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Foxtail Millet (*Setaria italica*): A Detailed Review on Nutritional Value, Anti-Nutritive Value, Potential Health Benefits

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Abstract

Millets are a diversified collection of small-seeded grasses that have been used as a primary source of grain for generations in various regions of Asia and Africa. Millets are a staple grain this is historically consumed in dry regions everywhere in the international. They are high in protein, fats, minerals, nutrients, and fiber. Millets are highly nutritious grains rich in essential amino acids, minerals, and dietary fiber, offering health benefits such as managing diabetes and improving cardiovascular health. Key millet varieties embody foxtail millet (Setaria italica), proso millet (Panicum miliaceum), barnyard millet (Echinochloa spp.), finger millet (Eleusine coracana), pearl millet (Pennisetum glaucum), and small millet (Panicum sumatrense). Various processing methods like roasting, milling, germination, and fermentation are used to enhance the bioavailability of nutrients in millets by reducing anti-nutritional factors. Including millets in agricultural practices can help deal with the problem of hunger, enhance sustainable agriculture, and assist objectives concerning vitamins, food protection, and mitigating the outcomes of climate exchange. Millets possess exceptional nutritional value, being rich in protein, fiber, vitamins and minerals. Their inclusion in diets helps combat malnutrition and achieve Zero Hunger (SDG 2). These climate-resilient crops require fewer resources including water and contribute to Clean Water and Sanitation (SDG 6). Millets are also gluten-free, low glycemic index alternatives that promote Good Health and Well-being (SDG 3). In phrases of millet production, foxtail millet is ranked second globally and keeps maintaining a outstanding position. Its significance as a meals that is right for diabetics is widely known. It is rich in dietary fiber, minerals, micronutrients, protein, and has low glycemic index (GI).

Keywords: Millet, Foxtail Millet, Sustainable Development Goals, Glycemic Index, Anti-nutritional factors.

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INTRODUCTION

Agricultural development and food security are dependent on our ability to effectively and sustainably expand the range of underutilised crops. There's a need to introduce these alternative, sustainable crops in common households in order to fulfil their nutritional needs and to combat malnutrition and other health problems [1–2]. Wheat and rice offer food security, but millets along with the food security provide various other security benefits such as health, nutrition, livelihood and animal feed. Therefore millets are the sustainable crop of the present times [3–5].

Millets are commonly perceived as a diverse collection of small-seeded grasses, extensively cultivated globally as cereal crops or grains for both

human consumption and animal fodder. Small-seeded grasses, millets thrive in arid regions of Asia and Europe [6]. They are known as poor people's food because they are less expensive than wheat and rice. In terms of protein, mineral, and vitamin content, they are three to five times more nutritious than grains that are typically consumed [7]. For underprivileged and economically vulnerable populations, millets' special nutritional and nutraceutical qualities contribute to nutritional security [8]. India can make giant progress toward accomplishing several Sustainable Development Goals (SDGs) concerning meals protection, nutrients, sustainable agriculture, mitigating climate exchange, and biodiversity maintenance by using incorporating millets into agricultural practices and dietary conduct. The foremost goal of incorporating millets into the system is to combat hunger [9–10].

Foxtail Millet

Millets have recently been acknowledged as substantial replacements for main cereal crops in order to cope with global food storage and fulfil the demands of both developing and developed countries' growing populations. Millets are also known for their tolerance to various agro-ecological conditions including a semi-arid climate and nutritionally deficient soil, and its cultivation need little inputs and produces extremely nutritious grains. Among all millets, here's brief discussion about foxtail millet, benefits and properties [11–13].

The historic crop known as foxtail millet (Setaria italica) is a member of the Poaceae circle of relatives's Setaria genus. It is the sector's second-largest manufacturer of millet and maintains to play a prime role in agriculture globally, generating about six million lots of meals yearly. It is a significant crop that is consumed as a staple meal in many regions of the globe. The crop has been cultivated in China for 8000 years and has moved through southern Europe and western part of India. People in ancient China used a combination of Foxtail millet (*Setaria italica*) and proso millet (*Panicum miliaceum*) cultivation [14–15]. Due to its rapid growth and capability to thrive in numerous elevations, soil types, and temperatures, it serves as a handy quick-time period crop for human intake and as feed for rooster and cage birds. Foxtail millet with its 1482 accessions of germplasm is cultivated in Asian and African countries including India [16].

In India, foxtail millet is known as kangni, tinai, camai, kavalai, kambankorai.

Foxtail millet is also known by various alternative names such as Italian millet, Italian foxtail, German millet, Siberian millet, and Foxtail bristle grass. It is ideal for dryland and hilly agriculture because it is resistant to environmental stress conditions such as heat, drought, salt, and poor soil quality [17–18].

Foxtail Millet and Nutritional Properties

Nutritive value of foxtail millet is completely comparable to whole wheat, bengal gram and semolina. It is a good source of minerals and vitamins which strengthen the immune system by fighting back against the diseases and germs. It has low glycemic index which is very beneficial for type 2 diabetic patients [19]. The popped foxtail millet contained significantly lower amount of crude fiber and crude fat whereas higher energy and carbohydrate content as compared to raw foxtail millet [20].

The foxtail millet are rich of calcium, protein, dietary fibers, and polyphenols make millets unique among other common cereals. They contain essential amino acids like isoleucine, leucine, valine, histidine, and tryptophan, apart from sulfur-containing amino acids like cysteine and methionine [21]. Foxtail varieties that are yellow seeded, possess therapeutic properties such as constringent, palliative and assist in digestion. The yellow pigments present in millet are mostly cryptoxanthin, zeaxanthin and xanthophyll. The content of yellow pigment (mg/kg) is 10.1–16.4 in gray millet, 5.4–19.6 in yellow millet and 1.1–2.5 in white millet [23–24]

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Foxtail Millet and Anti-nutrients

Foxtail millet possess anti-nutrients like tannins, phytates, polyphenols, and trypsin inhibitors.

These anti-nutrient factors are affected by various processing methods and can enhance or reduce micronutrient and macronutrient bioavailability. Foxtail millet is considered to be rich in phytochemicals. Phytochemicals are plant bioactive elements that improve health and are primarily produced by plants to protect them. Antioxidants, phenolics, flavonoids, isoflavonoids and anthocyanidins come under wide spectrum of health-promoting phytochemicals. The phenolics in foxtail millet works as antioxidants, lowering the quantity of free radicals created in the body [25]. They're also recognised for their capacity to reduce, metal chelate, and quench reactive oxygen. The fibre has even been found to have considerable free radical scavenging, reducing power, and ferrous ion chelating properties. with so many nutritious and health-promoting components, it's feasible that foxtail millet can be used as a food supplement [26].

Foxtail Millet and Health Benefits

Traditionally, malting or fermentation methods had been frequently used to technique millets. The ensuing fermented and malted flours have been broadly used inside the production of beverages, quick mixes, weaning ingredients, and prescribed drugs. Malting of grains improved its vitamin C content and phosphorus bioavailability along with synthesis of amino acids like lysine and tryptophan. Physico-chemical properties are the functional characteristics that are reflected by a food product. It describes the nature, intrinsic parameters, extrinsic parameters and overall quality of the product [27]. It varied from one food component to the other one. It describes the relationship between the molecular conformation, structure and composition of the food products with the external environment. The behavior of new proteins, fats, carbohydrates and fiber is also measured and whether conventional proteins can be replaced or enhanced by addition or utilisation of new proteins [28–30]

One of the most without problems digested and hypoallergenic grains, foxtail millet is rich in crucial amino acids, fatty acids, and minerals which are useful to human fitness. Its ability to adapt to abiotic stress associated climate change facilitated development of high-quality grain that satisfies consumers.

Compared to rice, particularly polished rice, millets produce much less glucose over a longer time frame, which lowers the threat of growing diabetes [31]. The boom in the prevalence of diabetes international is ascribed to various factors, inclusive of urbanization, getting old populations, rising obesity prices, and sedentary life. Small dietary changes and the use of low dosages of medicine are often important for the treatment of diabetes. When it involves protein, electricity, vitamins, and minerals, millet grains outperform different cereals and provide an amazing nutritional value. Beside, they are a rich source of dietary fiber, phytochemicals, non starchy polysaccharides and have a low glycemic index [32].

A dietary approach focused on enhancing both diabetes management and reducing cardiovascular risk factors involves the adoption of diets with a low glycemic index. However, they also possess anti-nutrients like tannins, phytates, polyphenols, and trypsin inhibitors. These anti-nutrient factors are affected by various processing methods and can enhance or reduce micronutrient and macronutrient bioavailability [33]. To achieve the absorption of nutrients by the intestine, the nutrients must be released from the food matrix and should be mixed with the corresponding biological fluid. The release of nutrients from food is based on the physicochemical characteristics of the food matrix like morphology, size, electric charge, load degree, etc. It can be measured by estimating the amount of nutrient available for intestinal absorption using in vitro methods, simulated in vitro gastric and small intestinal digestion processes and through the uptake of Caco-2 by the cells [34].

Methods to Increase Bioavailability of Nutrients by Different Processing Method

Food structure plays a major role in affecting the bioavailability of the nutrients from millets. Both the bodily and enzymatic breakdown of food, which promotes the discharge of absorbable nutrients in the gastrointestinal tract, have a large position in how plenty of the nutrients in food may be absorbed with the aid of the body.

In addition, millets also contain anti-nutritional factors such as phytates, tannins, and polyphenols. The presence of these anti-nutritional factors exhibit adverse effects [35]. The presence of these factors exhibiting metal chelating and enzyme inhibition activity results in the formation of extremely insoluble salts, which leads to a significant reduction in the bioavailability of minerals. Various traditional food processing methods like roasting, milling, germination, malting, fermentation etc. are utilized for food products prepared from millets to enhance the nutritional and sensory properties. Both dietary and physiological factors influence the bioavailability of nutrients in millets. Factors that affect the nutrient release include the localization of nutrients within the food matrix, the physical condition of the food during breakdown, enzymatic/chemical breakdown of the food during ingestion and initial digestion. Availability of a suitable lipid phase also influences nutrient release by forming micelles with long chain fatty acids [34–36].

Food processing significantly influences the nutrient bioavailability in humans. Processing and value addition of millets involves several unit operations. These processing steps, depending on the methods and severity, can have remarkable effects on the nutritional bioavailability of millets

The FAO (Food and Agriculture Organization of the United Nations) reports that traditional food processing techniques such as decortications, milling, germination, fermentation, malting, and roasting can enhance both organoleptic and nutritional properties [37–40].

For example, milling can alter the food structure and increases the glycemic response. Processing techniques have significant impact on the GI of foods. Semi-refined flour showed a low level of anti-nutrients and increased mineral bioaccessibility. Studies have also documented a 80% reduction in the phenolic content of dehulled millets. Hydrothermal treatment and germination can also alter the phenolic content of millets.

In addition, soaking followed by cooking can contribute to the reduction of anti-nutrients in millets, and in turn contribute to the enhancement of nutrient bioavailability [41]. For example, a dehulling–soaking–cooking process is known to decrease the levels of phytate and polyphenols, thereby enhancing the bioavailability of iron, zinc, and in vitro protein digestibility. Altogether, processing of millets significantly influences nutrient bioavailability in human. Studies report that fermentation increases the bioavailability of nutrients such as minerals, proteins, and dietary fiber by limiting the action of tannins, phenols, phytate, and trypsin inhibitors [42].

The above information makes it clearly evident that foxtail millet is a complete nutritional package it has good amount of high biological value protein and has low fat and also has moderate amount of dietary fiber and has low glycemic index. Foods containing carbohydrates are labeled using a numerical scale by means of the glycemic index. A low-GI weight-reduction plan might also assist with weight control, probable selling weight reduction or supporting one keep a wholesome frame weight. Making healthier meal choices could be aided by using the glycemic index as one tool rather than the primary instrument.

CONCLUSION

This paper provides information on the nutritional composition, health benefits, and processing methods of millet grains, with a focus on foxtail millet. It highlights the importance of millets in addressing malnutrition, achieving sustainable agriculture, and contributing to food security and climate change mitigation goals. Millets are grains with high nutritional value, containing essential amino acids, minerals, and dietary fiber in abundance. Various processing methods like roasting, milling, germination, and fermentation are used to enhance the bioavailability of nutrients in millets. Second inside the global's millet production scores, foxtail millet is well-known for its many fitness advantages, in particular its excessive protein, fiber, diet, and mineral content. Millets are gluten-free, low glycemic index alternatives that promote good health and well-being, combat malnutrition, and contribute to sustainable development goals.

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