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Quality traits; measurement and possible breeding method to improve the quality traits of tef [*Eragrostis tef* (Zucc.) Trotter]

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Abstract: **Tef may be a resilient crop that performs higher than different cereals underneath native conditions together with drought, water-logging, and poor soil. Genotype versus straw quantity and quality continuous efforts has been created to develop improved styles of tef for grain production. However, the breeding programs primarily geared toward improvement of grain yield with very little thought for yield and quality of the straw. Tef injera is that the commonest and therefore the main staple food in abundant of the central, western and northern highlands ofEthiopia furthermore as among the urban community. Tef may be a terribly nutritive cereal grain with glorious supermolecule, supermolecule and mineral contents. The organic process content of the grain is usually equivalent to that of the key world cereals like wheat, barley, rice, maize and sorghum. In fact, it's superior in several aspects significantly in minerals like iron, calcium, Mg and Zn. Starch accounts for regarding seventy-three of the tef grain; thence, it plays a dominant role in influencing the top properties of varied tef grain product. The average protein content in the tef grain is about 11% which is higher than in maize but comparable to that of wheat. The crude fat in tef grain is equivalent to that of wheat and is less than in maize, sorghum and millets. Each the grain and soured product from tef are recognized to possess high mineral contents compared to the grains of different cereals as a result of tef is consumed as whole grain and sometimes soured as injera. Health good thing about tef injera consumption is advantageous for Anemia, Diabetes, Celiac and Osteoporosis Disease. Farmers are mistreatment tef straw as feed since the beginning of tef cropping with all the restrictions related to its use. Tef breeding up to now has targeted totally on breeding and on up science practices. Applied breeding work to boost tef enclosed direct choice from the landraces, inter-specific and intra-specific cross and mutation breeding, whereas at the fundamental analysis level investigations were created within the space of biotechnology. This paper reviews quality traits and measurement, and possible breeding method to improve the quality traits of tef.**

Keywords: **quality, injera, breeding, tef.**

1. INTRODUCTION

Tef [*Eragrostis tef* (Zucc.) Trotter] is associate degree allotetraploid (2n=4x=40), small cereal grain crop that belongs to the family Poacea, sub-family Eragrostoideae, tribe Eragrostidae and genus eragrostis (Seyfu, 1997). it's the foremost vital cereal crop within the Horn of Africa particularly in Ethiopia, wherever the last twenty years have shown tremendous will increase in each the full space dedicated to the crop and its production. Tef may be a staple food supporting some fifty million people in Ethiopia. Ethiopia is that the center of diversity and origin of tef (Vavilov, 1951).

Currently, the crop is more and more receiving world attention for its nutritional benefits as a result of it's wealthy in nutrients and is gluten free. It contains eleven percent protein, eightieth complicated carbohydrates, three percent fat (Piccinin, 2002). Tef has become globally glorious and numerous products are out there in Europe and North America as health foods particularly for persons with gluten intolerance (Saturni et al., 2010). Recently, some levels of tef cultivation have started within the USA, the Netherlands and Israel. Tef straw is additionally a valuable supply of eutherian feed. In African country, India, Pakistan, Uganda, Republic of Kenya and African country tef is principally adult as a forage or pasture crop (Kebebew et al., 2011). curiously, in contrast to different cereals, tef is small laid low with field and storage pests and diseases (Seyfu, 1997). Both tef and finger millet are glorious to be tolerant to extreme environmental condition and soil conditions; therefore, they're favorite crops in semi-arid areas with wetness limitations (Zarihun and Kebebew, 2012). Tef grows underneath a good vary of ecological conditions from sea level to 2800 meter on top of sea level (m.a.s.l). It performs best at Associate in Nursing elevation vary of 1800 to 2100 m.a.s.l. The rain demand of the crop varies from 450 to 550 mm. Tef needs temperatures of 10 to 27oC and flowers best under 12-hour day length (Seyfu, 1997). it's annually cultivated on over 3 million hectares of land, that is corresponding to thirty percent of the whole space allotted to cereals (CSA, 2019).

Tef is most well-liked each by farmers and consumers. Farmers like cultivating tef to alternative cereals since tef is additional resilient to environmental stresses like poor soil drainage throughout time of year and moisture deficiency. Additionally, as a crop, each the grain and straw of tef fetch higher and increasing costs than the various products from alternative cereals. Consumers like tef not solely as a result of it makes smart quality “injera”, a pancake-like soft bread, however conjointly it's wholesome thanks to its high macromolecule and mineral content (Geremew et al., 2002), and also the absence of gluten (Spaenij-Dekking et al., 2005) that makes it another food for individuals stricken by upset. Thanks to this life-style nature of the crop, it's been publicized as a brilliant food or super grain (Jeffrey, 2015; Provost and Jobson, 2014). In general, tef plays an important role in food security, nutrition, and financial gain generation to farmer farmers in Ethiopia. The objectives of this review paper are: to review quality traits and measurement of tef and to review possible breeding method to improve the quality traits of tef.

Tef quality traits

Genotype versus straw quantity and quality continuous efforts has been created to develop improved varieties of tef for grain production. However, the breeding programs are essentially geared toward improvement of grain yield with very little thought for yield and quality of the straw. On the opposite hand, tef straw is often used as a very important supply of feed for placental mammal, a situation probably to extend as a lot of lea is anesthetize cultivation because of quickly increasing population pressure, so reducing out their lea. Beneath such circumstances, it's fascinating to supply a better yield of better-quality straw while not sacrificing grain yield. this can profit each animal production and crop production and consequently the farmer. Farmers could reject high yielding varieties owing to their low straw yield or poor quality of straw.

Morphological traits

These traits are simply evident, and frequently play the most role in determinant client acceptance of the produce. Tef grains and flour don't contain gluten (Spaenij-Dekking et al., 2005) and are made in minerals, particularly iron (Melak-Hail, 1966, Yewlsew et al., 2007). These two characteristics build tef flour a fascinating ingredient in health product significantly for celiac disease patients. Tef will replace gluten-containing cereals in product like food, bread, beer, cookies and pancakes.

Grain seed color

The weighted several marketability (have high price), food quality and taste property, grain color (white), food security and social price are the foremost choice criteria and had higher values of tef cultivars on farmers’ preference throughout tef seed and/or grain utilization. Farmers pay a lot of attention to cultivars with most popular market traits with grain color to expeditiously utilize obtainable tef genetic resources to get higher range of marketable yield (Melkam, 2014).

Organoleptic traits

These traits are involved with the taste property of the turnout simply detected and are vital in influencing consumer preferences. Example, taste, aroma, smell, juiciness, softness, etc.

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Tef injera

The principal use of tef is in injera production that constitutes the seventieth of Ethiopians diet (Gamboa and Ekris, 2008). Tef injera is that the most typical and also the main staple food in a lot of of the central, western and northern highlands of African nation yet as among the urban community (Uraga and Narasimha, 1997; Bultosa, 2007; Ashenafi, 2006; Desiye and Abegaz, 2013; Umata and Faulks, 1988). where the soil sort and rain patterns area unit appropriate for cultivation of tef, injera from tef is a lot of favored than that from the opposite cereals (Uraga and Narasimha,1997; Bultosa, 2007; Umata and Faulks, 1988). Injera is soured, bitter leavened pancake-like bread made of tef that is most typical main stable food in African nation. Bubble eye is tiny wall fashioned on the highest surface of injera once the wetness has gaseous.

Nutritional quality of tef

The organic process characters embody protein content and quality, oil content and quality, vitamin content, mineral content, etc. conjointly the presence or absence of anti-nutritional factors (substances in human diet/animal feed that have potential to adversely have an effect on health and growth by preventing absorption of nutrient from food). These traits aren't simply appreciated by consumers and farmers, however they're of preponderating worth in deciding human and animal health. Tef could be a terribly nutritive cereal grain with wonderful supermolecule, macromolecule and mineral contents. The organic process content of the grain is usually love that of the most important world cereals like wheat, barley, rice, maize and sorghum (Table 1). In fact, it's superior in several aspects significantly in minerals like iron, calcium, metallic element and Zn. Among the unremarkably consumed cereals in Ethiopian tef grain has the best quantity of macromolecule, calcium, chemical element, iron, copper, barium, and vitamin B1 and its energy content is surpassed solely by maize (Table 1). It's thought-about to own a well-balanced organic compound composition. Tef is consumed as an entire grain this makes tef flour extremely wealthy in fiber and nutrients.

2. CHEMICAL COMPOSITION OF THE TEF GRAIN

The endosperm and starch

The endosperm, that is below the protein layer, and is that the main nutrient supply of nourishment for the germinating embryo. The outer layer of the endosperm is vitreous (glassy or horny), wealthy in protein reserves and a few starch granules, whereas the inner layer is floury thanks to richness in starch granules with few protein bodies. Tef grain bears compound starch granules like rice, oats, amaranthus and quinoa from that several terribly small (2-6 µm) starch granules are free throughout milling (Melaku and Parker 1996; Geremew et al., 2002). Starch accounts for concerning seventy-three of the tef grain; thence, it plays a dominant role in influencing the top properties of assorted tef grain product. On tef fermentation process, the fermenting microorganisms were known to utilize about 9% of starches (Melaku and Faulks, 1988). Amylose was reported to range 25-32% from extracted starch granules (Geremew et al., 2002) and 20-26% in flour starches (Geremew, 2007). Unlike in other cereals such as maize and rice, no waxyor amylotype starch traits were reported in tef. The diffraction study on tef starch granules indicated that it's A-type with similar crystallinity to rice (Geremew and Taylor, 2003). The A-type starches were noted for his or her sensible digestibleness. The nice digestibleness and keeping quality of tef injera for instance in *Dirqosh* (dried-form of injera, shelf stable) is said to the slow retro gradation nature of tef starches (Geremew et al., 2008). Tef starch pasting temperature is analogous to maize starch, however cookery time for peak consistency is longer (Geremew et al., 2002). Peak, breakdown and black eye viscosities area unit not up to that for maize starch (Geremew, 2007). The tef starch paste clarity is opaque and sleek with short gel texture (Geremew and Taylor, 2004b). As a result of tef starch granules area unit terribly tiny, and sleek with uniform size, they provide sensible practicality as fat substitute, flavor and aroma carrier kind of like different smallgrain starches. Tef starches application in high-shear processed foods appearance promising thanks to its shear breakdown resistance.

Grain proteins

The average protein content within the tef grain is about eleven percent that is above in maize however adore that of wheat (Fufa, 1998; Geremew, 2007). this suggests that consumption of 469 g for feminine and 571 g for male of dried injera per day will meet the daily protein dietary reference intake (DRI) for adults (19-50 years old), as long as the protein is 100% predigested (WHO, 2007). In Ethiopia, tef contributes upto two-third of the protein intake of the population overwhelming tef as staple food (NRC, 1996). Recent study with 3 tef varieties showed that prolamins (extraction by 60%

tert-butanol, v/v containing 0.05% 4-dithiothreitol, w/v) represent regarding four-hundredth of tef grain storage proteins (Adebowale et al. 2011). in line with these authors, the prolamins of tef square measure totally different from sorghum prolamins by being additional hydrophobic and fewer polymerized with low thermal stability, and such high level of prolamins in tef were concerned as contributors for creating superior semi-leavened flat bread as critical sorghum. Tef proteins square measure noted to be wealthy in predigested kind proteins of albumins and globulins (Endeshaw, 1995). Tef grain is thought to be glorious supply of essential amino acids when put next to FAO reference pattern (FAO/WHO, 1973), except that's restricted in essential amino acid and somewhat additionally in essential amino acid. Tef contains additional essential amino acid than barley, millet and wheat and slightly less essential amino acid than rice and oats.

Table 1. Amino acid content of tef (g/16 g N) compared with some gluten containing and gluten free cereals

Amino acid	Gluten rich cereals			Gluten free-cereals		
	Barley	Wheat	Tef	Pearl millet	Rice	Sorghum
Lysine	3.46	2.08	3.68	2.89	3.7	0.34
Isoleucine	3.58	3.68	4.07*	3.09	4.5	0.65
Leucine	6.67	7.04	8.53	7.29	8.2	2.13
Valine	5.04	4.13	5.46	4.49	6.0	0.79
Phenylalanine	5.14	4.86	5.69	3.46	5.5	0.87
Tyrosine	3.10	2.32	3.84	1.41	5.2	0.70
Tryptophan	1.54	1.07	1.30*	1.62	1.2	0.22
Threonine	3.31	2.69	4.32	2.50	3.7	0.53
Histidine	2.11	2.08	3.21	2.08	2.3	0.36
Arginine	4.72	3.54	5.15	3.48	8.5	0.62
Methionine	1.66	1.46	4.06	1.35	2.7	0.28
Cystine	2.21[c]	2.42 [d]	2.50*	3.19	1.8	0.33
Asparagine+Aspartic Acid	4.62[ac]	5.12 [d]	6.4		9.0	
Serine	3.51[c]	4.98 [d]	4.1		5.0	0.76
Glutamine+Glutamic Acid	18.86[bc]	29.53[d]	21.8		17	
Proline	9.58[c]	10.18[d]	8.2		5.0	1.34
Glycine	3.29[c]	4.04 [d]	3.1		4.5	0.48
Lysine	3.46	2.08	3.68	2.89	3.7	0.34
Isoleucine	3.58	3.68	4.07*	3.09	4.5	0.65
Leucine	6.67	7.04	8.53	7.29	8.2	2.13
Valine	5.04	4.13	5.46	4.49	6.0	0.79
Phenylalanine	5.14	4.86	5.69	3.46	5.5	0.87
Tyrosine	3.10	2.32	3.84	1.41	5.2	0.70

[a]Aspartic acid only; [b]Glutamic acid only; [c]Mean value of three varieties; [d]Mean value of 12 varieties; Bultosa and Taylor,2004; Chatterjee *et al.*,1975; *Jansen *et al.*,1962; Khoi *et al.*,1987; Mosse*et al.*,1985; Seyfu,1997; Shoup*et al.*,1969.

Fat

The crude fat in tef grain is resembling that of wheat and is below in maize, sorghum and millets. The crude fat content in injera is below within the grain most likely due to the loss throughout fermentation and baking. The limited available information (Fufa, 1998) indicates that the foremost fatty acids [linoleic (C18:2) > oleic (C18:1) >palmitic (C16:0)] were found kind of like different little cereal grains. although, it's cholesterol-free, tef is somewhat restricted in giving essential fatty acids like polyunsaturated fatty acid fatty acids. The merchandise development study is nearly absent on whether or not the changes within the total fat content of tef grain have an effect on the baking quality of injera or not.

Calorie

Tef is considered a good supply of calorie, and contributes the maximum amount as 40- 60 percent of the energy consumed by the body. Consumption of about 546 g of dried injera per day will meet the minimum dietary energy (2100 kcal) needs recommended for food security.

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Dietary fiber

Tef possesses high dietary fiber (DF) than millet, maize and sorghum though the fiber content often according is crude fiber. In distinction to commonest cereals, the quantity of uronic acid in tef grain is high (Melaku, 1986). Tef bears comparatively high β-glucans like oats and barley. It appeared that on injera creating, the crude fiber is reduced than what's found within the grain.

Ash

The ash content of tef grain is high as compared thereto of sorghum, maize, wheat and millet though in injera is reduced most likely thanks to losses throughout process.

Mineral content of tef

Both the grain and fermented product from tef are recognized to possess high mineral contents compared to the grains of alternative cereals as a result of tef is consumed as whole grain and sometimes fermented as injera. Studies showed that fermented injera has additional bio-available iron than the unfermented one. If the iron in injera is assumed 100 percent available, 30.78 g, 13.68 g and forty 46 g of dried injera will meet the DRI of iron for the adult (19-50 years old) feminine, male and pregnant ladies, severally. However, within the developing countries wherever plant-based diets are the dominant ones, the iron from the food may be bio-available to the extent of 5-100 percent (WHO/FAO, 2004). forward a most of 100 percent convenience, consumption of 307.8 g, 136.8 g and 461.5 g of dried injera will meet the iron DRI demand of the adult (19-50 years old) feminine, male and pregnant ladies, severally. Zinc content is high in tef grain than in maize grain. Fermentation can improve the availability of zinc in injera (Melakuet al., 2005). If this zinc is assumed 100% available, consumption of 250.0 g and 343.8 g of dried injera can meet the DRI for the adult male and female, respectively. But zinc availability is estimated to be 30% in plant-based diet (WHO/FAO, 2004), and once this can be thought of, consumption of 833 g and 1146 g of dried injera will meet the DRI for the man and feminine, individually. Calcium contents in each the grain and injera made up of tef are more than those found in sorghum, maize, wheat and millet grains. If this calcium is assumed 100% available, consumption of 662.3 g of dried injera can meet the DRI for the adult. But on intake of diet, gross and net calcium bio- availability is estimated at 25-30% and 10-12%, respectively (WHO/FAO, 2004). Based on 12% calcium availability, consumption of about 5519.2 g/day of dried injera can meet the calcium DRI required for adults between 19 and 50 years old. Both the grain and injera of tef contains high level of phosphorus, potassium and sodium as compared to the grains of maize, sorghum, wheat and millet.

Vitamins

The B-vitamin (thiamine and niacin) contents in tef grain are high as compared to other whole cereal grains (sorghum and maize). The riboflavin level is greater than that of sorghum, maize, wheat and millet. In the injera, somewhat an increase in the riboflavin and a decrease in the niacin levels are observed as compared to the content in the tef grain. Since the B-vitamins are concentrated in the bran portion of the grain and tef is consumed as a whole grain, it makes this cereal superior in B-vitamins than cereals such as wheat and maize in which the bran is removed during processing. In order to fulfill the daily thiamine requirement, 344 g and 377 g of dry injera should be consumed by an adult female and male, respectively while about 100 g of dry injera satisfies the daily DRI for riboflavin. The respective figures for niacin for an adult female and male are respectively 1077 g and 1231 g of dry injera.

Anti-nutritional factors

Tef grain contains less than 1% (528-842mg/100g) phytic acid and other inositol phosphates, which are strong inhibitors of Fe and Zn absorption. The amount of phytates in injera is considerably reduced to 35-76 mg/100 g (91-93% destruction) due to fermentation and the acidity nature of injera (Melakuet al., 2005; Yewulsewet al., 2007). The brown-colored tef grain was reported to contain tannins although the type of tannin was not described (Melakuet al., 2005). Trypsin inhibitor, a chemical that affects the availability of trypsin enzyme, was recorded in the tef dough at the start of fermentation. But this can be destroyed during steam heat baking of injera since these inhibitors are heat sensitive (Belitzet al., 2009).

Table 2. Nutritional composition of tef grains compared to other major world cereals per 100 g of grains.

Nutritional Item	White tef	Brown tef	Mixed tef	Finger millets	Barley	Maize	Wheat	Sorghum
Calories (g)	339	336	336	326	334	356	339	338
Moisture (%)	10.4	11.1	10.7	12.1	11.3	12.4	10.8	12.1
Protein (g)	11.1	10.5	8.3	7.2	9.3	8.3	10.3	7.1
Fat (g)	2.4	2.7	2.9	1.4	1.9	4.6	1.9	2.8
Carbohydrates(g)	73.6	73.1	75.2	77.1	75.4	73.4	71.9	76.8
Fiber (g)	3	3.1	3.6	5.6	3.7	2.2	3	2.3
Ash (g)	2.5	3.1	3.0	3.3	2	1.3	1.5	1.6
Calcium (mg)	156	157	140	386	47	6	49	30
Phosphorous(m)	366	348	368	220	325	276	276	282
Iron (mg)	18.9	58.9	59	85.1	10.2	4.2	7.5	7.8

Source: WHO (2007)

3. HEALTH BENEFITS OF TEF GRAIN FOOD PRODUCTS

Tef association with Anemia

Tef injera is understood pretty much as good supply of iron and has potential in reducing iron deficient anemia diseases (Kelbessa et al., 1998; Melaku et al., 2005; Yewulsew et al., 2007). Molineaux and Mengesha (1965) reported that non-tef shoppers have a lower level of Hb, and hookworm anaemia develops in non-tef shoppers if they're plagued with hookworm. On the opposite hand, since tef shoppers have higher levels of Hb in their blood, they are doing not suffer from hookworm anaemia. In persons living in areas of the country wherever consumption of red tef is most prevailing, Hb levels were found to be higher with a attenuated risk of anemia associated with parasitic infection. As studies of the enlarged health edges related to high iron contents in brown tef become elucidated, there's additional acceptance of this grain within the society. Today, in Ethiopia, brown tef is turning into additional fashionable associated with its enlarged iron content.

Tef association with Diabetes

The other health connected good thing about tef is that the high fiber content of the grain. this is often notably vital in coping with polygenic disease and helping with glucose management. associated with its little size, the grain cannot be separated into germ, bran and endosperm to form a spread of different products. Though this creates some disadvantages for the grain, it permits tef to yield abundant higher fiber content than the flour of the opposite grains. Tef injera is considered diet with low glycemic index (GI), even if systematic study is proscribed (Magaletta et al., 2010). There are some studies that cross-check the rates of polygenic disease sure enough populations in Ethiopia. However, as in most developing countries the information for establishing reliable estimates doesn't exist. Some researchers have checked out polygenic disease within the Ethiopian somebody immigrants to Israel, a set of the Ethiopian population. Most these studies ended that the prevalence is increasing for Ethiopians each reception and abroad as their lifestyles and diet amendment. As a whole grain and being high in dietary fiber (DF), tef can offer beneficial roles as pre-biotic and for health benefit (reduction in the risk of chronic diseases) (Seal and Brownlee, 2010). The slow release of glucose to blood on consumption of tef injera is probably influenced by the surface erosion of endo-corrosion nature of amylase enzymes' attacks to tef starches (Geremew and Taylor, 2004b). In part, digestibility is also modulated by the influence of high dietary fiber since tef is consumed as whole grain flour, and whole grain products are very well known for such action.

Tef association with Celiac Disease

The products of tef grain are becoming popular globally mainly due to the absence of gluten, the cause for celiac disease (CD) (Hopman et al., 2008; Bergamo et al., 2011) which is affecting about 1% of the USA and Europe population (Engleson and Atwell, 2008; See and Murray, 2006). In the patients of CD, ingestion of gluten (from wheat, barley and rye) damages the lining of the small intestine and prevents normal digestion and nutrient absorption, thereby leading to chronic disorders of nutrient deficiency diseases like anemia, diarrhea and weight loss (See and Murray, 2006). There is a global move towards tef grain-based gluten free recipe developments. Patent has already been granted for baked tef products including a variety of bread, cookies and cake (Roosjen, 2007). With popularization of consumption of tef injera

and other tef products around many global restaurants, tef consumption will become culture as that of bread. Global effort is required to boost tef grain production, so that tef grain can be fetched at affordable price, since at present it commands premium prices among cereal grains.

Tef association with Osteoporosis

Osteoporosis, or porous bone, is a disease characterized by low bone mass and structural deterioration of bone tissue, leading to bone fragility and an increased risk of fractures of the hip, spine, and wrist. Some of the risk factors like; - shortage of calcium intake and vitamin D, lifestyle, cigarette smoking, intake of alcohol and the use of medication. Tef maybe have a positive influence on osteoporosis, because it is high in calcium content, which prevents osteoporosis. Calcium makes the bones stronger.

Tef Biological Quality

The traits included in this group define the actual usefulness of the produce when consumed by experimental animals. Their usefulness to humans is usually predicted on this basis. Examples of biological quality traits include, protein efficiency ratio, biological value, body weight gain, etc. These traits are not obvious to consumers and growers, but are extremely valuable in determining the utility of produce for human and/or animal consumption.

Straw quality and value

Farmers have been using tef straw as feed since the start of tef cropping with all the limitations associated with its use. Tef straw is a preferred animal feed because of its high palatability and feed quality (Seyfu, 1997). The information on tef straw utilization as feed is limited to work done in Ethiopia since the crop is not used elsewhere as a staple food crop, even though this seems to be changing in recent years. Farmers highly value tef straw. It is stored and used as a very important source of animal feed especially during the dry season. The feeding value of crop residues including tef straw is variable depending on the crop variety, content of anti-nutritional factors (tannins, lignin, silica etc.), stage of harvest, length of storage, leaf to stem ratio, soil fertility and fertilizer application as well as the effects of agronomic practices such as irrigation. For example, Kernan*et al.* (1984) reported that straw from irrigated wheat had a 41% in vitro digestibility compared to 34% for non-irrigated wheat straw.

Possible breeding method to improve quality traits of tef

Scientific research on tef began in 1956 at the then Jima Agricultural and Technical High School, now Jima University. In 1960, tef research was transferred to the then Central Experiment Station and now the Debre Zeit Agricultural Research Center. Debre Zeit Agricultural Research Center is the center for the coordination of tef research program. However, shortage of adequately trained manpower, lack of adequate facilities and shortage of budget were mentioned above as the main problems limiting tef research. Breeding is currently the best functioning aspect of tef research. Improvement could be achieved through direct selection large number of pure line accessions or by effecting gene recombination between parental lines selected from them, to create genetically superior cultivars through conventional breeding or biotechnology techniques. To date has focused mostly on breeding and on improving agronomic practices. Mechanization and processing have not been widely researched. Tef breeding technique used by the center is conventional and focuses on cross breeding and selection.

In tef, many wild relatives were identified to be the source of desirable gene (Jones *et al*., 1978b), but their applications are very limited. So far, no systematic and comprehensive collection and subsequent evaluation, characterization and conservation activities related to the germplasm of the wild relatives of tef have been conducted. *Eragrostispilosa* is the only wild relative that crosses relatively easily with tef (Hailu *et al*., 2003a). This species is closely related to tef (Ingram and Doyle, 2003). A previous breeding attempt has demonstrated importance of *Eragrostispilosa* in diversifying the germplasm pool for tef breeding, and one variety named Simada (DZ-Cr-285 RIL295) has been developed and released in Ethiopia through an inter-specific hybridization of tef with *Eragrostis Pilosa*. On the other hand, the direct selection from the landraces and the intra-specific hybridization program which was employed to effect gene recombination were successful in developing several improved cultivars of tef with desired traits. In the intra-specific hybridization programs the single seed decent method, pedigree and modified pedigree selection methods were used to handle the segregating population. The improved cultivars developed include: cultivars that have high grain yield with wide or specific

adaptation, cultivars with acceptable high grain quality, and early maturing, high- yielding varieties. All the improved cultivars were accepted by farmers and currently are in production. Direct selection from the landraces, mutation breeding and intra-specific hybridization was tried for developing lodging-resistant varieties. However, so far, no success has been achieved.Applied breeding work to improve tef included direct selection from the landraces, inter-specific and intra-specific hybridization and mutation breeding, while at the basic research level investigations were made in the area of biotechnology. The applied research attempts in the areas of mutation and inter-specific hybridization programs have been started with research team at the University of Bern, supported by the Syngenta Foundation contributed to the development of improved cultivars.

4. TOOLS AND RESOURCES FOR TECHNOLOGY GENERATION TO IMPROVE QUALITY TRAITS OF TEF

Mutation Breeding

Mutation breeding is a process which includes three steps, namely mutation induction, mutation detection and mutation utilization (Zarihun*et al.* 2010). Mutation induction refers to the exposure of seeds or other parts of the plant to chemicals or radiation to induce random nucleotide mutations in a plant genome. In order to establish mutagenized populations, seeds of three improved tef varieties, namely *Tsedey* (DZ-Cr-37), *Dukem* (DZ-01-974) and *Kora* (DZ-Cr-438 RIL 133B) were treated with the chemical ethyl methanesulfonate (EMS). The stock of seeds and the DNA from 10,000 mutagenized M_2 populations from these three elite cultivars are available for screening for the trait(s) of interest. Screening of a mutagenized population for candidates based on their phenotype is a simple and effective way to find new candidates if the desired phenotype is readily observable. As lodging is one of the main production constraints for tef, screening was first applied to the discovery of semi-dwarf tef lines.

TILLING and Eco-TILLING

TILLING (Targeting Induced Local Lesion IN Genomes) is a high-throughput non-transgenic method that allows for screening single-base mutations in a specific gene over an entire mutagenized population (Mc Callum et al., 2000). The technique comprises the following steps: i) mutagenesis, ii) development of a non-chimeric population, iii) preparation of a germplasm stock, iv) DNA extraction and sample pooling, v) population screening for induced mutations including validation, and vi) evaluation of candidate mutants particularly when the ultimate goal of the study is to develop a crop with desirable trait(s) (Esfeld et al., 2013 and Zerihun et al., 2010).

In-Vitro Regeneration

In-vitro regeneration has applications in the embryo rescue technique which is important to circumvent the hybridization barrier between tef and wild species as well as in modern improvement techniques including.

Biomechanics

In order to investigate the lodging-tolerance of diverse tef genotypes, we use a custom-made robot employing Cellular Force Microscopy (CFM). With this robot, 3-point bending is used to measure the stiffness of stem sections, while pushing is used to assess root anchorage strength. Tef breeder are also planning to investigate diverse thigmo-conditioning (Iida 2014) on tef plants in order to identify the most efficient and economical way of inducing lodging resistance. Information from these techniques is valuable for tef breeders as lodging resistance of the tef plants might be associated with morphological parameters of the plant.

5. CONCLUSION

Genotype versus straw quantity and quality persistent endeavors has been made to create improved varieties of tef production. Tef injera is the most well-known and the primary staple food in a large part of the central, western and northern highlands of Ethiopia just as among the urban areas. Tef is an exceptionally nutritious cereal grain with amazing protein, sugar and mineral substance. The dietary substance of the grain is for the most part practically identical to that of the significant world oats like wheat, grain, rice, maize and sorghum. It is unrivaled in numerous angles especially in minerals, for example, iron, calcium, magnesium and zinc. Starch represents about 73% of the tef grain; henceforth, it assumes a prevailing part in impacting the end properties of different tef grain items.

The normal protein content in the tef grain is about 11% which is higher than in maize however tantamount to that of wheat. The unrefined fat in tef grain is equivalent to that of wheat and is lower than in maize, sorghum and millets. Both the grain and fermented products from tef are recognized to have high mineral contents compared to the grains of other cereals because tef is consumed as whole grain and often fermented as injera. Medical advantage of tef injera utilization is profitable for Anemia, Diabetes, Celiac and Osteoporosis Disease. Farmers have been utilizing tef straw as feed since the beginning of tef cultivation with all the constraints related with its utilization. Nonetheless, the breeding program are fundamentally focused on progress of grain yield with little thought for yield and nature of the straw due to low efficiency of tef, Orphan crops, restricted asset, restricted logical data, restricted interest of scientists and government push.Breeding has focused mostly on breeding and on improving agronomic practices.Applied breeding work to improve tef included direct selection from the landraces, inter-specific and intra-specific hybridization and mutation breeding, while at the basic research level investigations were made in the area of biotechnology. The tef quality credits both in grain and straw are not focused to know the characteristics and get advantage. It is worthy in future if the tef quality recognitionsgive attention to obtain advantage from the yield.

AUTHOR CONTRIBUTIONS

Worku Kebede was carried out the review different papers and collects data for analysis and arranged for review

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COMPETING INTERESTS

The author declares that they have no competing interests.

REFERENCES

[1] Adebowale, A.A., M.N.Emmambux, M. Beukesand J.R.N. Taylor,2011. Fractionation and characterization of tef proteins. *Journal of Cereal Science, 30:1*-7.

[2] Ashenafi, M., 2006. A review on the microbiology of indigenous fermented foods and beverages of Ethiopia. *Journal of Biological Science*, 5: 189-245.

[3] Belitz, H.D., W.GroschandP.Schieberle, 2009.FoodChemistry. Springer,4th revisedandextendeded., Berlin, Germany.

[4] Bergamo, P., F, Maurano,G. Mazzarella,G. Iaquinto,I. Vocca,A. R. Rivelli,D.EnricaFalco,C.GianfraniandM. Rossi,2011.Immunologicalevaluationofthealcohol-solubleproteinfractionfromgluten-freegrainsinrelationtoceliac disease.MolecularNutrition and Food Research,55:1266-1270.

[5] Bultosa, G., 2007. Physicochemical Characteristics of Grain and Flour in 13 Tef. *Journal of AppliedScience Research*, 3(12): 2042-2051.

[6] Bultosa, G., Taylor, J.N.R., 2004. Teff. *In*: Wringley, C., Corke, H., Walker, C., editors. Encyclopedia of grain science. Oxford: Academic, pp. 281–289.

[7] Chatterjee, S.R., Verma, N.S., Gulati, S.C., Bakshi, J.S., Abrol, Y.P., 1975. Identification of barley strains with improved amino acid balance. *Euphytica*, 24: 725–730.

[8] CSA (2019). Central Statistical Agency, Agricultural Sample Survey 2018/2019 (2011E.C). Volume I. Report on Area and Production of Major Crops. Statistical Bulletin 584. Addis Ababa, Ethiopia.

[9] CSA (Central Statistical Agency), 2015. Agricultural sample survey 2014/2015. Volume I. Report on area and production of major crops. Statistical Bulletin 578. Addis Ababa, Ethiopia.

[10] Desiye, A. and K. Abegaz, 2013. Isolation, characterization and identification of lactic acid bacteriaandyeast involved in fermentation of Teff (*Eragrostistef*) Batter. *Access International Journal*, 1(3): 36-44.

[11] EndeshawBekele,1995.Essentialandnon−essentialaminoacidsinafreestateandinthe major proteinfractions of tef seeds. SINET: An Ethiopian Journal of Science,18: 79-99.

[12] Engleson,J.and B. Atwell, 2008. Gluten free product development. Cereal Foods World, 53: 180-184.

[13] Esfeld, K., C. Uauy and ZarihunTadele, 2013. Application of TILLING for Orphan Crop Improvement *In*: Jain SM, Gupta SD (eds). Biotechnology of Neglected and Underutilized Crops. Springer, pp 83-113.

[14] FAO (Food and Agricultural Organization) /WHO (World Health Organization), 1973.Energyandproteinre quirements. Report of a Joint FAO/WHO Ad-Hoc Expert Committee. Geneva: World Health Organization Technical Report, Series522.

[15] FufaHundera, 1998.Variationsofmorpho−agronomiccharactersandgrainchemical composition ofreleasedvarietiesoftef[*Eragrostistef*(Zucc.) Trotter].*Journalof Genetics andBreeding*,52: 307-311.

[16] Gamboa, P.A. and L.V. Ekris, 2008. Tef: survey on the nutritional and health aspects of tef [*Eragrostistef* (Zucc.) Trotter]: 319-367.

[17] GeremewBultosaandJ.R.N.Taylor,2004b.Pasteandgelpropertiesand*in-vitro*digestibilityoftef[*Eragrostistef*(Zucc.) Trotter]starch.*Starch/Stärke*, 56: 20−28.

[18] GeremewBultosaandJ.R.N. Taylor,2003, Chemicalandphysical characterization of grain tef [*Eragrostistef*(Zucc.) Trotter]starchgranulecomposition.*Starch/Stärke*,55: 304-312.

[19] GeremewBultosa,2007.Physicochemicalcharacteristicsofgrainandflourin13tef[*Eragrostistef*(Zucc.) Trotter]grainvarieties. *Journal ofApplied SciencesResearch*, 3: 2042-2051.

[20] GeremewBultosa, A.N. Hall and J.R.N. Taylor, 2002. Physico-chemical characterization of grain tef [*Eragrostistef*(Zucc.) Trotter] starch. *Starch-Starke*, 54: 461-468.

[21] GeremewBultosa,B.R. HamakerandJ.N.BeMiller, 2008.AnSEC-MALLS studyofmolecular features ofwater-solubleamylopectinandamylose of tef[*Eragrostistef*(Zucc.)Trotter] starches. *Starch/Stärke*,60: 8-22.

[22] HailuTefera, 1988. Variability and association of characters in tef [*Eragrostistef* (Zucc.)Trotter] cultivars. M.Sc. Thesis, Alemaya, Ethiopia.

[23] Hopman, G.D., E.H...A.Dekking, M.L.J.Blokland,M.C. Wuisman, W.M. Zuijderduin, F.KoningandJ.J. Schweizer, 2008.Tef inthedietofceliacpatientsintheNetherlands.*ScandinavianJournal ofGastroenterology*,43:277-282.

[24] Iida, H., 2014. Mugifumi, a beneficial farm work of adding mechanical stress by treading to wheatandbarley seedlings.*Front Plant Science journal*, 5: 453.

[25] Ingram, A. L., and J. J. Doyle, 2003. The origin and evolution of *Eragrostistef* (Poaceae) and related polyploids: evidence from nuclear waxy andplastidrps16. *American Journal of botany*, 90, 116–122.

[26] Jansen, G.R., DiMaio, L.R., Hause, N.L., 1962. Amino acid composition and lysine supplementation of teff. *Journal of Agriculture and Food Chemistry*, 10: 62–64.

[27] Jeffrey, J., 2015. Will Ethiopia's teff be the next 'super grain? BBC, London.

[28] Jones, B.M.G., J. Ponti, A. Tavasoli and P.A. Dixol, 1978b. Relationship of the Ethiopian cereal tef (*Eragrostistef* (Zucc.) Trotter): Evidence from morphology and chromosome number. *American Journal of botany*, 42: 1369-1373.

[29] KebebewAssefa, J.K. Yu, M. Zeid, Getachew Belay, HailuTefera and M.E. Sorrells, 2011a. Breedingtef [*Eragrostistef* (Zucc.) trotter]: conventional and molecular approaches. *Plant Breeding*, 130: 1–9 x.

[30] KelbessaUrga,H.V.Narasimha,B.V.SasikalaandS.Vishwantha, 1998.Bioavailability ofiron andzinc fromtef inrats. *Bulletin oftheChemicalSocietyofEthiopia*, 12: 95-103.

[31] Kernan, J.A., E.D. Coxworth, W.C. Crowle and D.T. Spurr, 1984. The nutritional value of crop residues from several wheat cultivars grown at different fertilizer levels. *Animal Feed Science Technology*, 11: 301-311.

[32] Khoi, B.H., Dien, L.D., Lasztity, R., Salgo, A., 1987. The protein and the amino acid composition of some rice and maize varieties grown in North Vietnam. *Journal of Science and Food Agriculture*, 39: 137–143.

[33] Magaletta, R.L.,S.N.DiCataldo,D. Liu,H.L. Li,R.P.BorwankarandM.C. Martini, 2010.*Invitro*method for predicting glycemic index offoodsusing simulateddigestionandanartificialneural network.*CerealChemistry*,87: 363-369.

[34] McCallum, C.M., L. Comai, E.A. Greene, S. Henikoff, 2000 Targeted screening for induced mutations.*National Biotechnology*, 18: 455-457.

[35] Melak-HailMengesha, 1966.Chemical composition oftef (*Eragrostistef*)comparedwiththat of wheat,barley and grainsorghum. *Economical Botany*,20: 268-273.

[36] MelakuUmetaandM.L.Parker,1996.Microscopicstudiesofthemajormacro−componentsofseeds,doughandi n j e r a fromtef(*Eragrostistef*).*SINET:AnEthiopianJournalofScience*, 19: 141-148.

[37] MelakuUmetaandR.M.Faulks, 1988. Theeffectof fermentationonthecarbohydrates intef(*Eragrostistef*).*Food Chemistry*,27: 181-189.

[38] MelakuUmeta,1986.Studiesonthefermentationoftef*(Eragrostistef)*andits nutritional Significance,M.Sc.Thesis, Universityof East Anglia, UK.

[39] MelakuUmeta,C.E.WestandHabtamuFufa,2005.Contentofzinc,iron,calciumandtheirabsorptioninhibitorsin foodscommonlyconsumedinEthiopia.*Journal ofFoodComposition and Analysis*, 18: 803-817.

[40] Melkam, A., M. Firew and T. Mulualem, 2014. Assessment of farmer's indigenous knowledge and selection of tef [*Eragrostistef* (Zucc.) Trotter] in East Gojjam zone, Ethiopia. *Sky Journal of Agricultural Research*, 3: 142-14.

[41] Mosse, J., J.C. Huetand J. Baudet, 1985. The Amino acid composition of wheat grain as a function of nitrogen content. *Journal of Cereal Science*, 3: 115–130.

[42] Piccinin, D., 2002. More about Ethiopian food: Tef. University of Washington, USA. http://ethnomed.org/ clinical/nutrition/more-about- Ethiopian-food-teff. (Accessed on April 27.2017).

[43] Provost, C. and E. Jobson, 2014. Move over quinoa, Ethiopian's teff poised to be next big super grain.http://www. theguardian.com/global-development/2014/jan/23/quinoa-ethiopia-teff- super-grain.

[44] Roosjen,J.,2007.Processingoftef flour:Europeanpatentspecification(EP1646287B1, grantofthepatent10-01-2007Bulletin2007/02),PublicationNumber:WO 2005/025319(24.03.2005Gazette2005/12), European Patent Office. http://www.abs-africa.info/uploads/media/Teff-PatentEP_1_646_287_B1_01.pdf (accessedon1April 2017).

[45] Saturni, L., G. Ferretti and T. Bacchetti, 2010. The gluten-free diet: safety and nutritional quality. *Nutrition quality*, 2: 16-34.

[46] See, J.and J.A. Murray, 2006. Gluten-free diet: the medical andnutrition management of celiac disease. *Nutrition inClinicalPractice*,21: 1-15.

[47] SeyfuKetema, 1993. Tef (*Eragrostistef*): Breeding, Agronomy, Genetic Resources, Utilization, and Role in Ethiopian Agriculture. Institute of Agricultural Research, Addis Ababa, Ethiopia.

[48] SeyfuKetema, 1997. Tef: [*Eragrostistef* (Zucc.) Trotter]: Promoting the Conservation and Use of Underutilized and Neglected crops. 12 Institute of Plant Genetics and Crop Plant Research, Gatersleben/International Plant Genetic Resources Institute, Rome, Italy.

[49] Shoup, F.K., Deyoe, C.W., Campbell, J., Parrish, D.B., 1969. Amino acid composition and nutritional value of milled sorghum grain products. *Cereal chemistry*, 46: 164–172.

[50] Spaenij-Dekking, L., Y. Kooy-Winkelaar and F. Koning, 2005. The Ethiopian cereal tef in celiac disease. *New England Journal of Medicine*, 353: 1748-1749.

[51] Umeta, M. and R.M. Faulks, 1988. The effect of fermentation on the carbohydrates in tef, [*Eragrostistef* (Zucc.)Trotter].*Food Chemistry*, 27 (3): 181-189.

[52] Uraga, K. and H.V. Narasimha, 1997. Effect of natural fermentation on the HCl- extractability of minerals from Tef[*Eragrostistef (Zucc.)*Trotter].*Bullinof Chemical Society of Ethiopia*, 11: 3-10.

[53] Vavilov, N.I., 1951. The origin, variation, Immunity and Breeding of cultivated plants. Ronald Press, New York. [Translated from Russian by Sarrchester, K].

[54] WHO (World Health Organization),2007.Protein andaminoacid requirementsinhumannutrition:report ofajoint FAO/WHO/UNUexpertconsultation.WHO technical reportseries; no.935, Geneva, Switzerland.

[55] WHO (World Health Organization)/FAO (Food and Agricultural Organization), 2004.Vitaminandmineralrequirement sinhumannutrition,2nded., Geneva, Switzerland

[56] YewlsewAbebe, AlemtsehayBogale, K.M. Hambidge, B.J. Stoecker, K. Bailey and R.S. Gibson, 2007. Phytate, zinc, iron and calcium content of selected raw and prepared foods consumed in rural Sidama, Southern Ethiopia, and implications for bioavailability. *Journal of Food Composition and Analysis*, 20: 161-168.

[57] ZarihunTadele and KebebewAssefa, 2012.Increasing food production in Africa by boosting the productivity of understudied crops. *Agronomy*, 2240–283.

[58] ZarihunTadele, C. Mba and B.J. Till, 2010. TILLING for mutations in model plants and crops.*In*: S.M. Jain, D.S. Brar (eds). Molecular Techniques in Crop Improvement: 2nd Edition Springer, pp 307-332.