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Review article

Breeding for Quality improvement in Tef (*Eragrostis tef*)

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Tef [Eragrostis tef (Zucc.) Trotter] is one among the foremost stable food crop originated and diversified in Ethiopia. It's highly preferred by Ethiopian people for consumption as food, especially its good nutrition content and freed from protein referred to as gluten. Additionally, tef used as sources of income in order that most of the farmers again like better to produce tef. Thus, the development of tef is primarily important to maximize productivity. Since tef breeding program was started during the late 1950s. From the initial so far several attempts are through with the satisfactory result. During this era over forty-two varieties were released and therefore the yield was relatively increased. There are constraints that require to be addressed through a research project. The main constraints are the low yield of landrace cultivars under widespread cultivation, susceptibility to lodging and a scarcity of knowledge concerning the genetic control of agronomic traits. Yield gain from tef breeding has been linear with a mean annual increase of 0.8%. Tef [Eragrostis tef (Zucc.) Trotter] could also be a cereal crop resilient to adverse climatic and soil conditions, and possessing desirable storage properties. Although tef provides top-quality food and grows under marginal conditions unsuitable for other cereals, it's considered to be an orphan crop because it's benefited little from genetic improvement. Hence, unlike other cereals like maize and wheat, the productivity of tef is extremely low. In spite of the low productivity, tef is widely cultivated by over six million small-scale farmers in Ethiopia where it's annually grown on quite three million hectares of land, accounting for over 30% of the entire cereal acreage. It's highly preferred by Ethiopian people for consumption as food, especially its good nutrition content and freed from protein referred to as gluten. Therefore, this review paper presented the role of breeding in the quality improvement of tef.

Keywords: breeding, teff, nutrient, quality

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INTRODUCTION

Tef [*Eragrostis tef*] is an Ethiopian indigenous tropical cereal crop and it's been cultivated for several years in Ethiopian highlands. It's the most stable within the country mostly wont to make injera, traditional fermented flatbread. The entire tef grain is ground to flour for creating injera, local beverage, porridges and soup and sweet matzo (Bultosa & Taylor, 2004). Globally, it's also becoming a lifestyle diet and potential grain of attraction thanks to its nutritional and health benefits. The tef crop has several merits in terms of husbandry and utilization (Ketema, 1993; Assefa *et al.,* 2011, 2013) to extend crop production and to feed the ever-growing population in an environmentally friendly and sustainable way.

The grain of tef is gluten-free (Spaenij-Dekking *et al.,* 2005) and nutritious human food (Mengesha, 1966). It's the foremost important source of the highest quality and consumer-preferred “injera” which has a long time period, unique flavor, pliability, smooth and glossy texture (Bultossa and Umeta, 2013). It provides high returns in flour upon milling (99%) compared to wheat (60-80%)while its flour has also a good water holding capacity to offer high returns in injera upon baking (Ebba, 1969). Furthermore, tef grain has high market value, long time period, low post-harvest pest problems (Ketema, 1993; Assefa *et al.,* 2011) and provides 600 and 200 kcal/ day per person within the Urban and rural areas of Ethiopia, respectively (FAO, 2015).

The straw of tef is additionally the foremost preferred, nutritious and palatable livestock feed compared to other cereal crops grown in Ethiopia (Bediye *et al.,* 1996; Yami, 2013). Besides, it's also useful as a binder of mud for plastering walls of local houses. Hence, both the grain and straw of tef generate high income for farmers within the major tef production areas of Ethiopia who don't have alternative cash crops like coffee, tea, or cotton (FAO, 2015). In Ethiopia, cereals contribute for 81.3% of the entire area and 87.4% of the entire production of grain crops (CSA, 2017). Tef is one of the main cereals in terms of area and volume of production among grain crops. Among cereals, tef, maize, sorghum and wheat are annually cultivated on29.5%, 20.9%, 18.4% and 16.6% of the entire area under cereal crops indicating their large-scale coverage within the country.

Regarding the entire production, the contribution of equivalent cereals within the same order to the entire cereal grain production is nineteen .8%, 31%, 18.7% and 17.9%, respectively. This shows that tef stands first within the total area and second to maize within the total grain production and therefore the number of households involved in its production while, it ranked last in terms of productivity among major cereals grown in Ethiopia (Thus, despite its large-scale cultivation and its preferences by both growers and consumers, its national average the productivity is that the lowest and is merely about 1.66tons per hectare (CSA, 2017). Nevertheless, it's possible to urge over 4.5 plenty of grain per hectare by using improved varieties and management practices under non-lodging conditions. Such low productivity of tef at the national level is especially resulted due to lodging, drought and different biotic stresses (Assefa *et al.,* 2011; Assefa et al., 2015). Hence, tons are predicted from tef breeders and every one stakeholder to enhance the productivity and minimize the yield gap with other major cereals.

Despite the varied research efforts to extend production and productivity, there are still many gaps in tef breeding that need further research and investigation. Thus, the morphological, molecular and biochemical markers based on genetic diversity studies conducted on tef germplasm weren't intrinsically exhaustive. The Ethiopian Biodiversity Institute (EBI) was reported to hold 5169 tef accessions in its gene bank (Tessema, 2013). Of the entire accession within the EBI gene-bank, 3315 were collected directly by EBI, while the remaining 1854 accessions were acquired through donations and repatriations (Assefa et al., 2017). Quite half the entire accessions at EBI haven't yet been characterized and a few of these characterized were found to be redundant. Besides, the extent and pattern of genetic diversity in existing germplasm haven't yet been exhaustively studied (Chanyalew et al., 2013). The EBI tef accessions collected from diverse growing regions in Ethiopia are predicted to harbor genotypes with beneficial agronomic and nutritional traits for the development of tef crop. Therefore, assessing the extent and pattern of genetic diversity among genotypes from various genetic and eco-geographic origins employing a combination of markers is very essential.

Tef produced under various altitudes, soil and climate also as crop management conditions whereby the same/or different genotypes may perform differently. Hence, the study of genotype by environment (G x E) interaction may be a vital research area in crop breeding and varietal development (Ketema, 1993). So far, limited studies are made on G x E interaction in tef (Kefyalew, 1999). The study of G x E enables breeders to get appropriate information on the magnitude and nature of G x E interactions and to style a workable future tef breeding strategy. Hence, it's long been suggested to conduct such a study across the main tef growing areas of the country (Kefyalew, 2001).

The mid and highland areas categorized to possess a farming system are the main tef production environment in Ethiopia. In such a system, crop and livestock husbandry is practiced under an equivalent management unit whereby the livestock provides draught power, cash and plant nutrition (manure) while crop residues are used as feed sources for livestock. Hence, proper use of crop residue may be a good tactic choice to be implemented. This is often thanks to the very fact that tef straw provides nearly half the entire annual cereal straw within the central highland (Yami, 2013) and 1 / 4 of the straw within the whole country. However, the number and quality of the grain and straw of tef vary among varieties, and its growing climatic and soil conditions (Bediye et al., 1996). So far, limited information is out there on the straw quality of released tef varieties and therefore the food-feed traits haven't yet been investigated. The importance of tef as food and feed, the critical decline in the pasture, and therefore the incontrovertible fact that farmers began to worry about crop residues and its grain require identification of tef genotypes with better grain and straw yield and quality. Hence, assessing the feed quality traits and identification of tef genotypes with top quality food-feed traits is important so as to develop and release new varieties that fulfill these criteria. Therefore the target of this review paper is to assess the role of breeding for quality improvement in tef (Eragrostis tef).

LITERATURE REVIEW

Description of the tef crop

Tef is an allotetraploid species with chromosome number (2n =4x = 40) (Tavassoli, 1986) and maybe a cereal crop grown primarily in Ethiopia (Amanda and Doyle, 2003). The genome size of tef ranges from 714 to 733 Mbp and 648 to 926 Mbp (Hundera et al., 2000) supported different sets of cultivars suggesting that it varies with cultivars. Gina et al., (2014) also reported a draft genome containing 672 Mbp representing 87% of the genome size estimated from flow cytometry. Morphologically, tef has fibrous rootage, fine stem and lots of tillers. It's a C4, self-pollinated chasmogamous annual cereal crop consisting of both the stamens and pistils within the equivalent floret (Ketema, 1997). Tef features a very minute seed size starting from 0.9-1.7 mm length and 0.7-1.0 mm diameter and therefore the weight of its 100 to 150 grains is adequate to a grain of wheat. Tef spikelet has 2-12 florets consisting of a lemma, palea, three stamens, an ovary, and mostly two feathery stigmas. The maturity periods of tef cultivars range from 60 to 180 days counting on their growing environments (Ketema, 1997; Assefa et al., 2001; 2011; 2013).

Grain and lemma color, panicle form and plant height also as maturity period are the most distinguishing features among various tef cultivars (Berhe et al., 1989; Ketema, 1997). Berhe et al., (1989) found that lemma and seed color, and panicle forms are inherited independently whereby parents with colored lemma can produce white or red lemma and colored lemma are often produced within the absence of coloration. Regarding dominance level, colored lemmas were reported to be dominant over non-colored ones (Berhe et al., 1989). Furthermore, panicle form and maturity were reported to be linked among tef landraces and thus, the late-maturing genotypes have compact panicles and bigger plants whereas the first maturing ones have very loose or open panicle forms. However, consistent with equivalent authors, seed and lemma color isn't linked to panicle form revealing that the seed and lemma color isn't determined by the panicle form or the other way around.

Origin and domestication of tef

The center of origin and variety of tef crop is believed to be in Ethiopia (Vavilov, 1951). The domestication of tef for human consumption was made by pre-Semitic inhabitants of Ethiopia between 4000 and 1000 B.C. (Ketema, 1997). Tef is that the only cultivated species within the Eragrostis which consists of 350 species. The very fact that 14 of the 54 Eragrostis species found in Ethiopia are endemic (Tefera and Ketema, 2001) is robust evidence for Ethiopia to be considered as a middle of origin and variety of tef. About 43%, 18%, 12%, 10%, 9%, 6% and a couple of the 350 Eragrostis species were reported to be originated in Africa, South America, Asia, Australia, Central America, North America and Europe, respectively (Costanza 1974; Ketema, 1997).

Nutritional compositions of tef

Although tef is one of the well-liked cereal crops for wider health consumption, the shortage of familiarity by consumers and limited interests in tef causes the Ethiopians to think for hundreds of years that their crop is lesser in quality (Yetneberk, Rooney and Taylor, 2005). On the opposite hand, for the last ten years, the invention of the gluten-free property of tef grain has encouraged researchers in nutrition, agronomy, breeder, and food science to exert more endeavors to enhance the historically neglected crop. Thus, numerous studies are made on the post-harvest values and composition of tef nutrition. Nowadays, the event of the latest tef-based food products has accelerated outside Ethiopia initially in Denmark (Baye, 2014).

The nutritional value of tef compares with a number of the most staple crops and actually, it's superior to a number of these cereal crops in mineral content especially copper, zinc, and manganese (Ketema, 1993). The nutritional profile of tef showed the very best amount of protein compared to usually consumed staples in Ethiopia and its calorie status is solely exceeded by maize. It's considered to contain excellent amino alkanoic acid contents, and it is also said to possess higher lysine levels than barley and wheat and a touch less than oats and rice (Stallknecht, 1997).

Baye, (2014) reported that eighty percent of the tef grain is complex carbohydrates. It contains approximately 73 percent starch making tef a starchy cereal. The amylose content of 13 tef varieties tested ranged from 20 to 26 percent which is like other cereals (Bultosa, 2007).In general, the extent of carbohydrate, which is digested and absorbed within the intestine, determines its health effect. Rapidly digested and absorbed carbohydrates (glycemic carbohydrates) have a greater effect on blood sugar levels, as they result in greater metabolic perturbation (Lafiandra et al., 2014). Such perturbations are associated with metabolic diseases like cardiovascular diseases and type-2 diabetes (Ludwig, 2002). Hence, from a health point of view, slow-digesting carbohydrates are chosen over rapidly digesting ones.

Harris and Geor (2009) said that the speed of carbohydrate digestion of food is often characterized by its glycemic index. The glycemic index of a food depends on endogenous factors of the food matrix-like protein and lipid content, starch susceptibility to α-amylase and therefore the macroscopic structure of the food. Starch susceptibility to α-amylase is successively determined by its structure, crystal structure, encapsulation, and degree of gelatinization, the proportion of damaged granules and therefore the retro gradational properties of starch granules (Fardet et al., 2006). Nonetheless, the in vitro starch digestibility of tef was found to be considerably lower as compared to wheat, which has larger starch granules. In line with this, the anticipated glycemic index of tef (74) was considerably less than that of white wheat (100) (Wolter et al., 2013).

Tef is taken into account to be a good source of protein. During a typical Ethiopian diet, 41g of 65g total daily protein content comes from tef products (Jansen et al., 1962). On average, the crude protein content of tef is within the range of 8 to 11 percent, which is far more almost like other more common cereals like wheat. Tef's fractional protein composition indicates that albumins (37 percent) and glutelins (45 percent) are the main protein storages, while prolamins are of small constituent (Bekele et al., 1995). In contrast, most of the recent studies reported that prolamins are the main protein storages in tef. The various methods of extraction between these studies may explain the clashing findings. supported the examination of the amino alkanoic acid profile of tef, the upper contents of leucine, glutamine, alanine, and proline and therefore the relatively lower content of lysine further indicate that prolamins are the main storage proteins (Adebowale et al., 2011).

According to Baye (2014), the amino alkanoic acid composition of tef is well balanced. Relatively, a high concentration of lysine, a serious limiting amino alkanoic acid in cereals grain, is found in tef. Within the same way, compared to other cereals grain, higher contents of tyrosine, isoleucine, valine, threonine, leucine, methionine, arginine, alanine, phenylalanine and histidine are found in tef. Another important aspect of tef is that it's no gluten (Hopman et al., 2008). Spaenij-Dekking, et al. (2005) acknowledged that the presence or absence of gluten in pepsin and trypsin digests of 14 tef varieties and therefore the digests were analyzed for the presence of T-cell–stimulatory epitopes. This makes tef a valuable ingredient for functional foods intended for celiac patients who are gluten intolerant.

According to the American Association of Cereal Chemists definition, dietary fiber is "edible parts of the plant or analogous carbohydrates immune to digestion and absorption within the human intestine with complete or partial fermentation within the large intestine" (DeVries, 2003). The recent Codex definition further added that dietary fibers should have "proven physiologic effects of benefit to health" (Cummings et al., 2009). Lowering blood sugar levels after eating, fecal bulking (laxation) and lowering plasma LDL-cholesterol are a number of the physiologic effects of the fiber. The crude fiber, total and soluble dietary fiber content of tef is many folds above that found in common cereals, maize, rice, wheat and sorghum (Baye, 2014). There could also be many reasons for this. Consistent with Bultosa (2007), first, whole grains have a larger fiber content than decorticated ones. Second, small cereal grains have a comparatively high proportion of bran, which is high in fiber. Therefore, higher dietary fiber intake and therefore the associated health benefits are expected with increased consumption of tef.

The research indicates that of the antioxidants in grains, phenolic compounds seem to be the most contributors to the antioxidant activity (Adom and Liu 2002). Although antioxidants in fruits and vegetables have received more attention from researchers and contain high levels of antioxidants, grains and grain products contribute to the most important food intake consistent with the nutritional guidelines (Food Standards Agency 2001), hence providing a substantial contribution to the antioxidant content within the diet. The research on antioxidants and antioxidant activity in Tef is extremely sparse. The sole published data on vitamin C content of Tef is by National Research Council (1996). Investigators reported 88mg/100g of vitamin C in Tef grains. This value is about average for cereal grain. Dykes and Rooney (2006) reviewed phenolic compound levels in millets, including sorghum, ragi, bulrush millet and Tef. It had been reported that Tef grain contained 0.09-0.15 mg/100mg catechin equivalents of phenolic compounds. The most phenolic compounds in Tef were ferulic acid (285.9μg/mg), vanillic acid (54.8μg/mg), cinnamic acid (46μg/mg), coumaric acid (36.9μg/mg) and protocatechuic acid (25.5μm/mg).

Tef grain features a high concentration of various nutrients with very high calcium content and a significant amount of the minerals iron, copper, phosphorus, magnesium, aluminum, zinc, boron, barium, and thiamin (Stallknecht, 1997). The difference in mineral content between and within different tef varieties is wide-ranging. Red tef contains higher iron and calcium content than white and mixed tef (Abebe et al., 2007). On the opposite hand, higher copper content than red and mixed tef were seen on white tef (Baye, 2014).The bioavailability of zinc and iron is reduced by the tannins present in cereals but the tannin content of foods can vary widely (Umeta et al., 2005). Umeta et al. (2005) reported injera prepared from tef, sorghum and maize, the tannin content was 2–3 times that of wheat injera. Fermentation during tef injera preparation showed a discount of phytic acid and tannin content of 75% and 55%, respectively, after 96 hours of fermentation (Urga et al., 1997). Furthermore, consistent with the study of Ramachandran and Bolodia (1984) fermentation of tef has resulted in the rise of the dialysable portion of iron, phosphorus and zinc content from 9%, 16% and seven, respectively, to 24%, 60%, and 43%, which can account for the enhancement of this mineral bioavailability in tef injera.

Health Benefits of Teff and Teff-Based Products

Iron Deficiency

Globally Iron deficiency is the most widespread micronutrient deficiency, affecting quite 2 billion people (Zimmermann and Hurrell 2007). Growth retardation, impaired mental and growth, child and maternal morbidity and mortality, and decreased immunity and work performance are among the adverse effects of iron deficiency. The etiology of iron deficiency includes diseases that induce excessive loss or cause malabsorption of dietary iron, low intakes of bioavailable iron, or increased requirements thanks to physiologic status (for example, pregnancy, infants, and young children) (Pasricha et al., 2013)

The bioavailability of iron in teff is probably going to vary counting on processing. as an example, during the fermentation of injera, significant decreases in phytate content leads to a perfect phytate to iron molar ratio (Umeta et al., 2005; Baye et al., 2014). As long as a part of the iron in teff has been attributed to soil contamination, to what extent molar ratios accurately predict iron bioavailability has been questioned (Baye et al., 2014). However, Bokhari et al., (2012) showed that the consumption of 30 percent teff-enriched wheat bread can help maintain serum iron levels in pregnant women. The study also suggested that degradation of phytates may cause better iron bio-availability. Given the high iron content of teff and its potential contribution to food-based approaches to enhance nutrition, further investigations on the iron bioavailability of teff are required.5 Indeed, if the bioavailability of iron in teff is often confirmed, teff is often a really good ingredient for celiac patients not only thanks to the absence of gluten but also for its high iron content.

Disorder

Worldwide, 0.6 percent to 1.0 percent of the population is suffering from the disorder. The prevalence of the disease in populations in danger of disorder is as follows: 3 to six percent in type 1 diabetic patients, up to twenty percent in first-degree relatives, 10 to fifteen percent in those with symptomatic iron-deficiency anemia, 3 to six percent in those with asymptomatic iron-deficiency anemia, and 1 to three percent in individuals with osteoporosis (Dubé et al., 2005). The disorder is caused by aberrant T-cell responses to glutens and gluten-like proteins found in wheat, barley, rye, and possibly oats (Arentz-Hansen et al., 2004). The symptoms include diarrhea, abdominal pain, and disturbances in nutrient absorption caused by histological alterations of the tiny bowel. Extra intestinal complications like osteoporosis, infertility and cancer have also been reported (Alaedini and Green 2005).

The only treatment for those with disorders available so far is to follow a strict diet (Fasano and Catassi 2001). This in practice is difficult given the abundance of food products containing wheat or other gluten-containing cereals. Consequently, inadequate intakes of essential nutrients like folate and vitamin B12 (Hallert et al., 2002), calcium, iron, and fiber are observed in those with disorders. Also, a better percentage of energy intake in such patients was found to be from fat rather than carbohydrates. This features a negative impact on their nutritional status (Bardella et al., 2000). Therefore, nutrient dense gluten-free alternatives are needed. Tef contains an honest amount of minerals, fiber, and phytochemicals. Compared with gluten-free cereals and pseudo cereals like quinoa, amaranth, buckwheat, maize, rice, and sorghum, teff is more nutrient-dense. Furthermore, the low glycemic index of teff may help maintain good glycemic control. This is often vital given the high incidence of diabetes in those with the disorder (Viljamaa et al., 2005).

Diabetes

The global incidence of diabetes is increasing alarmingly and has become a serious public ill-health (Danaei et al., 2011). The socioeconomic and health implication of this disease, particularly in low- and middle-income countries, are enormous. The onset and progression of diabetes are often pre- vented by modifying lifestyle factors, of which diet constitutes an excellent part (Hu 2011). Several features of teff suggest that its consumption may prevent or control diabetes. Diets high in whole grains are related to a 20 to 30 percent reduction in the risk of developing type-2 diabetes (Hu 2011). As long as teff is consumed as an entire grain, similar effects are often expected from the consumption of teff. Although the mechanism by which whole grains help with the prevention of type-2 diabetes isn't clearly elucidated, it's thought to be through the synergistic effects of the essential macronutrients and micronutrients also as phytonutrients.

Among macronutrients, the sort of carbohydrate and its digestibility play a central role in glucose levels after eating and hence on the danger to diabetes. Relative to wheat, teff features a low glycemic index and thus is best fitted to diabetic patients (Wolter et al., 2013). Additionally, the relatively high dietary fiber in teff relative to other common cereals can decrease fasting blood sugar levels and thus contribute to the prevention and management of diabetes (Post et al., 2012). The conditions of impaired antioxidant status and inflammation are linked to the event of insulin resistance and type-2 diabetes (Wellen and Hotamisligil 2005). During this regard, the high phytate and polyphenol content in teff (Abebe et al., 2007; 2007; Baye et al., 2014) and therefore the associated antioxidative property is probably going to stop and control diabetes (Munir et al., 2013). However, while studies to gauge the anti-diabetic property of teff consumption are of interest, thus far such studies are very limited.

Quality characteristics of tef flour

Different quality characteristics of tef flour were reported by many researchers in past years. Rheological, textural and pasting properties, flow ability, color, falling number, starch digestibility, thermal properties, starch damages, foaming capacity and foam stability, particle size distribution, water holding capacity, water absorption capacity, water absorption index and water solubility index and nutritional values (Abebe et al., 2015, Bultosa and Taylor, 2004, Bultosa 2007, Adebowale et al., 2011). However, study on the consequences of processing on quality characteristics of tef flour isn't sufficient.

Constraints of tef production in Ethiopia

Despite its major importance in Ethiopia as a source of food, feed, cash, and as a rescue crop, tef is reported to possess several production constraints. Hence, its national average yield is merely about 1.64 tons per hectare (CSA, 2017) which is way below its expected Assefa et al., (2011) as follows: low yield potential of the widely cultivated farmers' varieties; susceptibility to lodging especially undergrowth and yield promoting conditions; biotic stresses (diseases, insects, etc.); abiotic stress; the labor-intensive husbandry and therefore the weak seed and extension system. Thus, the poor extension linkage has hampered the penetration of improved varieties and production package to succeed in the specified level. As a result, most farmers within the larger parts of the country are still using local landraces or traditional agronomic practices. Such a wide gap between using improved production packages and using local landraces and cultural practices, is, therefore, seriously affecting the national productivity of tef. Besides, lodging may be a major production bottleneck causing a grain yield loss of 17 to 27% (Ketema, 1993) under natural conditions and 15 to 45% (Zhu et al., 2012) counting on the weather and varietal inherent nature. The very fact that tef production may be labor-intensive husbandry (requires up to 5 plowings) and therefore the difficulty of farmers to satisfy such requirement is another factor affecting the productivity of tef (Assefa et al., 2011). Good land preparation usually allows tef to grow better and become more competitive to weed so on increase yield (Hundera et al., 2000). Last but not least, inadequate research investment allocated to tef improvement at the national level and lack of worldwide attention thanks to its localized importance has been considered as another critical constraint of tef (Assefa et al., 2011).

SUMMARY AND CONCLUSION

Tef is an emerging small cereal grain crop presently being worldwide advocated as a food for people with gluten intolerance. It's one of the foremost popular and traditional crops in Ethiopia supporting over 50 million people for food security. Within the country, tef covers the most important cultivated area of production, but it remains a rock bottom yielder compared to other cereals. this yield level of tef needs significant improvement to achieve the demand for food security, to buffer the volatile market value of the grain which is most valued to form quality injera and consequently to extend the profitability of tef growers within the entire value chains of the crop. There's a possible export market of tef in countries like the USA and people in Europe.

Tef, perhaps the world's smallest cereal grain, consists of complex carbohydrates with slowly digestible starch. It is an identical protein content to other more common cereals like wheat but contains no gluten. Tef amino alkanoic acid composition is well balanced and contains relatively higher concentrations of lysine than what's commonly found in other cereals. Teff might be a moderately good source of essential fatty acids, fiber, minerals (especially calcium and iron), and phytochemicals, like polyphenols and phytates. Regardless of having a really good nutrient profile, tef consumption is restricted to Ethiopia and Eritrea. The limited knowledge of tef nutrient composition alongside processing challenges tackled in making tef-based food products adapted for international consumers has restrained its global use for human consumption.

Tef is among the foremost widely grown cereals in Ethiopia. The crop may be a staple diet of most of the population and therefore the most generally planted by farmers. Additionally, to the present, several basic studies especially in molecular and biotechnology are done which are vital for tef improvement. However, there are also many challenges are existed during this era. Such challenges are the nature of crops like the smallness of seed size, difficulties of crossing, shattering and lodging; Limited focus, mechanization problems and capacity building. A number of these challenges are relatively solved and a few are persisted.

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