



## Teff: Nutritional Compounds and Effects on Human Health

Hacı Omer Yılmaz\* and Mahir Arslan

Nutrition and Dietetics, Gümüşhane University, Turkey

\*Corresponding Author: Hacı Omer Yılmaz, Nutrition and Dietetics, Gümüşhane University, Turkey

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### Abstract

For centuries, Teff (*Eragrostis tef*) has been planted and used in Ethiopia where it originated from. Teff is one of the major grains, mainly used a traditional bread in Ethiopia. In other countries such as South Africa, Australia and United States, it is principally used for animal feed. The global use of teff for human consumption has been restrained partly due to limited knowledge about its nutritional values and the processing challenges faced in making teff-based food products. Over the past decade, the discovery that teff does not contain gluten has raised interest across the world. As a result, number of researchers on the nutritional composition, and potential benefits of teff has increased considerably. The current literature suggests that teff contains complex carbohydrates with slowly digestible starch. Teff has a similar protein content to other cereals like wheat but is richer than other cereals in terms of lysine an essential amino acid. In addition, due to teff proteins contains a small amount of prolamin, they are presumed easily digestible. Teff is also a good source of essential fatty acids, fiber, minerals (especially calcium and iron), and phytochemicals such as polyphenols and phytates. Present studies about the nutrition and health benefits of teff are limited. Nevertheless, the studies undertaken so far suggest teff has considerable potential to be a functional food for health promotion and disease prevention. On the other hand, further research is needed to determine potential health impacts and alternative uses of teff.

**Keywords:** Teff; Functional Food; Nutrition

### Introduction

Teff [*Eragrostis tef* (Zucc.) Trotter] is a tropical cereal crop belonging to the family of Poaceae, subfamily Eragrostoidae, tribe Eragrosteae, and genus *Eragrostis*. It grows up to 3000 m from sea level but grows most efficiently between 1500 - 2500m altitudes. Teff' main center of the origin and diversification is Ethiopia, which covers about 1 in 3 of 8 million hectares used for cereal production and has an annual production approximately 3.8 million tons and almost all of which are consumed in the country [1]. Compared to other cereal crops, teff is a low-risk crop to drought and has become a highly preferred product by Ethiopian farmers because it is resistant to adverse weather conditions and feeds with rain [2].

Research on the nutritional, health and functional characteristics of teff has been increased probably due to its worldwide acceptance and the interest among consumers to know more about the health benefits of this cereal has also increased. The aim of this review was to summarize nutritional and health significance of teff.

### Compositions and effects on health

#### Carbohydrates

Total carbohydrate is the total of monosaccharides [3], disaccharides, oligosaccharides, polysaccharides and total dietary fiber while that of available carbohydrate excludes the dietary fiber. The total carbohydrate content of teff ranges from 57 to 86 g/100 g. However, a relatively low total carbohydrate content was reported in a study (57 g/100 g) [4]. Generally, the total carbohydrate content of teff varieties was determined at 83 - 86 g/100 g [5]. Studies have reported that the content of teff carbohydrates produced in different ecologies can change and have detected total carbohydrate content of 66% and 76%, respectively, in different types of teff grown in Ethiopia and the Netherlands [6,7].

#### Starch

Starch is divided as amylose and amylopectin macromolecules. Food processing affects to amylose: amylopectin rate. As a result of the studies, it was determined that the starch of the teff

changed between 20% and 31% depending on the product starch [6-8]. Amylose: amylopectin ratio of 20:80 are considered normal starchy foods. This increase is called high amylose starch [9]. High amylose starches require 150°C heat to be fully gelatinized in the presence of water. This temperature is not fully achieved under normal cooking conditions, resulting in low digestibility. Glucose linear chains in amylose form a complex with fatty acids and make hydrolytic enzymes difficult to access during digestion and starches containing higher amylopectin do not form the glucose lipid complex, which increases their vulnerability for easy access by hydrolytic [10]. The rate of teff' amylose was determined to be 21-22% as a result of the studies. In addition, the granules of teff starch are quite small. Teff gelatinization temperature is 66 - 80°C. Glycemic index of teff (74) is also lower than that of white rice (100), because of the slow digestion of the starch it contains [11,12]. Due to this property, it is particularly useful for diabetes patients [13].

### Dietary fibers

The American Association of Cereal Chemists defines dietary fiber as the "edible parts of plant or analogous carbohydrates resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine". The most recent Codex definition further added that dietary fibers should have "proven physiologic effects of benefit to health" [14]. Some of these physiologic effects include faecal bulking (laxation), lowering blood glucose levels after eating, and lowering plasma LDL-cholesterol [15]. Total and soluble dietary fiber content of teff is higher than wheat, rice and corn. There may be a few reasons for this. First, whole grains have a higher fiber content than the crustaceans. Second, small grained grains may have higher fiber content because of containing high bran [16]. For this reason, with the increase in consumption of teff, high dietary fiber intake will be achieved and protect the health. Teff contains high dietary fiber (5.12-3.7 g/100g) compared to other cereal products [5].

### Proteins

The average protein content of teff ranges from 8 to 11%, similar to other grains. Its main proteins are 45% glutelin and 37% albumin. Prolamin (12%) is a micromolecule. It has been reported that the amino acid pattern is also balanced, with high amounts of glutamine, alanine, leucine and proline. Also, lysine, an important limiting amino acid in cereals, has a relatively high concentration. Similarly, it contains higher isoleucine, leucine, valine, tyrosine,

threonine, methionine, phenylalanine, arginine, alanine and histidine compared to other cereals [17]. In addition to, teff is gluten-free. Because of this, teff is becoming a functional food and uses especially in foods produced for celiac disease [18].

### Lipids

Cereals are not specified lipid source but may be a good essential fatty acid supplier when considering daily consumption. The lipid content of teff (3.7%) was higher than a range of other Ethiopian staple grains such as maize and wheat [19]. Another comparative study showed that the lipid content of teff (4.4%) was higher than that of wheat (3.6%), rice (0.9%), sorghum (3.5%), and maize (2.5%) flours, and was lower than that of oat (6.7%) and quinoa (8.6%) [20]. Fatty acids have important effects for growth, development and future health problems. For example, the intake of omega-3 fatty acids (a-linoleic acid) has been found to reduce biological markers associated with cardiovascular disease, cancer, inflammatory and autoimmune diseases [21]. Teff' lipid content is higher than wheat and rice, but lower than corn. In addition, the intake of omega-3 and omega-6 fatty acids are decreasing due to the refining processes of these widely consumed grains. Raw grain is richer than those refined in terms of fatty acids. Teff predominantly contains oleic acid (32.4%) and linoleic acids (23.8%). Optimal ratio between linoleic acid and a-linoleic acid is not exactly clear, but the ratio of 5 to 15 is recommended for formulas used for infants. This ratio is 7:1 in teff, which is acceptable compared to legumes, a good fatty acid source [4].

### Minerals

There are a wide range of mineral content among the varieties of teff. Red teff has higher iron and calcium content than mixed or white teff. On the other hand, white teff has a higher copper content than red and mixed [22]. The contents of a range of minerals of teff grain (1 variety, uncooked) including Ca (180 mg/100 g), Fe (7.63 mg/100 g), Mg (184 mg/100 g), P (429 mg/100 g), K (427 mg/100 g), Na (12 mg/100 g), and Zn (3.63 mg/100 g) (wet basis) were reported. Another study showed that the Fe, Zn, and Ca contents of whole grain teff were 31.6, 2.31, and 78.8 mg/100 g (dry basis), respectively [23]. In one study, 12 different types of teff and 5 types of teff grown in a sericulture were reviewed and it is indicated that genetic and environmental factors affected the iron content of teff. When different ecological environments are ignored, teff has higher content of iron, calcium and copper than other grains. Moreover, the zinc content of teff is higher than that of wheat and sorghum [24].

## Vitamins

Vitamins of teff include that niacin: 3.363 mg/100 g, vitamin B6: 0.482 mg/100 g, thiamin: 0.39 mg/100 g, riboflavin: 0.27 mg/100 g, vitamin K: (phylloquinone) 1.9 mg/100 g, vitamin A: 9 IU, and a-tocopherol: 0.08 mg/100 g [25]. These values may be different due to analytical techniques and teff genotypes.

## Polyphenols

Polyphenols are secondary metabolites that participate in defense of plants against pathogens or ultraviolet radiation [26]. Polyphenols protect cell components against oxidative damage and reduce oxidative stress-related disease risk [27]. Teff' polyphenol content is moderate, when it compared to other grains. Ferrulic acid is the main component of phenolic acid in teff. Phenolic acids in teff do not have galloyl and catechol functional groups and are therefore less incline to inhibiting iron absorption. This suggests that it may be possible to utilize teff' anti-oxidative properties. Briefly, the polyphenol content of teff does not inhibit iron bioavailability [28].

## Conclusion

As a result, teff is superior to other grains in terms of some nutritional values and composition. Various teff-based food products have been developed, the majority of which being gluten free. These include injera, pasta, bread, sourdough, cookie, extrudate, fat replacer, weaning food, malt, and lactic acid beverage. These food products tend to have desired nutritional quality such as gluten free, enhanced dietary fiber contents, and reduced glycaemic index. It has balanced amino acid composition. Teff is also a good source of unsaturated fatty acids and has a balanced linoleic: alpha linoleic acid ratio. In addition, it has rich content in point of iron and calcium minerals. Also, it contains high dietary fiber and phytochemicals. Because of these properties, teff is a functional food for the health development and prevention of diseases. The production and consumption of teff, although widely available in Ethiopia and Eritrea, is expected to increase over time in the world due to its functional properties.

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