



A Review on Nutritional and Health Benefits of Millets

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This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Millets are esteemed for their healthy benefit incorporates nutrients, minerals, carbohydrates, and dietary filaments source and potential medical advantages. Millets have gained attention in recent years due to their remarkable nutritional composition and potential health-promoting properties.

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This review examines the diverse types of millets, their historical significance, and their distribution across different cultures. The paper highlights millets' rich nutrient content, including proteins, dietary fibers, vitamins, and minerals, making them a valuable addition to a balanced diet. Furthermore, it explores the gluten-free nature of millets, catering to individuals with specific dietary requirements. The health benefits of millet consumption are discussed, focusing on their potential in preventing and managing chronic diseases like diabetes and cardiovascular disorders. The presence of bioactive compounds, such as antioxidants and polyphenols, is investigated for their role in supporting these health benefits. Additionally, the review discusses the impact of millets on gut health and their future prospects to global food security and sustainability. Overall, the findings underscore millet as a promising and nutritious option for enhancing human health.

Keywords: Millets; nutritional value; health benefits of millets.

1. INTRODUCTION

The international year of Millets was celebrated in 2023 recognizing their importance by the government. As ancient crops with a long history of cultivation, millets have played a crucial role in providing sustenance to diverse cultures worldwide. Roti, produced using pearl millet has been the essential food of farmers in the state of Gujrat [1]. In the context of evolving dietary patterns and increasing health awareness, millets have emerged as a promising nutri-cereal crop with the potential to address various nutritional and health challenges. They can get through cruel climatic circumstances and are extremely tolerant to drought [2]. They are significant dietary sources of energy [3]. They can flourish without the utilization of pesticides since they are Resistant to various types of diseases prevailing in society [4]. Some common types of millets include Pearl Millet (*Pennisetum glaucum*), known for its drought tolerance and rich source of iron and calcium; Finger Millet (*Eleusine coracana*), recognized for its high protein content and

essential amino acids the nation .; Foxtail Millet (*Setaria italica*), a gluten-free grain rich in fiber and minerals like iron and magnesium; Sorghum (*Sorghum bicolor*), often considered a millet, valued for its antioxidant properties and dietary fiber; and Proso Millet (*Panicum miliaceum*), a significant source of B-vitamins, iron, and calcium. These millet varieties offer diverse culinary applications and contribute to sustainable and nutritious diets worldwide. They are viewed as the Nutri-cereals of today and the coarse grains of yesterday due to the excellent quality of nutrients present in it [4]. In order to address the dietary requirements of the world's population, millets have seen a steady increase in production over the past few decades. All important constituents including protein, carbs, fat, minerals, vitamins, and bioactive substances, are abundant in millets, making them a great food source The tendency of millet fiber can lower harmful cholesterol causing improvements in good cholesterol in humans [5]. Table 1 shows the Type, Common Name, botanical name, origin, and uses of millets.

Table 1. Type, Name, origin, uses of millets [6]

Type of Millet	Common Name	Botanical Name	Origin	Uses
Pearl Millet	Bajra	<i>Pennisetum glaucum</i>	Africa	Human consumption, livestock feed, biofuel
Finger Millet	Ragi	<i>Eleusine coracana</i>	East Africa	Staple food, porridge, baking
Foxtail Millet	Kangni	<i>Setaria italica</i>	East Asia	Human consumption, bird feed, brewing
Proso Millet	Barri	<i>Panicum miliaceum</i>	Eurasia	Human consumption, bird feed, alcoholic beverages
Little Millet	Kutki	<i>Panicum sumatrense</i>	India	Human consumption, livestock feed
Kodo Millet	Kodra	<i>Paspalum scrobiculatum</i>	India	Human consumption, bird feed
Barnyard Millet	Sanwa	<i>Echinochloa frumentacea</i>	India	Human consumption, bird feed, livestock feed

2. NUTRIENT CONTENT OF MILLETS

Millets indeed possess a rich nutrient content that contributes to their nutritional and health benefits. Millets are recognized for their relatively higher protein content compared to other major cereals. Table 2 explains protein, dietary fiber, vitamins, and minerals in different types of millet crops. For instance, finger millet (*Eleusine coracana*) contains about 7.7-12.3% protein, while foxtail millet (*Setaria italica*) contains approximately 8-12% protein [7,8]. Proso millet (*Panicum miliaceum*) has been reported to contain 10-15% protein (Saleh et al., 2013). The protein content in millets makes them an essential source of plant-based protein in various diets. Millets are abundant in dietary fibers, which consist of both soluble and insoluble forms. The dietary fiber content in millets contributes to various health benefits, including improved digestive health and management of blood sugar levels. For example, barnyard millet (*Echinochloa frumentacea*) contains approximately 11-15% dietary fiber [9]. Similarly, finger millet (*Eleusine coracana*) is reported to have a dietary fiber content of about 3.6-5.8% [10]. Millets are rich in various B-complex vitamins and other essential vitamins. For example, pearl millet (*Pennisetum glaucum*) is known for its high content of niacin (B3) and thiamine (B1) [11]. Finger millet (*Eleusine coracana*) is a good source of riboflavin (B2), niacin (B3), pyridoxine (B6), and

folate (B9) [10]. Millets are rich in essential minerals like magnesium, phosphorus, manganese, and zinc. Finger millet (*Eleusine coracana*) has been reported to contain a higher concentration of calcium, iron, and zinc compared to other millets [10]. Pearl millet (*Pennisetum glaucum*) is known to be a good source of iron and zinc [11]. The principal capability of dietary starch is to supply energy [12]. Millets are also rich in antioxidants, which help combat oxidative stress and reduce the risk of chronic diseases. Foxtail millet (*Setaria italica*) and proso millet (*Panicum miliaceum*) have been found to contain significant amounts of phenolic compounds and flavonoids, exhibiting strong antioxidant activity [13]. Millets by and large contain critical measures of fundamental amino acids especially the sulfur-containing amino acids (methionine and cysteine); they are likewise higher in fat substance than maize, rice, and sorghum [14].

Millets likewise help in losing weight, diminishing the risk of colon disease, diminishes high BP, helps in easing back muscle degradation, helps in rest, helps in alleviating, menstrual cramps. Concentrates by Eunyoung Lee et al. [16] recommend that millets seed oil enacts beta-catenin flagging and promotes hair development which is valuable for forestalling or treating androgen etic alopecia by advancing hair development.

Table 2. Nutritional content in millets [15]

Millet Type	Protein (%)	Dietary Fiber (%)	Vitamins	Minerals
Pearl Millet	8-18	2-3	Thiamine (B1), Niacin (B3)	Magnesium, Phosphorus, Iron, Zinc
Finger Millet	7.7-12.3	3.6-5.8	Thiamine (B1), Riboflavin (B2), Niacin (B3), Pyridoxine (B6), Folate (B9)	Calcium, Iron, Phosphorus, Zinc
Foxtail Millet	8-12	5-8	Thiamine (B1), Niacin (B3), Folate (B9)	Magnesium, Phosphorus, Iron, Zinc
Proso Millet	10-15	1.2-12	Niacin (B3), Pyridoxine (B6), Folate (B9)	Magnesium, Phosphorus, Potassium, Zinc
Little Millet	7-12	6-9	Niacin (B3), Folate (B9)	Magnesium, Phosphorus, Iron, Zinc
Kodo Millet	8-11	8-9	Thiamine (B1), Niacin (B3), Folate (B9)	Magnesium, Phosphorus, Iron, Zinc
Barnyard Millet	6-11	11-15	Thiamine (B1), Niacin (B3), Folate (B9)	Magnesium, Phosphorus, Iron, Zinc

3. HEALTH BENEFITS OF MILLETS

Millets are coarse grains just similar to crops like wheat and rice grown subsequently in the Indian subcontinent. Millets are nutritional powerhouses, offering a range of essential nutrients that are vital for human health. They are rich in dietary fiber, which aids in digestion, promotes satiety, and helps maintain a healthy weight. Millets are also excellent sources of protein, essential vitamins (particularly B-complex vitamins), and minerals such as iron, calcium, magnesium, and zinc. These nutrients play crucial roles in supporting various bodily functions, from energy metabolism to immune system function. Incorporating millets into diets can help bridge nutrient gaps and improve overall nutritional status. The grain is additionally wealthy in phytochemicals, including phytic corrosive, which is believed to bring down cholesterol, and phytate, which millets related with decreased disease risk [17] have been recognized for their positive impact on gut health due to their high dietary fiber content and prebiotic properties. Dietary fiber in millets helps promote regular bowel movements, prevent

constipation, and support overall digestive health [18]. The prebiotic effect of millet fibers nourishes beneficial gut bacteria, such as Bifidobacteria and Lactobacilli, leading to a balanced gut microbiome [19]. A diverse and balanced gut microbiome is associated with various health benefits, including improved immune function, reduced inflammation, and enhanced nutrient absorption. Millets are also rich in cancer preventing compounds including antioxidants [20]. Table 3 represents health benefits with the descriptions of millets.

Millets offer a plethora of health benefits due to their rich nutrient content and low gluten content. They are excellent sources of fiber, aiding digestion, and promoting a feeling of fullness, thus supporting weight management. These grains have a low glycemic index, regulating blood sugar levels and reducing the risk of diabetes. Foods with a low GI are known to cause a slower and more gradual rise in blood sugar levels, making them suitable for individuals with diabetes. Millets' low GI can contribute to better blood sugar management and reduce the risk of type 2 diabetes. Furthermore, their soluble

Table 3. Health benefits of millets

Health benefits	Descriptions
Cardiovascular Health	Millets contain antioxidants, fiber, and certain phytochemicals that support heart health and may help reduce the risk of cardiovascular diseases [13] Millet consumption has been associated with improved lipid profiles, such as reduced LDL cholesterol levels [21].
Diabetes Management	Millets have a lower glycemic index compared to other grains, which can help manage blood sugar levels and reduce the risk of type 2 diabetes [22]. The high fiber content in millets also contributes to better blood sugar control [23]
Digestive Health	The dietary fiber in millets supports healthy digestion and may prevent constipation (Saleh et al., 2013). Millets have prebiotic effects, promoting the growth of beneficial gut bacteria and supporting overall gut health [19]
Weight Management	The high fiber content in millets provides a feeling of fullness, helping in weight management and appetite control [21]. Millets are considered a good option for weight loss diets due to their nutrient density and lower caloric content [24]
Gluten-Free Alternative	Millets are naturally gluten-free, making them suitable for individuals with celiac disease or gluten sensitivity [25]. The inclusion of millet in gluten-free diets can add essential nutrients and variety to the menu [26]
Antioxidant Properties	Millets are rich in antioxidants, such as phenolic compounds and flavonoids, which help neutralize free radicals and protect against oxidative stress .Antioxidants contribute to overall health and reduce the risk of chronic diseases [19] .
Nutrient-Rich Food Source	Millets are excellent sources of essential nutrients like proteins, vitamins, and minerals (Bhullar et al., 2018). Including millets in the diet can help meet nutrient requirements and promote overall health and well-being [21]
Sustainable Agriculture	Millets are resilient to adverse environmental conditions, require less water, and have a lower carbon footprint compared to major cereals. Cultivating millets supports sustainable agricultural practices and can contribute to food security [24]

fiber content aids in lowering cholesterol levels, thus promoting cardiovascular health. Regular consumption of millets can be a preventive measure against two of the most pressing public health challenges - diabetes and cardiovascular diseases. Packed with essential minerals like iron, magnesium, and phosphorus, millets boost bone health and prevent anemia. They are gluten-free, making them suitable for celiac patients and aiding gut health. Additionally, millets are rich in antioxidants, helping combat free radicals and reducing the risk of chronic diseases. Incorporating millet into the diet promotes overall well-being.

4. USES OF MILLETS

Millets, once considered traditional grains, have re-emerged as nutritional powerhouses and sustainable alternatives to mainstream cereal crops. Their versatility and health benefits have led to their incorporation into various culinary, agricultural, and industrial domains. This section explores the multifaceted uses of millets. Millets,

such as pearl millet (bajra), finger millet (ragi), and foxtail millet, are staple foods in many regions due to their nutritional content [27]. Rich in dietary fiber, vitamins, and minerals, they contribute to balanced diets and address malnutrition concerns, especially in developing countries. Millets lend themselves to a plethora of culinary creations. From porridges and flatbreads to dosas and idlis, millets offer a unique flavor profile and desirable texture [28]. Their gluten-free nature appeals to those with gluten sensitivities, widening their culinary reach. The nutritional density of millets has made them popular choices for health-conscious consumers. Millet-based snacks, such as baked goods, energy bars, and puffed millet treats, offer a nutritious alternative to conventional processed snacks [29]. Millet-based beverages like ragi malt and millet-based smoothies are gaining traction as wholesome options. These beverages provide sustained energy release, making them ideal for active individuals [30]. Millets are utilized in the production of nutritional supplements, owing to their micronutrient content. Millet-based

Table 4. Uses of different kinds of millets

Type of Millet	Description	Primary Uses
Pearl Millet (Bajra)	A drought-resistant millet with a high nutritional content, rich in iron and fiber. [36]	- Staple food - Porridges and flatbreads - Livestock feed - Traditional alcoholic beverages
Finger Millet (Ragi)	Known for its high calcium content and low glycemic index, finger millet is especially beneficial for diabetes management. [37]	- Porridges and malted beverages - Baked goods and snacks - Nutritional supplements
Foxtail Millet	A gluten-free millet with a good balance of essential nutrients. [38]	- Staple food - Idlis and dosas - Bird feed
Proso Millet (Panicum miliaceum)	A fast-growing, adaptable millet rich in B vitamins and minerals. [39]	- Human consumption - Bird and poultry feed - Soil improvement
Little Millet	A small-grain millet rich in dietary fiber and minerals. [40]	- Staple food - Porridges and rice dishes - Traditional dishes
Barnyard Millet	A fast-growing millet with a mild flavor and a good source of protein.	- Staple food - Popped millet snacks - Animal feed
Kodo Millet	Nutrient-rich millet with a low glycemic index, suitable for diabetes management. [41]	- Human consumption - Traditional dishes - Crop rotation and soil improvement
Sorghum (Jowar)	Though technically not a millet, sorghum is often included due to its similar characteristics and uses.	- Human consumption - Animal feed - Biofuels and industrial applications

supplements cater to the needs of diverse consumer segments, including athletes, children, and the elderly [31]. Millets are valuable components in animal feed formulations. They provide essential nutrients to livestock and poultry, contributing to animal health and quality product outcomes [32]. Millets are valuable in agroecological systems. They exhibit drought tolerance and low water requirements, making them suitable for rain-fed agriculture. Their root systems improve soil structure, aiding in erosion control [33].

Millets find application beyond the culinary world. Their starch content makes them useful in paper, textile, and adhesive industries [34]. Millets contribute to biodiversity conservation. Their cultivation supports agroecosystem diversity and can play a role in mitigating climate change and preserving genetic resources [35]. The multifaceted uses of millets underscore their significance in modern agriculture and dietary patterns. Table 4 describes about the uses of different kinds of millets. From being staple foods to driving innovative culinary creations and finding applications in industries, millets offer a tapestry of possibilities. Their incorporation promotes health, sustains agriculture, and supports biodiversity. As consumers and industries increasingly recognize their value, millets transition from being traditional grains to modern superfoods, embracing both heritage and innovation.

5. CONCLUSION

Millets are nutritional powerhouses that offer a wide array of health benefits. These ancient grains are a valuable source of essential nutrients, including fiber, minerals, and antioxidants, contributing to improved digestion, bone health, and disease prevention. Their low glycemic index makes them an ideal option for maintaining stable blood sugar levels and managing diabetes. Moreover, their gluten-free nature makes millets suitable for individuals with celiac disease and supports a healthy gut. Embracing millet as a regular part of our diet can lead to enhanced overall well-being and a healthier lifestyle. With their versatility and numerous health advantages, millets undoubtedly deserve a prominent place in our daily food choices.

6. FUTURE PROSPECTS

The future prospects of the nutritional and health benefits of millets appear promising due to

increasing awareness of their nutritional value, sustainability, and potential to address global health challenges. Consumers are becoming more health-conscious and are seeking nutritious and sustainable food options. Millets, being rich in essential nutrients and gluten-free, align with these preferences, leading to an increased demand for millet-based products. Ongoing research on millets' nutritional composition and health benefits continues to unveil new insights. Studies on the bioactive compounds in millets, such as antioxidants and polyphenols, shed light on their potential role in disease prevention and health promotion. Millets are known for their resilience to adverse environmental conditions, requiring less water and inputs compared to major cereal crops. Their cultivation supports sustainable agriculture and can contribute to climate change mitigation. The nutritional composition of millets makes them suitable for addressing malnutrition and dietary deficiencies, especially in resource-constrained regions. Millets can play a vital role in achieving food and nutrition security goals. Increasing efforts in product development and innovation have led to a wide range of millet-based food products, catering to diverse consumer preferences. These products include millet-based snacks, cereals, beverages, and bakery items [42]. Many countries are recognizing the significance of millet in improving nutrition and promoting sustainable agriculture. Governments are implementing policies to promote millet cultivation, processing, and consumption. The global millets market is witnessing growth, driven by increased exports, demand for gluten-free products, and the expansion of health-conscious consumer bases [43].

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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