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SUMMARY OF **ESSP WORKING PAPER 67**

Synopsis: **Teff: nutrient composition and health benefits**

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Teff (*Eragrostis tef*), has been cultivated and used for human consumption in Ethiopia for centuries. However, teff's global use for human consumption has been restrained partly due to limited knowledge about its nutrient composition and the processing challenges faced in making teff-based food products. Over the past decade, teff's gluten-free property has raised global interest. Consequently, literature on the nutritional composition, processing quality, and health benefits of teff has grown considerably. Compared to grain of other more common cereals, teff is superior in its nutrient composition. Its starch is slowly digestible; it is a good source of unsaturated fatty acids; and it is high in fiber and minerals, especially iron and calcium.

As a gluten-free cereal crop, studies on teff suggest that its consumption can help in managing celiac disease as well as possibly preventing and controlling iron deficiency and diabetes. Existing studies of the nutrition and health benefits of teff, however, are limited, since they fail to take into account differences in teff varieties and growing conditions. Nevertheless, the studies undertaken so far confirm teff's excellent nutrient profile and suggest it has considerable potential globally to be a functional food for health promotion and disease prevention.

Ethiopia's teff

Teff (*Eragrostis tef*) is an ancient tropical cereal that has its center of origin and diversity in the northern Ethiopian highlands, where it is believed to have been domesticated. Teff is a minor cereal crop worldwide. However, in Ethiopia and Eritrea it is a major food grain, mainly used to make *injera*, a traditional fermented pancake. In other countries like Australia, South Africa, and United States, it is principally used as a fodder or forage crop for feeding animals.

Relative to more common cereals like wheat, rice, and maize, little is known about the nutritional composition and potential health benefits of teff. This, along with technological limitations in processing teff, has long restricted more widespread consumption outside of its center of origin in the Ethiopian highlands. However, over the past decade the recognition that teff is gluten-free has spurred global research into teff by nutritionists and food scientists. Consequently, more studies on the nutritional composition of teff and its processing qualities have been done and the development of new teff-based products has accelerated.

Characteristics of teff grain

Teff is possibly the smallest grain among all commonly consumed cereals with an average grain length of about 1 mm. Its minuteness has nutritional and technological implications. Since teff grains are difficult to decorticate, the cereal is typically consumed as a wholegrain, improving nutrient intake for teff consumers.

In Ethiopia there are three main categories of teff: white (*nech*), red (*quey*) and mixed (*sergegna*). White teff generally grows only in the highlands and require relatively good growing conditions. This, along with higher consumer preference for white teff, may justify why it is the most expensive type of teff. However in recent years, red teff, which is believed to be more nutritious, is also gaining popularity among health-conscious consumers in Ethiopia.

Complex carbohydrates make up 80 percent of the teff grain, with a starch content of approximately 73 percent. The extent to which carbohydrate is digested and absorbed in the small intestine

and the speed at which this digestion takes place impacts a person's blood glucose levels. As a slowly digestible starch, teff provides recognizable health benefits. The average protein content of teff is similar to other more common cereals such as wheat, but teff has a richer and more balanced essential amino acid composition than most other cereals. Additionally, teff has no gluten, which makes it a valuable ingredient for the diet of individuals with celiac disease, as such individuals are gluten intolerant.

Cereals are not the best source of fat, but as they are often consumed in large quantities, cereals can contribute a significant amount of essential fatty acids to the diet. The most common cereals, like rice, maize and wheat, are consumed after processing and refining, processing which reduces their fatty acids content. However, as the whole teff grain is maintained and refining is limited, teff serves as a better source of fatty acids than do other cereals.

The dietary fiber content of teff is several fold higher than that of wheat, sorghum, rice, and maize. The reasons for this may be that whole grains have higher fiber content than decorticated ones and that small grains, like teff, have a relatively high proportion of high fiber bran (Bultosa 2007).

The difference in mineral content between and within teff varieties is wide ranging, as Table 1 shows. Nevertheless, teff has a higher iron, calcium and copper content than other common cereals. However, the very high reported iron content of teff has been contested, with such estimates being attributed to soil contamination (Ketema 1997; Abebe et al. 2007), probably due to the small size of teff grain resulting in increased contact with soil.

Table 1—Mineral content of teff grain compared to other cereals, mg/100g

Mineral	White teff	Red teff	Mixed teff	Maize	Sorghum	Wheat	Rice
Iron	9.5-37.7	11.6- >150	11.5- >150	3.6-4.8	3.5-4.1	3.7	1.5
Zinc	2.4-6.8	2.3-6.7	3.8-3.9	2.6-4.6	1.4-1.7	1.7	2.2
Calcium	17-124	18-178	78.8-147	16	5.0-5.8	15.2-39.5	23
Copper	2.5-5.3	1.1-3.6	1.6	1.3	0.41	0.23	0.16

Source: Abebe et al. 2007; Baye et al. 2014; Gebremariam et al. 2012; Kebede 2009; USDA 2013.

For minerals to be used for normal metabolic functions, they need to be absorbed through the small intestine, which depends partly on dietary factors such as phytochemicals. Phytates, a set of phytochemicals, are a common constituent of cereals and legumes and are the primary form of phosphorus storage in seeds. They traditionally were considered to be a major mineral absorption inhibitors and hence were, for a long time, referred to as anti-nutritional factors. Teff contains high amounts of phytates in comparison to other wholegrain cereals. Phytates can be degraded by different food preparation processes, e.g. cooking, fermenting, soaking, and germination. However, on the positive side, phytates have been shown to prevent kidney stones by serving as crystallisation inhibitor of calcium salts in biological fluids. They also have glucose lowering and anti-cancer properties.

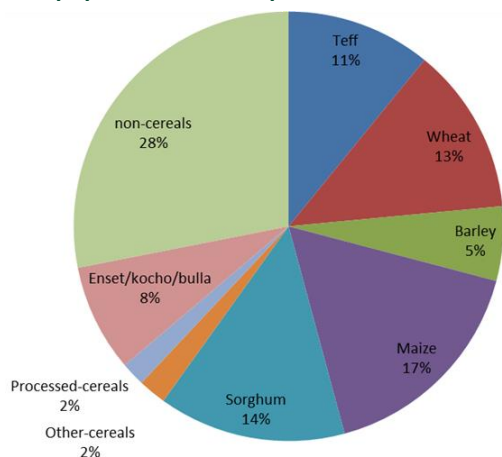
Polyphenols, another set of phytochemicals, are involved in the body's defenses against pathogens or ultraviolet radiation and help limit the risk of diseases associated with oxidative stress. Some types of polyphenols can hamper iron absorption, although this is not thought to be the case with teff (Baye 2013).

Consumption of teff in Ethiopia

Although teff has valued nutritional attributes, its consumption in the past was determined by its production and the challenges of processing the grain. However, with improvements in market linkages and technology, teff consumption patterns are changing. Teff is mainly used in Ethiopia for making *injera* – Ethiopia's national dish – but its use is diversifying into making other foods, such as teff-enriched bread. However, incorporating the grain into foods like bread to produce quality products is challenging.

In Ethiopia, teff contributes only 11 percent of the energy intake of the national population, yet the production figures suggest that it is a major staple.

Figure 1 -Contribution of different foods to the energy intake of the population of Ethiopia



Source: Berhane et al, 2011

Teff consumption may be decreasing over time. Indeed, the share of teff in household consumption has declined since 1999/2000, while that of maize, sorghum, and wheat have been rising (Berhane et al. 2011). Teff is the most expensive cereal in

Ethiopia, justifying its prominence in the food consumption of urban and semi-urban households with relatively higher incomes. With increases in urbanization and income, future demand for teff and therefore its consumption, is likely to increase in Ethiopia.

Teff as a global food

The unique qualities of teff's high mineral content and its gluten-free property have been recognized globally. However, incorporation of whole grains in bread making is often challenging. This is further complicated when gluten-free ingredients are used, since gluten plays an essential role in producing leavened bread with a fine open structure. Moreover, a lack of gluten sometimes has a negative effect on the sensory properties of the bread.

The use of enzymes and hydrocolloids to improve the texture and sensory properties of teff grain and teff flour in food production processes shows considerable promise. Although enzymes and hydrocolloids addition can improve the sensory attributes of teff-enriched or teff-based breads, there is a growing interest in reducing the use of such food additives. A good alternative is sourdough technology which can lead to improvements in the texture and shelf-life of breads into which teff has been incorporated.

The possibility of using teff for food products other than bread is being evaluated. Coleman et al. (2013) confirmed the suitability of teff flours for biscuits and cake making. Similarly, studies evaluating the possibility of using teff in pasta formulations, beer making, and gel-like food formulations have shown promising results. These efforts show that teff can be used in various products familiar to Western culture, especially in the formulation of a relatively wide range of gluten-free products.

Health benefits

Over the past decade, the growth in health consciousness, particularly in Western cultures, has raised the profile of this unique cereal of a high mineral content and gluten-free property. The possible health benefits gained from teff's consumption in preventing diabetes, preventing anemia through its high iron content, and its benefits in managing celiac disease, all point to the potential of teff to be a global functional food for health promotion and disease prevention.

Final remarks

This study has highlighted teff's unique properties as a cereal, yet has also exposed the limited knowledge globally available about this crop and its processing challenges within food industries. It is this lack of awareness and difficulties in processing teff that seem to have led to its geographical restriction for human consumption largely to Ethiopia and Eritrea and limited presence in global cereal markets. Overcoming the processing challenges and accelerating research into the health benefits of teff and how it can contribute to prevention of disease, along with research into better understanding variation in nutrient composition across teff varieties, could lead to significant expansion in the international market for teff and open up opportunities for human consumption at a global scale.

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