

# Millets: Ancient Grains for Modern Nutrition – A Comprehensive Review

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## Abstract

Millets are a group of small, drought-resistant grains that have been grown for more than thousands of years. They are highly nutritious, rich in essential vitamins and minerals, and have gained attention in recent years due to their potential to address global food security and environmental challenges. This review article provides an overview of millets, their nutritional benefits, environmental advantages, and their role in promoting sustainable agriculture and processing of millets. The article also discusses the various types of millets, their cultivation, and their potential to improve human health and combat malnutrition.

**Keywords:** Grains, millets, nutrition

## INTRODUCTION

Millets are grasses that have been cultivated since ancient times. They belong to the Poaceae family and are known for their resilience to adverse environmental conditions, making them an essential crop in regions with limited water resources and variable climates.<sup>[1]</sup> Millets have gained renewed interest in recent years due to their exceptional nutritional value, low resource requirements, and their potential to address food security challenges while mitigating the environmental impact of agriculture.

The main millets include sorghum, finger millet, pearl millet, foxtail millet, and proso millet, which have been cultivated for thousands of years in diverse regions of the world, especially in Asia and Africa.<sup>[2]</sup> Traditionally considered as “poor man’s food,” millets are now recognized as a vital source of nutrition, particularly in the context of food security and sustainable agriculture.<sup>[3]</sup>

After many years of negligence, nutri-cereals are making a strong comeback in India as cereals. Most of the millets are grown in India, and it is the leading cultivator of millets. Most of the millets are three to five times more nutritious than most in terms of vitamins, fiber, proteins, and minerals (calcium and iron) and are gluten-free; hence, they are known as

“superfoods.”<sup>[4]</sup> Millets are helpful in reducing the incidence of malnutrition and well as metabolic disorders. Furthermore, it helps to provide nutrition and improves food security and availability in the country.

Millets are an excellent source of protein as well as some amino acids (i.e., methionine and cysteine).<sup>[5,6]</sup> Millets contain a large amount of various vitamins like E and B and minerals, such as calcium, manganese, potassium, phosphorus, magnesium, and iron.<sup>[7,8]</sup> Millets have numerous health benefits, such as reducing the incidence of cancer,<sup>[9,10]</sup> obesity and diabetes,<sup>[11]</sup> cardiovascular diseases,<sup>[12,13]</sup> gastrointestinal problems,<sup>[14]</sup> migraine, and asthma,<sup>[1,15]</sup> hyperglycemia. These wonder grains play a vital role in day-to-day diet as an essential nutrient, especially in underdeveloped and developing countries.<sup>[16]</sup>

## NUTRITIONAL INDEX OF MILLETS

The nutritional index of millets is comparable to major cereals

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such as rice, wheat, and maize since they are an abundant source of carbohydrates, dietary fiber, protein, vitamins, micronutrients, and phytochemicals.<sup>[17]</sup> Millets are rich in essential nutrients, making them a valuable addition to diets. They are gluten-free and have a lower glycemic index compared to rice and wheat.<sup>[18]</sup> Millets are abundant in dietary fiber, vitamins (especially B-complex vitamins), minerals (iron, calcium, magnesium), and antioxidants.<sup>[19]</sup> These grains also offer an excellent source of plant-based protein, with variations among different millet types.<sup>[20]</sup> Millets' nutritional profile makes them particularly suitable for addressing malnutrition and lifestyle-related diseases. The nutritional composition of various millets [Table 1].

Proso contains a very high level of minerals and dietary fiber. It is a rich source of various minerals and vitamins. It contains potassium, iron, phosphorus, calcium, magnesium, zinc, vitamin B-complex, niacin, and folic acid. Pearl millet has less amount of carbohydrates as compared to other staple cereals, and it is mainly composed of starch and insoluble dietary fiber. It is gluten-free and high in omega-3 fatty acids; the amino acid score is also good,<sup>[22,23]</sup> further it contains fatty acids (alpha-linolenic acid, eicosapentaenoic acid, and docosahexaenoic acid), other micronutrients (iron, zinc, copper, potassium, magnesium, phosphorous, manganese), and B vitamins.<sup>[22]</sup>

Kodo millet provides gluten-free protein. It contains B-complex vitamins such as B6, niacin, and folic acid and minerals including magnesium, iron, potassium, calcium, and zinc. Moreover, it is highly digestible. Foxtail millet contains vitamins, minerals, high dietary fiber content, resistant starch, and essential amino acids.

Finger millet has the highest carbohydrate level; it is primarily of slowly digestible starch, dietary fiber, and resistant starch.<sup>[24]</sup> Around 7% protein is present in finger millet, which is less as compared to other millets. It contains various micronutrients such as calcium, potassium, magnesium, iron, and zinc, as well as B vitamins, especially B6, niacin, and folic acid, which are abundantly present.

In little millet, there is availability of around 8.7% of protein and amino acids (cysteine and methionine).<sup>[25]</sup> The little millet also contains various micronutrients. (iron, niacin, phosphorous, zinc) and also the proteins.<sup>[8]</sup>

Health benefits consuming millets has been associated with numerous health benefits. Their high dietary fiber content aids in digestion, reduces the risk of colon cancer, and helps manage diabetes by regulating blood sugar levels.<sup>[5]</sup> The presence of antioxidants in millets combats oxidative stress and lowers the risk of chronic diseases.<sup>[19]</sup> In addition, millets contain phytochemicals that exhibit anti-inflammatory properties, contributing to overall well-being.<sup>[18]</sup> Including millets in the diet has been linked to weight management, cardiovascular health, and improved bone health due to its mineral content.<sup>[20]</sup> Millets are a rich source of nutrients and offer several health benefits. They are free from gluten, hence suitable for persons suffering from celiac disease or gluten sensitivity. Millets are rich in protein, dietary fiber, and essential minerals such as magnesium, iron, and phosphorus.<sup>[3]</sup> They also contain antioxidants, which may help protect against chronic diseases.<sup>[20]</sup> Furthermore, millets have a low glycemic index, making them an excellent choice for managing blood sugar levels.<sup>[26]</sup> The millets have antioxidant Activity, anti-hyperglycemic effects, anti-cholesterol effects, anti-hypertensive effects, and anthropometric effects [Table 2].

## ANTINUTRIENT PROFILE OF MILLETS

Millets have some antinutrient factors or chemicals. Antinutrients are phytochemical compounds that are being produced by plants for their defense, and millets have more concentration of tannins, phytates, oxalates, trypsin, and chymotrypsin inhibitors compared to wheat and rice.<sup>[28]</sup> These chemicals reduce nutrient bioavailability by inhibiting nutrient absorption.<sup>[29]</sup> If these are consumed uncooked, they result in nutritional deficiency, micronutrient malnutrition, and bloating. For the elimination of antinutrients, their processing is needed.

## Processing of Millets

Millets are usually pretreated or processed before consumption to increase bioavailability and enhance nutritional value.<sup>[8]</sup> [Supplementary Figure 1].

These processing techniques aim to enhance digestibility and nutrient bioavailability.<sup>[30]</sup>

## ECOLOGICAL SUSTAINABILITY

Millets are highly resilient to adverse environmental conditions, such as drought and poor soil quality, making

**Table 1: Nutritional index of millets (per 100 g)<sup>[17,21]</sup>**

Name of millet	Energy (kcal)	Protein (g)	Carbohydrates	Fat	Calcium	Dietary Fiber	Starch
Sorghum	334	10.4	67.6	1.9	27	10.2	59
Pearl millet	363	11.6	61.7	5	27	11.4	55
Finger millet	320	7.3	66.8	1.3	364	11.1	62
Proso millet	341	12.5	70.0	1.1	14	-	-
Foxtail millet	331	12.3	60.0	4.3	31	-	-
Kodo millet	353	8.3	66.1	1.4	15	6.3	64
Little millet	329	8.7	65.5	5.3	17	6.3	64
Barnyard millet	307	11.6	65.5	5.8	14	-	-

**Table 2: Health Benefits of millets**

Type of Millet	Health benefits <sup>[24,27]</sup>
Foxtail millet	Improves hemoglobin levels and prevents anemia, and aids in controlling blood sugar levels. In addition, it contains antioxidants that help in combating oxidative stress and reducing the risk of chronic diseases.
Finger millet (Ragi)	Promotes bone health and prevents conditions like osteoporosis as it is rich in calcium. It is also a good source of amino acids, making it beneficial for muscle repair and development. Ragi is often recommended for infants and growing children to support healthy bone development.
Pearl millet (Bajra)	Pearl millet is rich in fiber and has a low glycemic index, which helps regulate blood sugar levels and contains a high content of iron and other essential minerals, which can help prevent anemia and promote overall well-being.
Barnyard millet	Barnyard millet is a good source of dietary fiber, which aids in digestion and can help prevent digestive issues such as constipation. It also contains high levels of antioxidants, which can contribute to reducing the risk of chronic diseases and promoting overall health.
Kodo millet	Kodo millet is rich in phytochemicals and antioxidants, making it effective in combating oxidative stress and reducing the risk of various diseases, including cancer. It also has a low glycemic index, making it a suitable option for individuals looking to manage their blood sugar levels.
Little millet	A good source of B vitamins, particularly niacin, and thiamine, which are essential for energy production and nerve function. It also contains minerals such as iron and potassium, contributing to overall health and well-being.

them an environmentally friendly crop choice.<sup>[31]</sup> Their low water requirements and ability to grow in marginal lands make millets crucial in the face of climate change and water scarcity. Cultivating millets can contribute to biodiversity conservation and reduce the need for chemical fertilizers and pesticides.<sup>[2]</sup> Promoting millet-based farming systems can foster sustainable agriculture and enhance resilience in agricultural communities.

The cultivation of millets is environmentally sustainable for several reasons. Millets are well-adapted to low-input farming systems and can thrive in poor soils with minimal water requirements. They have a short growth cycle, reducing the need for extensive water and chemical inputs.<sup>[32]</sup> In addition, millets are less susceptible to pests and diseases, reducing the reliance on pesticides. Their ability to grow in diverse agroecological zones also promotes biodiversity and reduces monoculture farming practices.

## MILLETS IN ADDRESSING MALNUTRITION

Millets have the potential to combat malnutrition, especially in regions where staple grains lack essential nutrients. Their high protein, iron, and zinc content can help address nutrient deficiencies, particularly among vulnerable populations like children and pregnant women.<sup>[33]</sup> Integrating millets into government nutrition programs and school meal initiatives could contribute to improved public health.

## ECONOMIC SIGNIFICANCE

The cultivation and consumption of millets have socioeconomic implications, particularly in rural areas of developing countries. Millet production can provide livelihood opportunities for smallholder farmers, empower women in agriculture, and improve food security at the local level.<sup>[34]</sup> Furthermore, the growing global demand for millets presents export opportunities and income generation potential for farmers in producing regions.<sup>[2]</sup> However, to fully realize these benefits, support in the form of research, infrastructure development, and market access is essential.

## CONCLUSION

Millets are an invaluable resource in the quest for sustainable agriculture, improved nutrition, and food security. Their rich nutritional content, health benefits, ecological sustainability, and economic significance make them a compelling option in addressing the complex challenges of the modern world. Promoting millets through research, policy support, and consumer awareness can contribute to healthier diets, resilient farming systems, and a more sustainable food future. The energy value of millets is comparable to staple crops. Furthermore, the health benefits due to their high fiber, minerals, vitamins, macro- and micronutrients, and phytochemicals to control chronic disorders provided by millets are much more. After pretreatment or processing, the dietary fiber, mineral, and vitamin content of most millets improved, making them more nutritious and a better source of a balanced diet.

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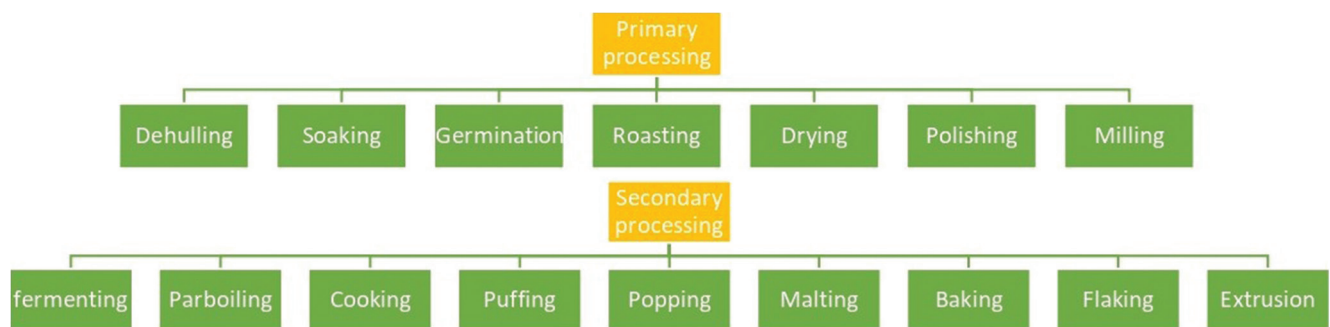
## Conflicts of interest

There are no conflicts of interest.

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**Supplementary Figure 1:** Types of processing in millets