The crude protein content in the samples was determined using the Micro kjeldahl method which involved protein digestion and distillation. Crude fiber was estimated by acid-base digestion. Crude fat in the sample was measured using Soxhlet extraction. The carbohydrate content in the samples was estimated as the difference between 100 and the sum of the percentages of moisture, protein, total fat, and ash. The Energy values in Kcal/100g determine as the sum of 4 times carbohydrate, 4 times protein and 9 times fat.

Mineral contents (Ca, Fe, Zn and K) of the samples were determined by atomic absorption spectrometer as described in AOAC (2000) method.

Data analysis

All data were analyzed by the Analysis of Variance (ANOVA) procedure using SAS software version. The means separation was done by the least significant difference (LSD) at 5 % probability level. Interrelationships among quality parameters were estimated using the Pearson's correlation coefficient.

RESULTS AND DISCUSSION

Proximate compositions of the tef varieties

The 35 tef varieties whole flour samples proximate composition was determined according to AOAC method. The proximate composition like grain crude protein, moisture, crude fiber, crude fat, total ash, carbohydrate and energy values contents were significantly different ($p<.05$) even though they were grown in the same agro ecological zones (Table 1).

The protein contents in tef varieties are ranged from 9.86-12.90% with mean 11.15%. Relatively higher protein contents (12.9-12.03%) were found in Local cheeks, Etsub (DZ-01-3186), Qun-cho-(DZ-cr-387), Mechare (ACC.205953), Tseday (DZ-Cr-37), Gerado(DZ-01-1281) and Magna(Dz-01-196) while the lower protein contents (9.86-9.92%) were found in Zobel (DZ-01-1821), Dima (Dz-01-2423) and Ajora (PGRC/E205396). The research result indicated that the genetic variability has a significant influence on the crude protein content of tef grain. Previous studies also indicated that the protein content in the tef grain varied between cultivars as because of growing condition and genetic variability (Bultosa 2007, Yigzaw et al 2001, Mulugeta 1979, Mengesha 1966). According to Bultosa (2007), the grain protein contents of 13 tef varieties ranged from 8.7–11.1 % with mean value of 10.4 %. The grain protein in DZ-Cr-37 (11 %), DZ-Cr-255 (11.1%) and DZ-01-1281 (11.1 %) varieties were the highest; and that of DZ-01-

1285 (8.7 %) was the lowest. Belay et al. (2005) reported the grain protein contents of 13 released tef varieties, which are also included in this study, ranged from 8.7 % to 12.4% with a mean value of 11.0 %. In general, the average protein levels of the tef cultivars studied were at least similar or higher than that of common cereals like barley, wheat, maize, pearl millet, rye, rice and sorghum (Gebremariam et al., 2014). However, the protein type available in tef is considered as nutritionally superior because of its high levels of amino acid profile and its gluten free natures which make it a suitable alternative to other cereals in the case of celiac disease and gluten-free diet (Hopman et al 2008, Taylor et al.2006, Dekking et al 2008, Lovis 2003, Piccinin, 2002). This makes tef to be a attracting the attention of the many modern food industries in all over the world.

The moisture content of tef grain varieties was ranged 9.92-10.90 % (Table 1). The highest value was recorded in Gerado (DZ-01-1281), while the lowest value was recorded in Ziquala (Dz-cr-3587). The range of the moisture content in this study is similar with the report of Bultosa (2007), he reported that the moisture contents of 13 tef varieties was ranged from 9.30% - 11.22 with mean 10.53%. The moisture contents of the grains are generally dependent on the storage condition and hydroscopic capacity of the grains. The quality of tef grain could affect by moisture contents as its value is inversely correlated with the amount of dry matter.

The mean values for the ash content in different tef varieties (Table 1) ranged from 2.0 to 2.78 %. The highest value for this parameter was observed in Dukem (DZ-01-974) and the lowest in Gola (DZ-01-2054). This value is comparable to previous study where the ash content of tef was reported in the range of 2.0-2.90 Bultosa and Taylor (2004) and slightly differ from reviewed report of the ash level in tef grain had ranged 3.00-2.66% (Corke et al., 2004b), a part from the genetics, the ash levels in tef grain are influenced by the degree of tef grain unseen surface contamination mostly from the threshing floor. Tef grain used in this study were prepared relatively in controlled laboratory and comparatively clean than purchased from the market and threshed by cattle, hence slightly less ash content were observed in this study are probably related to this reason. The ash content varies due to tef grain's proportionally high bran content (Bultosa & Taylor, 2004). The ash content of a food sample gives an idea of the mineral elements present in the food sample and also level of bran in the flour obtained from a given cereal grain. Apart from tef's genetically variation between cultivars, the mean ash contents of the tef cultivars varied in grown replication site. Bultosa (2007) reported that the crude fiber in the 13tef varieties ranged from 3.8–2.6 % with mean 3.3 %.

Crude fiber contents of the tef varieties were also de-pendent on variety type and growing sites as replication (Table 1). The mean values of the crud fiber content in different tef varieties (table1) ranged from 2.97 to 3.83. Acaccordingly, the highest values were found in Laketch (SR-R/L-273) and Menagesha (Dz-cr-44) while the lowest value was measured in Kora (DZ-01-438) (Table 1). The range value crude fiber in this study was fairly similar with Bultosa (2007), who reported that the crude fiber contents of 13 tef varieties are ranged from 2.6 –3.8 % with mean 3.3 %. Bultosa & Taylor (2004) also reported the crude fiber contents of these 13 released tef varieties in the range of 2.0–3.5 % with mean 3.0 %. The crude fiber con-tent in tef is generally higher than in most of other cereals (Gebremariam et al, 2014). As because of the higher pro-portion of bran with its very small grain size, fiber content tef was also relatively higher than most of other common cereals (Bultosa & Taylor, 2004). Moreover, the high fiber content of the grain makes it to be useful in preventing diabetes and other health problems as well as assisting with blood sugar control (Gebremariam, 2014).

The crude fat content was significantly different at ($P < 0.05$) among varieties. It was ranged from 2.64 to 3.27% (Table1). The minimum value was found in Gemechis (DZ-CR-387) while the maximum value (3.27) was that of Keytena (DZ-01-1681). Similarly, Bultosa (2007) reported that the crude fat content of 13 tef varieties is ranged between 3.0–2.0 % with mean of 2.3 % which is similar to this report. According this report, the highest crude fat content was found in DZ-Cr-82 and the lowest values were observed in DZ-01-1681 and DZ-Cr-37. The crude fat content of tef grain, in general higher than that of other common cereals like wheat, rye, and brown rice but lower than that of barley, maize, sorghum and pearl millet (Gebremariam et al, 2014). The amount of fat in tef grain is almost comparable with other cereals, but it contains mainly unsaturated fat acid and it can contribute a significant amount of essential fatty acids to the diet (El-Alfy et al, 2011).

Table 1. The proximate compositions of the Tef varieties

No	Tef variety type	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	Carbohydrate (%)	Energy (Kcal/100g)
1	Ajora (PGRC) E205396	10.30^{a-d}	2.42^{abc}	9.87^{e}	2.91^{e-m}	3.20^{gfdeh}	71.29^{a}	350.81^{a-g}
2	Amarech (HO-cr-136)	10.41^{a-d}	2.47^{abc}	11.20^{a-e}	2.66^{no}	3.13^{gfeh}	70.14^{a-e}	349.28^{c-g}
3	Ambo toke (DZ-01-1278)	10.34^{a-d}	2.24^{bc}	11.29^{a-e}	2.92^{e-m}	3.12^{gfeh}	70.09^{a-e}	351.80^{a-f}
4	Asgori (Dz-01-99)	10.44^{a-d}	2.12^{bc}	10.12^{edc}	3.20b^{ac}	3.72^{ba}	70.41^{a-e}	350.88^{a-g}
5	Boset (DZ-CR-409)	10.35^{a-d}	2.51^{ba}	11.20^{a-e}	2.76^{l-o}	3.24^{gfdeh}	69.94^{a-e}	349.40^{b-g}
6	Degatef(DZ-01-2675)	10.18^{b-d}	2.25^{bc}	11.04^{a-e}	3.05^{a-h}	3.27^{gfdeh}	70.22^{a-e}	352.45^{a-d}
7	Dima (Dz-01-2423)	10.36^{a-d}	2.28^{bc}	9.92^{ed}	2.96^{e-l}	3.33^{gfdec}	71.15^{ab}	350.92^{a-g}
8	Dukem (DZ-01-974)	10.20^{b-d}	2.78^{a}	10.75^{a-e}	2.78^{j-o}	3.36^{fdec}	70.13^{a-e}	348.54e^{fg}
9	Enatite (DZ-01-354)	10.64^{a-c}	2.26^{abc}	10.19^{edc}	2.78^{k-o}	3.52^{bdac}	70.61^{-e}	348.19^{fg}
10	Etsub(DZ-01-3186)	9.98^{cd}	2.27^{bc}	12.29^{bac}	2.82^{j-o}	3.07^{gfh}	69.58^{a-e}	352.85^{abc}
11	Gemechis(DZ-CR-387)	9.94^{cd}	2.48^{abc}	11.77^{a-e}	2.64^{o}	3.27^{gfdeh}	69.9^{a-e}	350.44^{a-g}
12	Genete(DZ-01-146)	10.63^{a-c}	2.23^{bc}	10.96^{a-e}	2.84^{h-o}	3.10^{gfeh}	70.24^{a-e}	350.38^{a-g}
13	Gerado(DZ-01-1281)	10.90^{a}	2.39^{abc}	12.06^{a-d}	2.76^{l-o}	2.98^{ga}	68.9^{a-e}	348.68^{d-g}
14	Gibe (DZ-Cr-255)	10.11^{b-d}	2.15^{bc}	11.47^{a-e}	2.81^{j-o}	3.09^{gfeh}	70.37^{a-e}	352.62^{abc}
15	Gimbichu(Dz-01-899)	10.73^{ba}	2.43^{abc}	10.38^{ebd} c	3.00^{c-j}	3.72^{ba}	69.73^{a-e}	347.50^{g}
16	Gola(DZ-01-2054)	10.33^{a-d}	2.00^{c}	11.76^{a-e}	3.00^{c-j}	3.12^{gfeh}	69.8^{a-e}	353.24^{ab}
17	Guduru(DZ-01-1880)	10.40^{a-d}	2.27^{bc}	10.75^{a-e}	3.02^{b-j}	3.31^{gfdeh}	70.24^{a-e}	351.15^{a-g}
18	Holeta key(DZ-01-2053)	10.33^{a-c}	2.32^{bac}	10.64^{b-d}	3.10^{a-f}	3.30^{gfdeh}	70.32^{a-e}	351.71^{a-f}
19	Kena(23-tafi –adi-27)	10.31^{a-d}	2.27^{ac}	10.92^{a-e}	3.00^{c-j}	3.31^{gfdeh}	70.2^{a-e}	351.44^{a-f}
20	Keytena(DZ-01-1681)	10.48^{bdac}	2.04^{ac}	11.73^{a-e}	3.27^{a}	3.75^{ba}	68.73^{b-e}	351.25^{a-g}
21	Kora (Dz-01-438)	10.15^{bdc}	2.22^{ac}	10.89^{a-e}	2.71^{nmo}	2.97^{h}	71.03^{abc}	352.18^{a-e}
22	Koye(DZ-01-1285)	10.69^{ba}	2.48^{abc}	12.03^{a-e}	2.89^{f-n}	3.29^{gfeh}	68.63^{cde}	348.61^{d-g}
23	Laketch(SR-R/L-273)	10.00^{dc}	2.14^{bc}	11.00^{a-e}	3.08^{a-g}	3.82^{a}	69.96^{a-e}	351.60^{a-f}
24	Magna(Dz-01-196)	10.25^{a-d}	2.24^{bc}	12.02^{a-e}	3.11^{a-f}	3.03^{gfh}	69.36^{a-e}	353.45^{a}
25	Mechare(ACC.205953)	10.20^{bdc}	2.52^{ba}	12.23^{bac}	3.12^{a-d}	3.19^{gfdeh}	68.74^{b-e}	351.96^{a-f}
26	Melko (Dz-cr-82)	10.48^{bdac}	2.29^{abc}	11.37^{a-e}	3.08^{a-f}	3.16^{gfeh}	69.62^{a-e}	351.65^{a-f}
27	Menagesha (Dz-cr-44)	10.62^{bac}	2.15^{bc}	10.91^{a-e}	3.18^{a-d}	3.83^{a}	69.31^{a-e}	349.48^{b-g}
28	Quncho-(DZ-cr-387)	10.74^{ba}	2.09^{bc}	12.26^{bac}	3.23^{ba}	3.42^{bdec}	68.25^{e}	351.11^{a-g}
29	Simada (Dz-cr-385)	10.63^{bac}	2.48^{abc}	11.04^{a-e}	2.80^{i-n}	3.07^{gfh}	69.99^{a-e}	349.31^{c-g}
30	Tseday (DZ-Cr-37)	10.707^{ba}	2.46^{abc}	12.50^{ba}	2.96^{d-l}	3.15^{gfeh}	68.22^{e}	349.55^{b-g}
31	Wellenkomi (Dz-01-787)	10.23^{bdc}	2.37^{abc}	10.42^{b-e}	3.01^{b-i}	3.25^{gfdeh}	70.72^{a-e}	351.64^{a-f}
32	Workiye(21476A)	10.30^{bdac}	2.12^{bc}	10.57^{b-e}	2.90^{e-m}	3.35^{fdec}	70.76^{a-d}	351.46^{a-f}
33	Yilmana (DZ-01-1868)	10.28^{bdac}	2.26^{bc}	10.27^{b-e}	2.86^{h-o}	3.67^{bac}	70.66^{a-e}	349.46^{b-g}
34	Ziquala (Dz-cr-3587)	9.92^{d}	2.27^{bc}	10.89^{a-e}	2.97^{d-l}	3.73^{ba}	70.23^{a-e}	351.17^{a-g}
35	Zobel(Dz-01-1821)	10.62^{bac}	2.23^{bc}	9.86^{e}	2.84^{h-o}	3.21^{gfdeh}	71.24^{ba}	349.96^{a-g}
36	Local cheek	10.20^{bdc}	2.17^{bc}	12.90^{a}	3.06^{a-h}	3.35^{fdec}	68.33^{de}	352.44^{a-d}
	Lsd	0.661	0.49	2.19	0.23	0.35	2.51	3.84
Replication								
	1	9.77^{c}	2.84a	10.99^{b}	3.01^{a}	3.12^{c}	70.27^{b}	352.09^{a}
	2	10.92^{a}	1.93^{c}	10.02^{c}	2.95^{a}	3.31^{b}	70.98^{a}	349.27^{b}
	3	10.42^{b}	2.11^{b}	12.43^{a}	2.87^{B}	3.51^{a}	68.85^{c}	351.01^{a}
	Lsd	0.19	0.14	0.63	0.07	0.1	0.55	1.10
	Total CV	3.92	13.24	12.04	4.72	6.44	2.20	0.67

Values within the same column with different letters are significantly different (p<0.05). Lower case latters stand for comparison between the varieties, while the upper case letters stand for comparison between growing locations

Carbohydrate values in the varieties significantly (p<0.05) affected by variety type ranging from 68.39% for Tseday (DZ-Cr-37) to 71.46% in Ajora (PGRC) E205396. Previous studies showed that like other cereals tef is predominantly starchy; the approximately starch reach about 73% (Bultosa, 2007; Baye, 2014). The energy values of the 35 tef varieties were significantly (p<0.05) and ranged from 347.50 Kcal/100g for Gimbichu (Dz-01-899) to 353.45 Kcal/100g for Magna (DZ-01-196) (Table 1). The mean energy value recorded in this study is close to the report by Bultosa and Taylor (2007) and relatively lower than the value stated in USDA (2016) (Table 3)

Mineral content

Tef variety type had significant ($p<0.05$) on all the measured mineral contents of the cultivars (Table 2). Fe contents of Tef variety type had significant ($p<0.05$) on all the measured mineral contents of the cultivars (Table 2). Even though the iron content of red and white tef varieties are still controvrtional the finding of this research agreed with the previous studies reported as the higher contents of iron were recorded in the brown tef than the white tef varieties (Kibatu, 2017 and Kebede and Yimer, 2015, Gebremariam et al., 2012, Baye et al, 2014, Abebe et al. 2007, Ketema, 1997). Fe contents in the brown tef varieties like Asgori (DZ-01-99), Holeta key (DZ-01-2053) and Keytena (DZ-01-1681) were comparatively high, while those in the white tef varieties like Quncho (DZ-cr-387), Yilmana (DZ-01-1868), Tseday (DZ-Cr-37),Genete (DZ-01-146), Enatite (DZ-01-354) and Boset (DZ-CR-409) appeared low. According to Kibatu (2017) the concentrations of iron (mg/100g dry weight basis) were recorded 22.60 and 16.05 in brown and white tef varieties, respectively. The variability in different research results could be due to error associated to sampling and sample preparation. According to Ketema (1997) the genetic and environmental factors affected the iron content of tef grown in different agro-ecologic settings.

The highest Zn and Ca content were observed in Asgori (Dz-01-99), while the lowest Zn and Ca contents were recorded for Quncho (DZ-cr-387) and Enatite (DZ-01-354), respectively. The K contents of the tef cultivars ranged be-tween 275.54 (mg/100g) for Mechare (ACC.205953) to 375.94 (mg/100g) for Gola (DZ-01-2054). These results showed that brown tef verities generally contained higher concentrations of most minerals as compared to white tef varieties. Review by Baye et al (2014) indicated wide differences in mineral content in tef varieties. As observed in this study, earlier studies showed that red tef had higher iron and calcium content than mixed or white tef (Abebe et al. 2007).

In comparison with other common cereals, tef is higher in its mineral content, particularly in calcium and iron (Kibatu, 2017, Bultosa and Taylor 2004; and Mengesha, 1966). Thus, tef is an excellent cereal to prevent the iron deficiency anemia and the aforementioned health problems associated with less consumption of calcium (Gebremariam et al, 2014). Result obtained in this study generally showed that more or lease similar with the previous works for most of tested parameters. As shown on table 3, result revealed in this study for protein content ranged from 9.86-12.90%, moisture content 9.92-10.90%, ash 2.0 to 2.78%, crud fiber 2.97 to 3.83%, crude fat 2.64 to 3.27% and Carbohydrate 68.39% to 71.46%, iron 15.56 to 23.75 mg/100g, zinc 2.8 to 5.12 mg/100g and calcium 116.52-170.14 mg/100g. These values are almost similar to previous finding by Bultosa (2007) for 13 teff grain varieties, the proximate compositions were in some ranges: grain protein 8.7–11.1% (mean 10.4%), moisture 9.30– 11.22% (mean 10.53%) , ash 1.99–3.16% (mean 2.45%), crude fat 2.0– 3.0% (mean 2.3%) and crude fiber 2.6–3.8% (mean 3.3%). In the same way, Bultosa & Taylor (2004) reported that the typical values of tef were 11.0% crude proteins, 2.5% crude fat, 3.0% crude fiber and 2.8% ash contents.

These results indicated that genotype variation had influenced the value of proximate composition. Several previous studies also confirmed that the proximate composition in the tef grain varied between cultivars (Baye et al. 2014, Bultosa (2007), Yigzaw et al (2001) Mulugeta, (1979). Moreover, the proximate composition of tef grain was significantly influenced by growing environmental condition and soil types.

In general, tef grain has a positive nutritional attributes for a human diet and health promotion, with its own unique qualities as compared to cereals such as wheat, rice, oats, and barley. It is a comparatively good source of essential fatty acids, fiber, minerals (especially calcium and iron), and phytochemicals, such as polyphenols and phytates (Gebremariam et al., 2014, Baye, 2014). Moreover, its gluten free proteins contents make tef to be an alternative for people with gluten allergy than other common cereals. The genetic variation among 36 tef varieties was also observed to select the specific varieties that satisfy consumer preferred parameters such as high mineral contents in read tef varieties. In addition to plant genetics, the environmental factors associated with altitude range was also affect the proximate and mineral composition of tef varieties.

Table 2. The mineral composition of tef varieties (mg/100g)

No.	Tef varieties	Fe	Zn	Ca	K
1	Ajora (PGRC)E205396	16.57^{l-O}	3.24^{o-q}	136.67^{e-k}	313.34^{ba}
2	Amarech (HO-cr-136)	17.95^{f-i}	3.97^{jhi}	128.02^{h-m}	360.19^{ba}
3	Ambo toke DZ-01-1278	16.82^{lm}	3.17^{qpr}	152.02^{bcd}	346.91^{ba}
4	Asgori (Dz-01-99)	23.75^{a}	5.12^{a}	170.14^{a}	304.55^{ba}
5	Boset (DZ-CR-409)	16.03^{pq}	3.64^{lk}	152.72^{bc}	340.24^{ba}
6	Degatef(DZ-01-2675)	19.19^{ed}	4.34^{f}	147.87^{b-f}	342.08^{ba}
7	Dima (Dz-01-2423)	19.48^{d}	4.4^{ef}	155.52^{ba}	354.48^{ba}
8	Dukem (DZ-01-974)	18.17^{gf}	4.07^{ghi}	136.72^{d-k}	326.01^{ba}
9	Enatite (DZ-01-354)	16.24^{n-q}	4.14^{gh}	116.52^{m}	351.13^{ba}
10	Etsub(DZ-01-3186)	17.53^{ij}	3.27^{npo}	118.06^{lm}	301.2^{ba}
11	Gemechis(DZ-CR-387)	16.90^{klm}	3.87^{j}	144.22^{b-g}	325.74^{ba}
12	Genete(DZ-01-146)	16.00^{rpq}	4.34^{f}	134.47^{f-k}	291.03^{ba}
13	Gerado(DZ-01-1281)	17.30^{kj}	4.24^{gf}	139.02^{c-j}	332.44^{ba}
14	Gibe (DZ-Cr-255)	19.40^{d}	4.57^{ed}	143.87^{c-g}	349.17^{ba}
15	Gimbichu(Dz-01-899)	16.75^{lm}	3.9^{ji}	127.24^{i-m}	374.83^{a}
16	Gola(DZ-01-2054)	17.65^{ijh}	3.04^{r}	143.97^{b-g}	375.94^{a}
17	Guduru(DZ-01-1880)	18.22^{f}	3.82^{jk}	124.02^{j-m}	290.03^{ba}
18	Holeta key DZ-01-2053	22.02^{b}	4.9^{b}	140.37^{b-i}	342.48^{ba}
9	Kena(23-tafi –adi-27)	17.72^{gijh}	3.54^{lm}	138.92^{c-j}	301.29^{ba}
20	Keytena(DZ-01-1681)	21.94^{b}	4.77^{cb}	124.47^{j-m}	360.44^{ba}
21	Kora (Dz-01-438)	16.92^{kl}	3.4^{nmo}	131.31^{g-m}	317.8^{ba}
22	Koye(DZ-01-1285)	16.99^{kl}	4.1^{gh}	147.47^{b-f}	344.71^{ba}
23	Laketch(SR-R/L-273)	18.78^{e}	3.4^{m-o}	123.37^{klm}	307.89^{ba}
24	Magna(Dz-01-196)	16.96^{kl}	3.07^{qr}	134.62^{e-k}	300.08^{ba}
25	Mechare(ACC.205953)	16.44^{m-p}	3.24^{qpo}	155.67^{ba}	275.54^{b}
26	Melko (Dz-cr-82)	16.11^{opq}	3.64^{lk}	149.97^{becd}	367.02^{ba}
27	Menagesha (Dz-cr-44)	18.05^{gfh}	3.24^{qpo}	137.62^{c-k}	363.4^{ba}
28	Quncho-(DZ-cr-387)	15.56^{r}	2.8^{s}	134.62^{e-k}	342.48^{ba}
29	Simada (Dz-cr-385)	16.74^{lm}	4.34^{f}	132.97^{f-l}	287.68^{ba}
30	Tseday (DZ-Cr-37)	15.87^{rq}	3.24^{qpo}	127.97^{h-m}	292.27^{ba}
31	Wellenkomi Dz-01-787)	17.77^{f-i}	4.07^{ghi}	146.82^{c-f}	294.37^{ba}
32	Workiye(21476A)	17.68^{ijh}	3.5^{lm}	131.12^{h-m}	299.95^{ba}
33	Yilmana (DZ-01-1868)	15.92^{rq}	3.07^{qr}	141.97^{c-i}	363.96^{a}
34	Ziquala (Dz-cr-3587)	16.66^{nlm}	3.84^{j}	142.87^{b-h}	303.3^{ba}
35	Zobel(Dz-01-1821)	17.58^{ij}	3.44^{nm}	136.72^{d-k}	303.43^{ba}
36	Local cheek	21.26^{c}	4.7^{cd}	143.02^{b-h}	339.13^{ba}
	LSD	0.50	0.19	15.433	125.55
	Replication				
	1	17.57^{b}	4.45^{a}	138.802	315.66^{b}
	2	18.00^{a}	3.90^{b}	140.023	308.75^{b}
	3	17.84^{a}	3.10^{c}	137.244	357.80^{a}
	LSD	0.14	0.05	NS	26.84
	Over all CV	1.62	3.01	6.8	17.44

Values within the same column with different letters are significantly different ($p<0.05$). Lower case latters stand for comparison between the varieties, while the upper case letters stand for comparison between growing locations

Table 3. Comparison of the results obtained in the current study with previous studies

Component	This study		Previous studies	
	Range	Mean	Bultosa& Taylor 2004	USDA (2016)
Moisture (%)	9.92-10.90	10.37	10.5	8.82
Crude protein (%)	9.86-12.90	11.15	11.0	13.30
Crude fat (%)	2.64- 3.27	2.95	2.5	2.38
Crude fiber (%)	2.97-3.83	3.32	3.0	8.0
Ash (%)	2.0-2.78	2.30	2.8	-
Energy (kJ/100 g)	347.50-353.40	5350.79	357	367
Calcium (mg/100 g)	116.52-170.14	138.69	165.2	180
Iron (mg/100 g)	15.56-23.75	17.16	15.7	7.63
Zinc (mg/100 g)	2.8-5.12	3.93	4.8	3.63

CONCLUSION

The study proved that there was a significant difference in proximate and some mineral content between the varieties, even though the varieties were from similar agro ecological locations. The findings of this study showed that the released tef varieties' could be good sources of proteins, fibers and minerals. However, the effect of tef variety type was important parameters that could dictate the nutritional contents of these cultivars. In this regard, the highest grain protein, fibre, carbohydrate and energy values were found in local cheek, Menagesha (Dz-cr-44), Ajora (E205396) and Magna (Dz-01-196), respectively, whereas the lowest values were observed in Zobel (DZ-01-1821), Kora (Dz-01-438), Tseday (DZ-Cr-37) and Gimbichu (Dz-01-899) tef varieties, respectively. Regarding with minerals (Fe, Zn and Ca), the highest contents were recorded in the brown seed colored Asgori (Dz-01-99) variety while the lowest values of Fe and Zn were recorded in white colored Quncho (DZ-cr-387) tef variety and also least Ca recorded in Enatite (DZ-01-354). As this study covers almost all the cultivars released up to the year 2017, the information generated can serve as a baseline for future breeding, agronomic and tef-based product development related activities. However this study was limited like only primary grain qualities, single planting season and single agro ecologies. Therefore, further studies on the grain nutritional composition in different planting season and agro ecologies should be studied by adding other physical parameters and chemical composition parameters. Further researches are also recommended on injera making quality of the grain in the above condition.

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