Proximate and Mineral Composition of Released Tef Varieties

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Abstract

In Ethiopia, more than 35 improved tef varieties have been released and disseminated to the farmers. However, so far the focuses of the improvement areas were better yield and good agronomic traits giving little emphasis to quality related 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 at three locations (DebreZeit, Chefedonsa and Alemtena) under uniform agronomic condition and their proximate composition (moisture, ash, crude protein, fat, fiber, and starch). Inaddition, mineral content (Ca, Fe, and Zn) were analyzed and compared.The results showed that variety and growing location had significant (p<0.05) effect on almost all the proximate and mineral contents of the 35 cultivars. The findings from the present study could serve as baseline for future breeding, agronomic and processing activities. However, this study was limited to the primary grain qualities and single planting season. Therefore, further studies on the grain nutritional and antinutritional contents, suitability for making injera and development of new tef based food products should be carried out and primary grain quality and process optimization should be done.

Introduction

Tef (*Eragrostis tef*) 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. The international popularity of tef is also rapidly growing as a gluten free healthier alternative to wheat (Dekking et al, 2005 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 et al., 2012). In connection to its medicinal values, interests are growing in many countries to utilize tef for production of gluten free foods (Mekonnen 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 fibre and 2.5 % fat (Bultosa&Taylor 2004). It is composed of complex carbohydrates with slowly digestible starch (Kaleab 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 tef and its 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 (Mekonnen 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 thenutritional quality of each tef varieties might have contributed to affect the processing quality of differenttef-based food products. The general objective of this activity is therefore, to generate base line information and robust quality database for released tefvarieties. The specific objective isto evaluate the proximate and mineral composition of the released tef varieties as an index of their nutritional worth.

Materials and Methods

Materials

A total of 35 released tef varieties and a local check were grown in three locations at DebreZeit, Chefedonsa and Alemtena areas. The experiment was conducted in a randomized complete block design (RCBD) with three replication of each site. The Tef yield samples were collected from the field at all location was brought in to the laboratory for quality parameter analysis.Similar agronomic practices according to the recommendation for the area were exercised for all varieties and locations. At maturity, the grains were harvested, processed and taken to Laboratory at DebreZeitAgricultural Research Center (DZARC).

The tef grain samples were manually cleaned very carefully by sieving, winnowing, sifting and sorting with handing picking to remove the stones, foreign materials (large chaff, dusts, and soils) and other cereals.The grain samples 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

The Proximate compositions(Moisture, Ash, Crude Protein, Fat, Fiber, and Starch) of the samples were determined using the AOAC (2000) method. Moisture content was determined by drying to a constant weight at 100^{0}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 inthe tsamples was determined using the Microkjeldahl method which involved protein digestion and distillation. Crude fiber was estimated by acid-base digestion. Total fat in the sample was measured using Soxhlet extraction.Then the carbohydrate content in the samples was estimatedas 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, 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 wasdone 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 result of proximate composition of the 35 tef varieties is shown in Table 1 and 2. It was found that moisture content of the varieties ranged from 8.12-11.62%, ash content 1.60-4.14% %, crud fiber 2.57-3.99%, protein content 7.78 -14.22% and crude fat 2.64 – 3.27% %. The observed results are closely corresponding to the results reported by Bultosa 2007. Similarly, the results agreed with the mean values for nine tef varieties obtained by Bultosa and Taylor (2004):11.15 % crude proteines of, 2.5 %crude fat (3.32%crude fiber, 2.8% ash (and10.5% moisture contents. The moisture contentsoftef varieties were in a range reported for filed dried tef grains.The ash content varies due to tef grain’s proportionally high bran content (Bultosa& Taylor, 2004) (Table 2). 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.

The proximate values were statistically different ($p<.05$) among all tef varieties (Table 1). A comparison of means showed that the protein content of tef varieties ranged from 9.86-12.90% that was closer to the finding by Bultosa (2007). The local cheek variety had the highest value of protein, followed by Tseday (DZ-Cr-37), Etsub (DZ-01-3186), “Quncho(DZ-cr-387) and Mechare(ACC.205953), while Zobel(DZ-01-1821) had the least value followed by Ajora (PGRC) E205396 and Dima (DZ-01-2423).Similarly, Bultosa (2007) reported that 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) also reported the grain protein contents of 13 releasedtef varieties, which are also included in this study, ranged from 8.7 % to 12.4% with a mean value of 11.0 %.

Both tef variety type and growing location had significant ($p<0.05$) effect on the crude protein contents of the tefvarieties. This could be could be due to the genotype variations and environmental differences (soil type, climate, etc.). The mean protein content of the 35 cultivars studied lied in the range reported by earlier workers (Table 2).Generally the average protein levels of thetefcultivars studied werecomparable to that of barley, wheat, maize and pearl millet, and higher than that of rye, brown rice and sorghum(Mekonnen et al 2014). In addition, the protein type available in tef is considered as nutritionally superior because of its highlevels of amino acid profile (FAO 1970) and this makes tef to be potential ingredient for designing nutritionally enhanced foods.

Table 1. The proximate compositions of the Tef varieties at DebreZeit, Chefedonsa and Alemtena

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Variety	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	Carbohydrate (%)	Energy (Kcal/100g)
Ajora (PGRC)E205396	10.30a-d	2.42abc	9.87e	2.91e-m	3.20gfdeh	71.29a	350.81a-g
Amarech (HO-cr-136)	10.41a-d	2.47abc	11.20a-e	2.66no	3.13gfeh	70.14a-e	349.28c-g
Ambo toke (DZ-01-1278)	10.34a-d	2.24bc	11.29a-e	2.92e-m	3.12gfeh	70.09a-e	351.80a-f
Asgori (Dz-01-99)	10.44a-d	2.12bc	10.12edc	3.20bac	3.72ba	70.41a-e	350.88a-g
Boset (DZ-CR-409)	10.35a-d	2.51ba	11.20a-e	2.76l-o	3.24gfdeh	69.94a-e	349.40b-g
Dega tef(DZ-01-2675)	10.18b-d	2.25bc	11.04a-e	3.05a-h	3.27gfdeh	70.22a-e	352.45a-d
Dima (Dz-01-2423)	10.36a-d	2.28bc	9.92ed	2.96e-l	3.33gfdec	71.15ab	350.92a-g
Dukem (DZ-01-974)	10.20b-d	2.78a	10.75a-e	2.78j-o	3.36fdec	70.13a-e	348.54efg
Enatite (DZ-01-354)	10.64a-c	2.26abc	10.19edc	2.78k-o	3.52bdac	70.61-e	348.19fg
Etsub(DZ-01-3186)	9.98cd	2.27bc	12.29bac	2.82j-o	3.07gfh	69.58a-e	352.85abc
Gemechis(DZ-CR-387)	9.94cd	2.48abc	11.77a-e	2.64o	3.27gfdeh	69.9a-e	350.44a-g
Genete(DZ-01-146)	10.63a-c	2.23bc	10.96a-e	2.84h-o	3.10gfeh	70.24a-e	350.38a-g
Gerado(DZ-01-1281)	10.90a	2.39abc	12.06a-d	2.76l-o	2.98ga	68.9a-e	348.68d-g
Gibe (DZ-Cr-255)	10.11b-d	2.15bc	11.47a-e	2.81j-o	3.09gfeh	70.37a-e	352.62abc
Gimbichu(Dz-01-899)	10.73ba	2.43abc	10.38ebdc	3.00c-j	3.72ba	69.73a-e	347.50g
Gola(DZ-01-2054)	10.33a-d	2.00c	11.76a-e	3.00c-j	3.12gfeh	69.8a-e	353.24ab
Guduru(DZ-01-1880)	10.40a-d	2.27bc	10.75a-e	3.02b-j	3.31gfdeh	70.24a-e	351.15a-g
Holetta key(DZ-01-2053)	10.33a-c	2.32bac	10.64b-d	3.10a-f	3.30gfdeh	70.32a-e	351.71a-f
Kena(23-tafi -adi-27)	10.31a-d	2.27ac	10.92a-e	3.00c-j	3.31gfdeh	70.2a-e	351.44a-f
Keytena(DZ-01-1681)	10.48bdac	2.04ac	11.73a-e	3.27a	3.75ba	68.73b-e	351.25a-g
Kora (Dz-01-438)	10.15bdc	2.22ac	10.89a-e	2.71nmo	2.97h	71.03abc	352.18a-e
Koye(DZ-01-1285)	10.69ba	2.48abc	12.03a-e	2.89f-n	3.29 7642279	68.63cde	348.61d-g
Laketch(SR-R/L-273)	10.00dc	2.14bc	11.00a-e	3.0082279 a-g	3.82a	69.96a-e	351.60a-f
Magna(Dz-01-196)	10.25bdac	2.24bc	12.0 re 25 a-e				

Quncho-(DZ-cr-387)	10.7433ba	2.09^{bc}	12.26^{bac}	3.23^{ba}	3.42^{bdec}	68.25e	351.11a-g
Simada (Dz-cr-385)	10.63^{bac}	2.48^{abc}	11.04^{a-e}	2.80^{i-n}	3.07^{gfh}	69.99a-e	349.31c-g
Tseday (DZ-Cr-37)	10.7067^{ba}	2.46^{abc}	12.50^{ba}	2.96^{d-l}	3.15^{gfeh}	68.22e	349.55b-g
Wellenkomi (Dz-01-787)	10.23^{bdc}	2.37^{abc}	10.42^{b-e}	3.01^{b-i}	3.25^{gfdeh}	70.72a-e	351.64a-f
Workiye(21476A)	10.30^{bdac}	2.12^{bc}	10.57^{b-e}	2.90^{e-m}	3.35^{fdec}	70.76a-d	351.46a-f
Yilmana (DZ-01-1868)	10.28^{bdac}	2.26^{bc}	10.27^{b-e}	2.86^{h-o}	3.67^{bac}	70.66a-e	349.46b-g
Ziquala (Dz-cr-3587)	9.92^{d}	2.27^{bc}	10.89^{a-e}	2.97^{d-l}	3.73^{ba}	70.23a-e	351.17a-g
Zobel(Dz-01-1821)	10.62^{bac}	2.23^{bc}	9.86^{e}	2.84^{h-o}	3.21^{gfdeh}	71.24ba	349.96a-g
Local cheek	10.20^{bdc}	2.17^{bc}	12.90^{a}	3.06^{a-h}	3.35^{fdec}	68.33de	352.44a-d
Lsd	0.661	0.49	2.19	0.23	0.35	2.51	3.84
Location							
DebreZeit	9.77^{C}	2.84^{A}	10.99^{B}	3.01A	3.12C	70.27B	352.09A
Chefedonsa	10.92A	1.93C	10.02C	2.95A	3.31B	70.98A	349.27B
Alemtena	10.42^{B}	2.11^{B}	12.43^{A}	2.87B	3.51A	68.85C	351.01A
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 letters stand for comparison between the varieties, while the upper case letters stand for comparison between growing locations.

Statistical analysis revealed significant differences ($p < 0.05$) in the crude fat content scoresfor the tef varieties.The minimum value 2.67% was found in Gemechis (DZ-CR-387), while the maximum value was that of Keytena (DZ-01-1681) (3.27). Bultosa (2007) has reported that crude fat content of 13 tef varieties ranged between 3.0–2.0 % with mean of 2.3 %, which is similar to this report (Table 2). According to Bultosa (2007), the highest crude fat was for DZ-Cr-82 (3 %) and the lowest values were observed inDZ-01-1681 (2 %) and DZ-Cr-37 (2 %). The crude fat content of tef grain, in general, is higher than that of wheat, rye, and brown rice but lower than that of barley, maize, sorghum and pearl millet (Mekonnen et al, 2014). Growing location also had significant ($p<0.05$) effect on the crude fat content of the cultivars where the tef cultivars grown in Alemtena (2.87%) exhibited significantly lower mean protein content than those grown in DebreZeit (3.01%) and Chefedonsa (2.95%) which did not show appreciable variations among themselves.

Crude fiber contents of the varieties were also dependent on variety type and growing location (Table 1). Accordingly, the highest value was found inLaketch (SR-R/L-273) while the lowestvalue was measuredin Kora (DZ-01-438). The mean ash contents of the tef cultivars grown in the three locations varied in the order: DebreZeit (3.12%) <Chefedonsa (3.31%) <Alemtena (3.51%). Bultosa (2007) reported that the crude fiber in the 13tef varieties ranged from 3.8–2.6 % with mean 3.3 %.

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. Effect of growing location was also important ($p<0.05$) making the mean values of the grains to vary as: Alemtena (68.85%)<DebreZeit (70.28%)<ChefeDonsa

(70.98%).Previous studies showed that like othercereals tef is predominantly starchy; the approximately starch reach about 73 percent (Bultosa,2007; Baye, 2014). The energy values of the 35 tef varieties were significantly ($p<0.05$) dependent and ranged from 347.50Kcal/100gfor Gimbichu (Dz-01-899) to 353.45 Kcal/100g for Magna (DZ-01-196) (Table 1). However, effect of growing location was not as such important on the mean energy value scores of the tef grains obtained from the three growing locations. 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 2).

In general, significantly higher crude protein and ash contents as well as significantly lower and carbohydrate was recorded for tef grains grown at Alemtena. This might indicate that the tef cultivars grown at Alemtena were smaller and this could be caused by time shortage during grain filing stage (Bultosa, 2007).

Table 2. 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 (%)	8.12-11.62	10.37	10.5	8.82
Crude protein (%)	7.78-14.22	11.15	11.0	13.30
Crude fat (%)	2.42- 3.38	2.95	2.5	2.38
Crude fiber (%)	2.57-3.99	3.32	3.0	8.0
Ash (%)	1.60-4.14	2.30	2.8	-
Energy (kJ/100 g)	345.17-357.40	350.79	357	367
Calcium (mg/100 g)	103.70-173.50	138.69	165.2	180
Iron (mg/100 g)	14.92-23.43	17.16	15.7	7.63
Zinc (mg/100 g)	2.07-5.16	3.43	4.8	3.63

Mineral composition

Tef variety type had significant ($p<0.05$) on all the measured mineral contents of the cultivars (Table 3). Fe contents in the brown tef varieties like Asgori (DZ-01-99), Holetta key(DZ-01-2053) and Keytena(DZ-01-1681)were comparatively high, while those in the whitetef 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. 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 Kcontents of the tef cultivars between 275.54(mg/100g) for Mechare (ACC.205953) to 375.94(mg/100g) for Gola(DZ-01-2054).Except on Ca content, growth location had significant ($p<0.05$) effect on the measured mineral contents of the tef cultivars. Results in this study were more or less comparable with earlier wre comparable with earlier works (Table 2). Review by Baye *et al.* (2014) indicated wide differences in mineral content in the tef varieties. As observed in this study, earlier studies showed that red tefhad higher iron and calcium content than mixed or white tef (Abebe *et al.* 2007). Previous evaluationby Ketema (1997) on 12 genotypes of tef grown in different agro-ecologic settings also revealed that genetic and environmental factors affected the iron content of tef.

Table 4. The mineralcomposition of tef varieties

No.	Tef variety	Fe (mg/100g)	Zn (mg/100g)	Ca (mg/100g)	K
1	Ajora (PGRC)E205396	16.19^{y}	2.84^{x}	136.67^{e-k}	313.34^{ba}
2	Amarech (HO-cr-136)	17.52^{n}	3.57^{m}	128.02^{h-m}	360.19^{ba}
3	Ambo toke (DZ-01-1278)	16.37^{w}	2.77^{y}	152.02^{bcd}	346.91^{ba}
4	Asgori (Dz-01-99)	23.58^{a}	4.69^{a}	170.14^{a}	304.55^{ba}
5	Boset (DZ-CR-409)	15.76^{z}	3.24^{q}	152.72^{bc}	340.24^{ba}
6	Dega tef(DZ-01-2675)	18.95^{g}	3.94^{g}	147.87^{b-f}	342.08^{ba}
7	Dima (Dz-01-2423)	19.3^{e}	4.00^{f}	155.52^{ba}	354.48^{ba}
8	Dukem (DZ-01-974)	18.16^{j}	3.67^{l}	136.72^{d-k}	326.01^{ba}
9	Enatite (DZ-01-354)	15.93^{z}	3.74^{j}	116.52^{m}	351.13^{ba}
10	Etsub(DZ-01-3186)	17.47^{o}	2.87^{w}	118.06^{lm}	301.2^{ba}
11	Gemechis(DZ-CR-387)	16.85^{s}	3.47^{n}	144.22^{b-g}	325.74^{ba}
12	Genete(DZ-01-146)	15.87^{z}	3.94^{g}	134.47^{f-k}	291.03^{ba}
13	Gerado(DZ-01-1281)	17.18^{q}	3.84^{i}	139.02^{c-j}	332.44^{ba}
14	Gibe (DZ-Cr-255)	19.25^{f}	4.17^{e}	143.87^{c-g}	349.17^{ba}
15	Gimbichu(Dz-01-899)	16.51^{v}	3.90^{h}	127.24^{i-m}	374.83^{a}
16	Gola(DZ-01-2054)	17.58^{m}	2.64y	143.97^{b-g}	375.94^{a}
17	Guduru(DZ-01-1880)	18.19^{i}	3.40^{p}	124.02^{jklm}	290.03^{ba}
18	Holetta key(DZ-01-2053)	22.23^{b}	4.50^{b}	140.37^{b-i}	342.48^{ba}
19		17.45^{o}	3.14^{r}	138.92^{c-j}	301.29^{ba}
20	Keytena(DZ-01-1681)	21.87^{c}	4.37^{c}	124.47^{j-m}	360.44^{ba}
21					

Conclusion

The findings of this study showed that the released tef varieties could be good sources of protein, fat, fibers, and minerals. However, the effects of variety and growing location were found to be important that could dictate the functional property, processing quality and nutritional content of the cultivars. As this study considered almost all the cultivars released up to the year 2017, the information generated can

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