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Nutritional and Soio-Cultural Values of Teff (*Eragrostis tef*) in Ethiopia

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Abstract
This paper focuses on the nutritional, socio-economic, and cultural values of Ethiopian indigenous crop, teff (*Eragrostis tef*). Teff is a prestigious cereal crop from which the Ethiopian staple food, *injera* is made. Two distinct teff varieties, *kuncho* and *key-teff* representing the white and red/brown varieties respectively, were analyzed for their nutrient compositions. The white varieties in general have higher market price, social and cultural values. The red varieties are considered to be more nutritious especially in rural areas. The nutrient composition of the two varieties in this study confirmed that *key-teff* (red variety) is superior to *kuncho* (white variety) in most minerals and essential amino acids. This crop has high socio-cultural values in Ethiopia but it is relatively low yielding. Ensuring sustainable production of teff requires improving its productivity, efficient domestic use, and promoting its international market values.

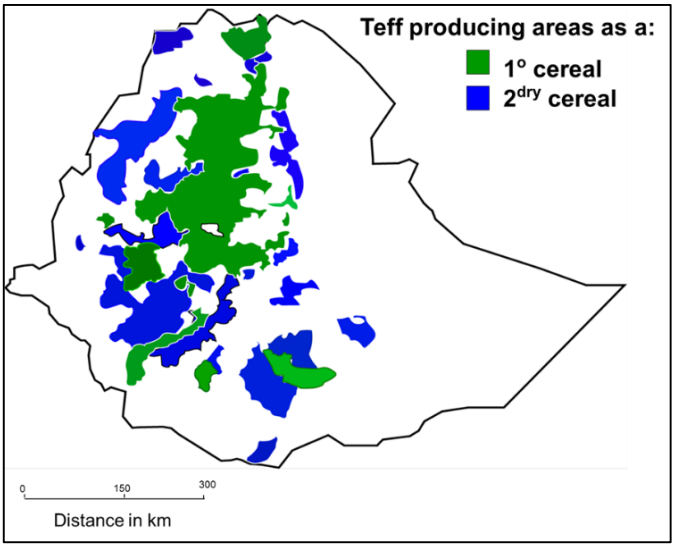
Keywords: ethiopia, nutritional value, socio-economic, teff, varieties

1. Introduction

Teff (*Eragrostis Tef*) is a cereal crop of *Poaceae* or *Gramineae* family with small grains. It is believed to have originated in Ethiopia between 4000 and 1000 BC [1]. Teff seeds were reported to be discovered in a pyramid which is thought to date back to 3359 BC [1]. It is a primarily cultivated cereal crop in Ethiopia with high market price and socio-economic values. Its center of origin and diversity is Ethiopia [2-4]. There are approximately 350 species of *Eragrostis* consisting of annuals and perennials, which are found over a wide geographic range [1]. Zewudu [5] mentioned that they are also produced in other countries such as USA, Canada, Australia, South Africa, and Kenya for different purposes like forage crop and a thickener for soups, stews, and gravies. Nowadays, the chemistry and physical characteristics of crops are well understood because of new analytical techniques [6]. Gamboa and Ekris [1] stated that a lot of scientists from developing countries are recently trying to offer new food products to satisfy nutritional needs.

Scientists are interested to know about the composition of teff because of its socio-cultural, market values, high preference, good nutrient compostion, and being gluten-free. As an evidence for the good nutritional quality of teff, some researchers mentioned the resistance and general good fitness of Ethiopian sportspeople. The nutritional properties, and the changes that happen during grain fermentation for preparation of *injera*, a flat bread that is responsible for about 70% of the Ethiopian population also received concern; many universities from Ethiopia and other countries, and privates companies are working on this crop to make it a "golden grain" [1].

More than 32 varieties of teff have been well characterized by the teff research program of EIAR so far. At least 35 cultivars of teff have been identified but the genetic resources of the cultivars and related wild species were largely untapped [7]. On the other hand, Davison [8] reported nearly 4,000 varieties or cultivars of teff have been identified in Ethiopia. The United States Department of Agriculture's (USDA), Agriculture Research Service Plant Germplasm Introduction and Testing Research Station (PGITRS) reported to have nearly 400 numbered teff cultivars. The number of varieties aforementioned by Davison and PGITRS are too many based on EIAR. The ecological ranges of production and productivities of the varieties were described by EIAR. The teff producing areas in the country as a primary and secondry cereal are indicated in Fig. 1 below.



***Source*:** Atlas of the Ethiopian Rural Economy 2006

Fig 1: Teff producing areas of Ethiopia as a primary and secondary cereal. Source: Atlas of the Ethiopian rural economy [9].

The typical Ethiopian staple food, injera is a thin pancake made from fermented dough of teff flour. It dominates the daily meal of most Ethiopians in the cities, central, and northern parts. Other food like alcoholic drinks such as *tella* (local opaque beer) and *katikalla* (local spirit), hot drinks like *atmit* (gruel), and *kitta* (unleavened bread) can be made from teff flour [10]. This ancient grain, small in size (≤0.002 g) is nutritient rich with a protein

content ranging from 10 to 12%, and high in iron and calcium [1, 11]. It is known to have excellent amino acid composition with lysine levels higher than wheat or barley and totally gluten free [6, 12]. It has high levels of minerals and important source of water soluble vitamins [13]. In contrast to most cereals crops, teff was reported to contain vitamin C and is typically good in its fiber and starch levels [12]. Amino acid analyses of some teff varieties were done by Jansen *et al*. [14] but they used few samples of unidentified varieties of teff bought from markets, hence the data has little value for plant breeding and other studies [7]. Teff varieties have different market and socio-cultural values. The higher consumer preference of white teff may justify why it is the most expensive type. Recently, some health conscious Ethiopians are preferring red teff [15]. The samples of 19 teff varieties shown in Fig. 2 were obtained from Holetta Agricultural Research Center (HARC).

(A)

(B)

(C)

Fig 2: Teff varieties. Some of teff panicle colors at ripening stage (A). Matured and ready to hartvest stage of kuncho and key-teff at HARC experimental station (B). The grains of teff varieties varying in color (C).

Despite the aforementioned nutritional facts and health benefits of teff, there are various shortcomings in its production. Some of the major ones are: low productivity, laborious production at all stages, and its need for large doses of commercial fertilizers. Therefore, the chances of teff continuing as a primary and secondary cereal or as a dominant daily meal of Ethiopian poor farmers is doubtful. On the other hand, there are good attempts and promising teff breeding schemes and agronomic practices improving its productivity. Teff production in the country will be sustained if it continues to be high value crop with better demand in the international markets. In such cases, the farmers will get good financial power to produce the crop in a better way and use alternative, productive cereal crops as families' daily food. Teff varieties have greatly visible morphological differences and there are some reports on their nutrient variations. Hence, this study is aimed to study the nutrient compositions and socio-economic differences of teff varieties.

2. Methodology

The samples of teff varieties and various information were obtained from teff research program of Holetta Agricultural Research Center (HARC), Ethiopian Institute of Agricultural Research (EIAR) in April - May 2014 and December 2014 - January 2015. The majority of the varieties were released by Debrezeit Research Center (DARC) and some by HARC. The teff samples where ground to 0.5 mm size and brought to Kyoto University, Japan for detail nutritional analysis.

The pulverized teff grain samples of two distinct varieties, white (DZ-Cr-387, *kuncho*) and red (DZ-01-1681, *key-teff*) were sent to Japan Food Research Laboratories (JFRL) for reliable nutrient composition analysis. *Kuncho* is the top preferred variety with high relative market price and productivity while *key-teff* was taken as a representative of red/brown teff varieties because of its productivity and wide areas of adaptation. However, this doesn't strictly mean that these varieties are the reperesentatives of the white and red varieties. Main nutritional qualities: carbohydrate, protein, fat, fiber, minerals, and some vitamines of these varieties were analyzed. The nutritritional values of the teff varieties are discussed in comparision with the world most common cereals. Some of the important nutrients were also compared against, the popular gluten-free cereal, quinoa.

3. Results and discussion

3.1 Teff production in Ethiopia

The cultivation of teff as a major cereal crop in Ethiopia was started thousands of years ago. As mentioned in the Introduction, some researchers have indicated that teff production in Ethiopia has a history of more than 4000 years. Teff is a primarily cultivated cereal crop in Ethiopia with high market price and socio-economic values [1]. Ethiopia is the center of origin and diversity of teff. In Westphal [16] it was stated that many researchers reported teff to be a cereal of Christian Ethiopians, although it gains importance among many Oromo and Sidamo [17-19]. Religion, however, doesn't entirely base on ethinicity and the production of crops is determined by environmental factors and food cultures instead of religion and ethinic group.

Teff was estimated to account for 16% of cereals grain production and cultivated on 2.7 million hectares based on Ethiopian Central Statistics Authority [20]. In the central, northern, and western parts of the country, it is the staple food [21]. Teff is a high-status cereal crop and a family who do not depend on teff as a daily food is considered poor in these parts of the country. The main reason behind such attitude is the long historical, socio-economic, and cultural values of teff developed by the society. *Injera* from whatever crop is the most common form of food in the central and north part of Ethiopia. Many people do not like *injera* made from other cereals such as wheat and barley as they lack the required organoleptic properties of *injera*. In a number of cases, families sell other cereals for cheaper prices and buy teff for food when they have enough cereals. Many Ethiopian people are very comfortable with the taste of teff *injera* than any other food.

3.2 Teff varieties and agronomy

Agronomy is a wide field of crop production but only the practices partinient to teff production are mentioned in this section. The number of well-characterized and released teff varieties by EIAR are close to that was reported by Lester and Bekele [7]. However, the number of varieties reported by Davison [8] is much higher than that of EIAR. Reasonably, only the well described varieties in Ethiopia by EIAR were considered for discussion in this study. The varieties considered vary in color from ivory white to deep brown as in Fig. 2.

The teff varieties were developed through selection from landraces and cross-breeding schemes targeting various merits for different agro-ecologies. Their productivities and favorable environmental conditions also vary greatly. Many environmental factors associated with altitudinal ranges can affect the productivity of the varieties. However, the seed color, market values, and the purpose for which it is produced is worth considering in addition to the productivity. The different varieties have their own merits like ecological adaptation, water or disease resistance, and duration of maturity. Researchers of teff in EIAR have been studying and recommended appropriate varieties to specific environmental conditions where they fit best. Depending on their respective flour or grain color, the final product, *injera* also takes the color of the teff grain they are made from (Fig. 3).

Fig 3: *Injera* made of red and white teff varieties. The left one is from red variety, the middle is from white variety, and on the right is the mixture of white and red rolled and cut *injera*.

In general, teff demands higher doses of recommended commercial fertilizers (100 kg/ha DAP, and 50 kg/ha urea depending on soil conditions) relative to other cereal crops though closer fertilizer rate is being used for wheat production nowadays. The seedbed preparation of teff is labor intensive because of its tiny seed size. Until very recently, crop weeding in Ethiopia was manual, by hand and teff weeding is time consuming and requires care. In spite of these facts, it is less productive than other common cereals. The maximum productivity reported so far was 35 quintal/ha (DZ-01-1278, *Ambo Tokey*) on research station. However, there are higher oral and media reports by Ethiopian Agricultural Transformation Agency (ATA) through improving teff agronomic practices like row planting. Conversely, the least productive teff variety with

only 13 quintal/ha on station is HO-Cr-136 (*Amarach*), which is tolerant to low precipitation and mid-altitude type variety. The most productive variety, *Ambo Tokey* is optimally adapted to high altitude. Many of the high yielding are mid and high altitude varieties, which can be suitable to use in combination with other high land prennial crops like enset.

Because of the low productivity of teff compared with other major cereal crops like wheat, barley, and maize, it is doughtful that it will keep as a staple food for the large proportion of the rapidily increasing population of the country. Therefore, serious attention needs to be given to further improving its productivity, processing for efficient domestic use and world market for good price.

3.3 Socio-economic values of teff and teff varieties

Various crops (cereals, pulses, perennial, root, oil, and cash crops) are cultivated in Ethiopia. Teff is a dominant crop with high socio-cultural values and high price among cereal crops considered as a formal and acceptable family food in the cities, central, and northern part of the country. It is a prestigious crop that can be served to guests on special occasions like weddings where *injera* from other cereal crops is not customary. The type of teff varieties from which *injera* is prepared also has great implication with the white color varieties are preferred. "Varieties" in this context is used to diffrenciate based on their grain color. The color of *injera* broadly shows the type of teff varieties as aforementioned. It is an indicator of the economic condition of the family. The whitest varieties are most appreciated irrespective of their nutritional compositions. A family depending on red varieties change to white varieties by selling the red/brown types in case where a guest is expected or in case of special ceremonies. This actually varies depending on the food culture of the community for instance, in the southeast foods from barley and wheat, and in southwest part of the country *Kocho* (*Ensete ventricosum*) is used instead of teff.

Teff, is therefore, an indicator of a family's economic status because it is relatively consumed more by the rich than by the poor. The less consumption by the poor is partly explained by the high market prices of teff which are about twice of the cheapest cereal, maize [22]. The current teff price in Addis Ababa, the capital varies from 1,800 birr/quintal for the whitest variety to 1,500 birr/quintal for the red varieties, the same price as wheat grain (per. comm., Dec., 2014). Physical appearance, aroma, and impurities are often used to judge the quality of teff [23]. Among the white varieties, *kuncho* and *magna* are the top preferred with high price. *Kuncho* has wider range of ecological adaptation and higher in productivity and hence, is the most appreciated variety in the apposite ecologies. From the red or brown varieties, key-teff has comparable productivity to kuncho and shorter maturity time. Therefore, kuncho from the white varieties and key-teff from the red varieties were evaluated for their dependable nutritional composition. It would have been great considering all the varieties but difficult to handle because of the analytical cost. We recommend consideration of the nutritional quality evaluation of all the varieties during their agronomic and breeding screening schemes.

3.4 Nutritional qualities of teff varieties

A food with good nutritional value refers to that composes of most essential nutrients in a fairly balanced manner. The nutrient composition variations may be derived from either of genetic or environmental factors. However, there are no comprehensive studies on the nutrient composition variations of teff varieties. White teff is preferred for making *injera*. However, farmers in the rural areas and elderly believe that red teff is better in nutritive values than the white varieties. Hence, unfermented red teff grain bread is used to supplement weakened and emaciated animals traditionally.

Many foods are rich in some and scanty or totally devoid of other nutrients hence, classified as energy foods, protein foods, etc. Teff grain has very good nutritive value, with a grain protein content, 10-12% [1] though others reported up to 14%. Sadik *et al*. [24] reported even lower protein content (10.7%) of teff grain sample, DZ-01-2423 variety. In this study the protein content of both kuncho and key-teff varieties is 12.8% on air dried basis, which is 14.7% and 14.5% in kuncho and key-teff, respectively, on dry matter basis (db). Besides containg protein and energy, teff is a good source of minerals, particularly iron and zinc, which are the most limiting minerals in developing countries. It has very high calcium, phosphorus, copper, aluminium, barium and thiamine [25]. The proximate values (db) of teff was reported to be 9.4% - 13.3% protein, 73.0% carbohydrate, 1.98% - 3.5% crude fiber, 2.7% - 3.0% ash, and 2.0% - 3.1% fat [26]. Teff contains excellent amino acid composition and higher lysine contents than wheat or barley [13]. While the lysine content of teff (327 mg/100 g) in our study is not more than that of wheat (378 mg/100g) reported [1]. However, enough daily lysine recommended intake can be obtained from *injera* (3 *injeras* or 600 g) consumed by an average Ethiopian farmer per day.

Some scientists think that the high iron content of teff is due to contamination from iron rich soil ground on the external surface of the grains. Sufian and Pittwell [26] checked the iron content of soil free teff garins and concluded that the true iron content of the actual soil-free teff grain is about 3.3 mg/100 g. However, higher value was obtained using fresh teff from the plant, threshed in the laboratory [27]. This indicates that the iron content of teff is very variable depending on many factors such as variety and environmental conditions. Some other claim that the iron actually embedded in the grain walls also should be considered as a dietary source of iron along with the actual true iron content of the grain itself.

Despite the arguments, it has been proved that teff grain has high iron composition. One point is that not all soils of teff growing areas are ferruginous and the other point is only small portion of bulk teff is contaminated with soil even in traditional threshing style. The threshing grounds are made with care to avoid soil contamination by sealing with animal dung and teff straw mixture. In research stations, teff is harvested and threshed with care not on a ground and hence, low chance of soil contamination but still teff is reported with high iron content. The nutrient compositions analysis result of the representative teff varieties are shown in Table 1 below.

From the nutrient analysis in Table 1, both teff varieties have virtually similar proximate (moisture, crude protein, fat, total ash, carbohydrate, fiber, and energy) compositions. The *key-teff* has better compositions of minerals and essential amino acids and generally tends to be slightly better even in carbohydrate, fiber, and energy contents. This clearly indicates that the speculations and over years observations of farmers' that red/brown varieties are nutritious than the white varieties is scientifically reasonable. On the contrary to the current market price and social values, red/brown teff varieties should have higher values because of its better nutrient composition.

Table 1: Comparative nutrient compositions of teff varieties (kuncho and key-teff).

Category	Nutrient	Kuncho (DZ-Cr-387)	Key-teff (DZ-01-1681)
		(g/100 g)	
	Water	12.9	11.5
Proximate	Protein	12.8	12.8
	Fat	3.2	3.0
	Ash	1.9	1.9
	Carbohydrate	61.6	62.5
	Fiber	7.6	8.3
	Energy	342 kcal	345 kcal
		(mg/100 g)	
	Sodium	1.9	1.4
Minerals	Phosphorous	270	291
	Iron	18.7	20.6
	Calcium	117	140
	Potassium	438	403
	Magnesium	156	158
	Copper	1.01	1.11
	Zinc	4.05	4.28
	Manganese	15.8	18.0
	Lysine	327	338
Essential	Histidine	270	291
Amino acids	Phenylalanine	653	649
	Leucine	891	977
	Isoleucine	412	463
	Methionine	456	461
	Valine	585	626
	Threonine	492	491
	Thiamine (B1)	0.83	0.57
Vitamines	Riboflavin (B2)	0.11	0.12

This composition is on the not on DM basis, it is on the basis of air dried sample flours.

However, these two varieties may not exhaustively represent the white and red teff varieties. *Kuncho* is superior in potassium, tyrosine, and thiamine (B1) while the riboflavin (B2) compositions of both representative varieties are almost similar. These teff varieties were sampled from HARC, which were cultivated on the same plots of experimental field and hence, the nutrient variations drived from environmental factors are very minimal. The difference in mineral content among teff varieties is wide ranging. Red teff has a higher iron and calcium content than mixed or white teff [28], which is in agreement with our result. Ketema [29] analyzed 12 genotypes of teff grown in different agro-ecologies grown in greenhouse and reported that genetic and environmental factors affect the iron content of teff. This may explain the mineral content variabilities in different studies.

Tarditionally, teff grain flour dough is fermented before making *injera* for its preferred taste and palatability except for people who have gastric problem to eat sour or fermented foods. Fermentation of cereals is a potentially important processing method that can be expected to improve the nutritive value such as bioavailability of nutrients. Certain anti-nutritional factors like phytates, protease inhibitors, and flatulence factors can be reduced through ferementation [1]. Interms of the daily nutrient requirement, *injera* provides quite substantial level of nutrients. Usually, *injera* is prepared two or three times a week and stored until needed in cities while it is made everyday in the rural areas mostly. A person eats two to four pancakes of *injera* a day [19, 30, 31] and an *injera* of 12 inch diameter is about 200g [32]. According to Daily Recommended Intake (DRI) the daily energy requirement for hard working people like Ethiopian farmers is about 3,550 kcal considering 2.20 PAL [33] and protein about 0.8 g/kg of bodyweight. Therefore, a farmer gets 2,061 kcal energy (686 kcal/*injera*) and 76.8 g protein, which constitutes 58% and 148% of daily energy and protein requirments (for 65 kg adult person), respectively from 3 *injeras* in a day. Kebede [34] reported that 1929 kcal energy from *injera* and 554 kcal, from stew (*shiro wot*) providing enough daily maintenance energy requirement for a middle class farmer during low PAL. However, it is usually eaten with a highly nutritious stews containing oil or butter, onion, garlic, different spices, and protein from beans or meat. In the stews, they add significant amout of salt (NaCl) leading to aboundant intake of sodium.

The nutritional profile of teff is very good compared to other cereal crops specially in essential amino acids and mineral compositions. Nutritional studies have been undertaken on teff varieties by different institutions and researchers so far. However, detail comparative studies under similar lab conditions for almost all released teff varieties has never been done. It has an excellent balance of the essential amino acids except for lysine, so that lysine supplementation e.g. by fenugreek could considerably improve its lysine content; perhaps, other protein-rich Ethiopian pulses may also be considered for this purpose [35]. On the contrary, it was reported by Lewis [12] and Stallknecht *et al*. [6] that teff has significantly higher level of lysine than other cereal crops. In our study, it was found to contain 327 mg/100 g and 338 mg/100 g of kucho and key-teff, respectively. This level is almost similar to the lysine contents of other common cereals and enough daily lysine requirement can be obtained from three teff *injeras* as shown in Table 3.

Teff was proved to be gluten-free grain like quinoa. Quinoa was recognized by UN General Assembly because of its good nutritional value and contribution to food security and the year 2013 was consigned as an an international year of quinoa (IYQ) [36]. Its adaptation to wide ecology and unique nutritional quality were also underlined [37]. The DM contents of teff (87.8%) is similar to that of quinoa (88.7%) their crude protein and total mineral (ash) contents are also similar as indicated in Table 2. In almost all the minerals analyzed, quinoa is much better than rice, one of the world most common cereal crop. However, teff is superior to quinoa in mineral compositions. There are some indications that Ethiopia's teff poised to be next big super grain, which may get recognition. It is visible from Table 2 that teff and quinoa have similar crude nutrient compositions though teff has higher mineral, protein, and amylose contents. The government of Bolivia and nutritionists highly contributed for introducing this healthy and nutritious crop, quinoa to the world. Such positive efforts in bringing optional and healthy foods to the world should be appreciated so that people will have free choices. Not only introduction, facilitation, and availing to the world is very essential.

Table 2: Comparative proximate and mineral contents of teff with quinoa and rice.

Parameter	Quinoa * (*Chenopodium quinoa*)	Teff (Kuncho) (*Eragrostis tef*)	Teff (Key-teff) (*Eragrostis tef*)	Rice* (*Oriza sativa*)
Proximate	**g/100 g**			
Moisture	11.3	12.9	11.5	13.1
Ash	2.0	1.9	1.9	0.4
Protein	12.1	12.8	12.8	7.1
Fat	6.3	3.2	3.0	0.6
Fiber	10.4	7.6	8.3	1.5
Starch	57.2	61.6	62.5	76.8
Amylose	19.7			29.2
Minerals	**mg/100 g**			
Copper	0.6	1.01	1.11	0.1
Manganese	2.0	15.8	18.0	0.8
Iron	5.5	18.7	20.6	0.2
Zinc	2.9	4.05	4.28	1.0
Magnesium	197	156	158	27
Calcium	44	117	140	-
Phosphorus	468	270	291	107
Potassium	664	438	403	91

* Source [36]

Quinoa contains higher total fat and fiber and significantly lower mineral contents accept phosphorous and potassium than teff (Table 2). Neverthless, their nutritional composition studies were conducted in different labs with different precisions and the possible descripancies arising is somehow expected. According to Schlick and Bubenheim [38], because of its high protein content particularily lysine and sulfur containing amino acids, NASA considered quinoa as an appearing crop with good nutrient composition for space missions. In view of sulfur containing amino acids (methionine and cysteine) teff is superior though quinoa contais higher lysine. Teff is better in most of essential amino acids composition as shown in Table 3 compared with other cereals reported by Nascimento *et al*. [36]. Hence, teff can be an alternative good food for NASA offering additional advantages. Lysine is a limiting indispensable amino acid in most cereal crops. However, 102% of daily lysine recommended intake can be obtained from 600 g of *injera* though quinoa contains twice of teff.

Table 3: Comparative essential amino acids (mg/g protein) compositions of (teff) and quinoa.

Amino acids	Quinoa*	Teff flour	ADA 65 kg (mg)***	Available in 600 g teff (mg)
Histidine	25	23	650	1766
Leucine	64	76	2535	5836
Isoleucine	37	36	1300	2764
Lysine	51	26	1950	1996
Methionine	21**	36	975 (Met + Cys)	2764
Phenylalanine	74	89	1625 (Phe + Tyr)	6836
Threonine	30	38	975	2918
Valine	45	49	1690	3764

* Ruales and Nair [39] **Methionine + Cystein *** FAO/WHO/UNU [40]

The 600 g teff in this table was considered to be the average daily intake of *injera* by a medium farmer in Ethiopia. One *injera* is about 200 g and three *injeras* is an average daily consumtion considered. The values for teff flour in the table are the average of kuncho and key-teff compositions.

Every product that can be made from wheat can also be made from teff [1]. Some additional ingredients may be required to increase its viscosity and elasticity to make some food products like spagetti. Teff has a lot of fanatic Ethiopian sportsmen consumers [41]. Some assume that teff products are not only gluten-free but also help consumers to control their weight and the body to well fit for life. In athletics, this may be possible because teff has high iron content, which makes the haemoglobin and carry more oxygen in the blood [1]. This may however entail an argument that iron supplementation can help sportsmen especially in athletics.

Gamboa and Eriks [1] recounted that teff *injera* has evidently high iron content than other Ethiopian foods, but it also contains high phytic acid and there is a big reduction in the ratio of phytate:iron ratio during fermentation; in teff, this ratio reduced by 4 times. The seed coat of cereals and legumes contains substancial amount of phytic acid [21]. This forms non-metabolizable complex and hinders the absorption of iron and zinc [42]. Copper and manganese are the other minerals of nutritionally important minerals chelated by phytate [43, 44]. The lower phytate:iron ratio of *injera* may be the reason for the promotion of fermentation by Ethiopian nutritionists [1]. Eventhough the nutritional bioavailability changes as a result of fermentation is not well understood, Ethiopians culturally prepare *injera* from fermented teff dough because of its prefereable taste.

3.5 Health benefits of teff

Most Ethiopians hardly suffer from diseases like anemia, osteoporosis, and diabetes (Gamboa and Eriks 2008). Some scientists do connect this to the consumption of teff as a daily diet. Some researchers believe that the bioavailablity of iron in *injera* contributes more than the iron content of teff for the less incidence of anemia in Ethiopia [11]. Among Ethiopian foods, teff *injera* was found to be the best bioavailable source of iron because of low phyatate:iron ratio rather than its high iron content [21]. The two most often deficient micronutrients in developing countries are iron and zinc. The deficiency of iron is caused not only by phytate but also tannins in the diet or low iron content of foods, which is important cause of nutritional anemia that emanates from the low bioavailability of non-haem iron [45]. This indicates that teff *injera* particularly fermented *injera* plays great role in reducing nutritional anemia.

Gluten-free and nutritious cereals can be a good alternative diet for celiac disease patients though it was thought that wheat treatment was the best possibility to be considered. Clinical

studies are required to prove the safety of other cereals, which otherwise may be harmful [1]. The debate continues on the acceptability of other cereals such as buckwheat, amaranth, quinoa, and teff [46] According to Gambeo and Eriks [1] this subject can be considered broadly in food processing, nutrition, and health project. A lot of adversaries may arise by people affliated to wheat flour industry on the use of teff and other grains such as quinoa, buckwheat, amaranth, and oats for different food products. Many gluten-free cereal foods can be made from these crops without requiring enrichment. Teff, a nutrient dense crop with can thus be a good alternative nutritious food for people with celiac disease [1].

As discussed in the previous sections, teff contains good amount of minerals and fiber. High mineral contents of teff indicates its importance in various metabolic and body functions as some of them are cofactors of enzymes and essential for bone development and resistance to osteophorosis. Teff is more nutrient-dense compared to other gluten-free cereals [47, 48]. Moreover, there is high incidence of diabetes in people with celiac disease and teff may help in maintaining the glycemic control in suh cases because of its low glycemic index [49].

4. Summary

Teff is an ancient indigenous cereal crop cultivated in Ethiopia. There are many teff varieties, with special merits for production in different agro-ecologies. They greatly vary in productivity, morphology, nutrient compositions, and socio-economic values. Traditionally, the quick and usual method of judging the quality of teff is based on its grain color and purity. The whitest grain color varieties are considered superior and have high market prices. Ethiopians have a long history and many cultural practices associated with teff production and feeding. The nutritional quality analysis of the top socio-economic value white variety (*kuncho*) and the red variety (*key-teff*) showed that the nutrient composition of key-teff is better specially in minerals and essential amino acids. Teff is better in nutrient composition than quinoa, the world known gluten-free cereal. It is gluten free and can completely substitute wheat for all kinds of foods. It has many health benefits in preventing anemia, diabetes, osteophoresis, and celiac diseases. However, it is low in productivity than other cereals and its production is laborious at all stages. This negatively affects its futurability as a primary or secondary cereal in the country. Hence, its efficient domestic use must be emphasized and also needs to be processed to the world standard and as an alternative, healthy, and nutritious food.

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