



## RESEARCH ARTICLE

### A REVIEW ON MILLET: A WONDER GRAIN OF NUTRITIONAL IMPORTANCE

Samreen Fatima<sup>1</sup> and Dr. Kahkashan Parvin<sup>2</sup>

1. Research Scholar, Department of Food and Nutrition, Era University, Lucknow.
2. Head and Associate Professor, Department of Food and Nutrition, Era University, Lucknow.

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#### Abstract

Millets are underutilized minor cereal crops belonging to the Poaceae family. These small seeded, nutrient dense grains are drought resistant, glutenfree and non-acid forming. They fall into two major categories, namely, the major millets, and the minor millets. Pearl millet and sorghum are classified as major millets. The minor millet category comprises foxtail millet, proso millet, finger millet, kodo millet, barnyard millet and little millet. They are rich source of phytochemicals with medicinal properties in the form of antioxidant activities, which help lower many health diseases. They have a low glycemic index, high fibre content, and polyunsaturated fatty acids (PUFA). It is a splendid source of essential nutrients such as protein, carbohydrates, fat, minerals, vitamins, and also some other bioactive compounds that eventually help through multiple biological activities, including antioxidant, anti-hyperglycemic, anti-cholesterol, anti-hypertensive, anthropometric effects and regulation of gut microbiota composition. In addition to staple food crops, such as wheat and rice millets are highly nutritious and beneficial and have great potential to help the world combat the food insecurity many countries face today. The current review is to collect the available information from existing literature related to the nutritional importance and health-benefiting properties of millet and trying to present the collected data in an easily-documented pattern.

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#### Introduction

Millet is the most significant cereal after rice, sorghum and wheat. It has been a staple diet in many regions of Africa and India for thousands of years. Many people worldwide, particularly those who reside in hot, tropical climates, rely mainly on millet for their sustenance. Millets are a staple food in many underdeveloped nations because they can flourish in harsh environmental circumstances like low precipitation. Millet is an important source of energy and protein for many people who live in arid regions. There are numerous nutritional and medicinal applications for millet (Obilana and Manyasa, 2002; Yang et al., 2012). Due to lack of awareness, millets are often overlooked as a primary food source despite their high nutritional value. On the other hand, millets have become increasingly important in the field of biological research due to increasing evidence that they have beneficial effects on human fitness (Rao et al., 2011).

**Corresponding Author:- Samreen Fatima**

Address:- Research Scholar, Department of Food and Nutrition, Era University, Lucknow.

Millets are small, spherical grains that are rich in nutrients. Their principal components are fat (1.5–5%), protein (7–11%), and crude fiber (2–7%). Millets are gluten free and also include significant levels of zinc, magnesium, iron, calcium, and vitamin B (Majid et al., 2020). There are usually seven distinct varieties of millet, each having its own colour, shape, size, and growth place. These tiny-seeded, spherical cereals, belonging to the Poaceae family, are the earliest and most likely the first cereal grain that humans have employed for domestic use (Kumar et al., 2023). The major millets are Proso millet, often known as white millet (*Panicum miliaceum*), Foxtail millet (*Setaria italica*), Finger millet (*Eleusinecoracana*), and Pearl millet (*Pennisetum glaucum*). Little millet (*Panicum sumatrense*), Guinea millet (*Brachiariadeflexa*), Barnyard millet (*Echinochloa* spp.), Kodo millet (*Paspalum scrobiculatum*), and Browntop millet (*Urochloa ramosa/Brachiaria ramosa/ Panicum ramosum*) are the types of minor millets (Chinchole et al., 2017; ICRISAT, 2017; Yanget al., 2012, Nithiyananthamet al., 2019). Bioactive phytochemicals such as lignans,  $\beta$ -glucan, inulin, resistant starch, sterols, and phenolic compounds namely ferulic acid are present in it. Research has proven that it possesses anti-oxidant, anti-carcinogenic, anti-inflammatory, antiviral, and neuroprotective properties. These attributes collectively demonstrate their potential to lower the risk of various diseases, including cancer, cardiovascular disease, diabetes, hypertension, high cholesterol, inflammatory disorders, metabolic syndrome, and Parkinson's disease (Park et al., 2008).



**Fig 1:-** Different types of millet.

Sources: Tiwari et al., 2023

### Finger millet

Finger millet is commonly known as ragi or mandua. It is grown throughout the world and in many regions of India (Vijaykumari et al., 2003). This small-seeded minor cereal has a seed coat which may vary from light brown to brick red in color or dark brown. It is primarily high in dietary fibre and phytochemicals like polyphenols. Finger millet is a highly nutritious grain that is readily and gradually absorbed. It contains calcium, fibre, antioxidants, and phytochemicals. Patients with diabetes can effectively regulate their blood glucose levels with the use of finger millet. Because finger millet has a low sugar content and releases sugar/glucose into the body gradually, it is therefore thought to be the best diet for those with diabetes (Kang et al., 2008).

### Foxtail millet

Foxtail millet aids in the steady release of glucose without hindering the body's metabolism. Due to its high magnesium content, it is also referred to as a heart-healthy diet and helps lower the prevalence of diabetes in humans (O.S.K.Reddy, 2017). Cooked rice, porridge, and roti are among the foods made from foxtail millet. Puddings, breads, cakes, and noodles are made with its composite flour. Compared to rice, foxtail millet has a higher protein content. Mineral matter content is also abundant in it. The free-radical scavenging qualities of the phytochemicals found in foxtail millet contribute to many health advantages (Ronda et al., 2023).

### Little millet

Grown extensively in tropical regions, little millet is a distinctive minor cereal that is a staple food for certain low-income communities worldwide. In addition to offering minerals and vitamins, little millet is a comparable source of protein, fat, carbs, and crude fibre when compared to other cereals like rice and wheat (Pradeep et al., 2011). Additionally, it contains tannins, phytate, phenolic acids, and flavonoids, among other phytochemicals. Although

little, little millet has a significant nutritious content despite its size. It is a good source of minerals, including calcium, iron, zinc, and potassium, as well as B vitamins. It also gives the body the kind of necessary fats that aid in weight loss. Another advantage is that it is high in fibre, which makes it perfect for kheer or pongal in place of rice (O.S.K. Reddy, 2017).

#### **Kodo millet**

Kodo millet is referred to as "nutri-cereals" because of its abundance in vitamins, minerals, and sulfur-containing phytonutrients. The ratio of leucine to isoleucine is roughly 2.0 (Ravindran, 1992; Antony et al., 1996) and it is also rich in important amino acids such as lysine, threonine, valine, and sulfur-containing amino acids. However, it lacks tryptophan. Vitamin B3, vitamin B6, folic acid, and minerals including calcium, potassium, magnesium, and zinc are all abundant in kodo millets. Glutamine is the main protein found in Kodo millet grain, which has an 8.3% protein content (Sudharshana et al., 1988). The highest free radical activity (DPPH) is seen in kodo millet, with finger millet and sorghum following (Deshpande et al., 2015).

#### **Barnyard millet**

Barnyard millet is grown mostly for human consumption, though it can also be fed to animals. Two of the most well-known species of barnyard millet, *Echinochloa frumentacea* (Indian barnyard millet) and *Echinochloa esculenta* (Japanese barnyard millet), are among the numerous cultivated and wild species (Sood et al., 2015). Barnyard millet is a short-duration crop that can tolerate a variety of biotic and abiotic challenges and grow in unfavourable environmental circumstances with very little input. Apart from these agronomic benefits, the grains are prized for their high nutritional content and cheaper cost when compared to main cereals such as maize, rice, and wheat. Protein, carbs, fibre, and most importantly, micronutrients like iron (Fe) and zinc (Zn) are all abundant in it (Singh et al., 2010; Saleh et al., 2013; Chandel et al., 2014) that have several positive health effects (Saleh et al., 2013; Ugare et al., 2014).

#### **Proso millet**

Proso millet helps prevent Pellagra, a disorder caused by the vitamin B3 niacin. Niacin is present in high concentrations in proso millet. Skin that has pellagra becomes rough, scaly, and dry. Niacin (Vitamin B3) and protein are the two main ingredients of proso millet. It is traditionally used as a healing food, particularly after childbirth or illness (Jana Kalinova, 2007).

#### **Pearl millet**

Pearl millet is a versatile cereal belonging to the Poaceae family. In many regional Indian languages, it is commonly called bajra, bajri, sajje, kambu, kamban, sajjalu, etc. It is commonly used as a food source and forage (Arora et al., 2003). Compared to other cereals, pearl millet has a higher fat digestibility. It has a great nutrient content of omega-3 fatty acids and is abundant in unsaturated fatty acids. In comparison to other millets, it has a maximum level of macronutrients and is significantly richer in resistant starch and soluble and insoluble dietary fibre (Ragaei et al., 2006). It has high levels of iron, zinc, magnesium, copper, manganese, potassium, and phosphorus. With a high fibre content of 1.2 g/100 g and a calorific value of 361 Kcal/100 g, this is a potent source of energy (Singh et al., 2018).

#### **Sorghum**

Sorghum is a gluten free grain rich in nutrients and physiologically significant chemical components. It is the world's fifth largest cereal crop and is widely farmed for its grain, sweet, low-lignin, fodder, and biomass qualities. It grows in many different types of climates. Due to its resistance to heat and drought, this crop can be produced in desert climates (Ratnavathi et al., 2016). Iron, calcium, fibre, protein, and wax policosanols are all found in sorghum and have been shown to have health benefits, including decreasing cholesterol (O.S.K. Reddy, 2017). The high concentration of tannins and polyphenols in sorghum has antimutagenic and anticancer properties (Awika et al., 2004).

**Table 1:** Nutritional composition of millet (per 100g).

	<b>Finger millet(g/100g)</b>	<b>Foxtail millet(g/100g)</b>	<b>Sorghum(g/100g)</b>	<b>Pearl millet(g/100g)</b>	<b>Proso millet(g/100g)</b>	<b>Kodo millet(g/100g)</b>	<b>Barnyard millet(g/100g)</b>	<b>Little millet(g/100g)</b>
<b>Protein</b>	7.3	11.2	10.4	11.8	11.0	8.35	10.5	8.92

<b>Fat</b>	1.3	4.0	3.1	4.8	3.5	1.5	3.6	2.5
<b>Fibre</b>	11.5	6.7	2.0	2.3	8.5	5.2	12.6	6.39
<b>Minerals</b>	2.7	3.3	1.68	2.2	1.9	3.3	2.0	1.72
<b>Carbs</b>	72.05	63.2	70.7	67.0	56.1	65.6	68.8	65.5
<b>Reference</b>	Himanshu et al., 2018	Jaybhaye et al., 2014	Tiwari et al., 2023	Saini et al., 2021	Das et al., 2019	Bunkar et al., 2021	Ugare et al., 2014	Rao et al., 2017

### Beneficial effects of millets

Millets have several nutritional benefits that can help individuals maintain their health, such as lowering blood pressure, reducing the chance of heart disease, preventing cancer and cardiovascular illness, and reducing the growth of tumours, among other things. It also increases the time it takes to empty the stomach as well as provides the intestine with some roughage (Sarita et al., 2016).

Millet's high protein content promotes children normal development and growth. The calcium content of millet reduces the incidence of bone fractures and promotes bone growth. Its high-quality iron content aids in the treatment of anaemia. Since millet is gluten-free, people with celiac disease and others who are sensitive to gluten benefit from it as well (Prathyusha et al., 2021). Millets are high in magnesium, which reduces the risk of heart attack. Millets are a good source of phytochemicals that help prevent heart disease by lowering cholesterol (Sarita et al., 2016).

Millet contains fibre, which helps regulate bowel habits and encourages good digestion. Furthermore, it has prebiotic properties that support the growth of probiotic bacteria in the microbiome by improving digestion and overall immunological function, all of which are beneficial to health (Kumar et al., 2023). The majority of knowledgeable people have never heard of millets or their benefits, despite the fact that they should be a regular part of our diet due to their numerous nutritious advantages. People worldwide are experiencing major health issues as a result of eating foods low in fibre (Habiyaemye et al., 2017, Muthamilarasan et al., 2016).

**Table 2:** Beneficial effects of millets

Name of millet	Scientific name	Common name	Beneficial effect
<b>Sorghum</b>	<i>Sorghum bicolor</i>	Jowar	Consists of antioxidants that lower the chance of colon cancer and cardiovascular disease. Their highly soluble fibres lower the chance of developing type II diabetes.
<b>Pearl millet</b>	<i>Pennisetum glaucum</i>	Bajra	Rich in vitamin E which protects the body tissues from free radical damage. Safe for those who are gluten-sensitive.
<b>Foxtail millet</b>	<i>Setaria italica</i>	Kangani	Rich in calcium which helps in combating diseases such as osteoporosis and fractures.
<b>Finger millet</b>	<i>Eleusine coracana</i>	Ragi	Rich in calcium and polyphenols which help in the strengthening and development of bones and prevent anaemia
<b>Little millet</b>	<i>Panicum sumatrense</i>	Kutki	Prevents rise in blood glucose levels and is helpful in the management of diabetes. Also, prevents cardiac disease.
<b>Barnyard millet</b>	<i>Echinochloa frumentacea</i>	Sanva	Increases the synthesis of haemoglobin and keeps the red blood cells healthy as they are rich in iron.
<b>Kodo millet</b>	<i>Paspalum scrobiculatum</i>	Kodo	Excellent support for the wellness of the nervous system.
<b>Proso millet</b>	<i>Panicum</i>	Chena	Reduces blood pressure, manages depression, and has anti-

	<i>miliaceum</i>		inflammatory properties. Due to their high thiamine and energy content, they are the preferred millet for cardiac patients.
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### **Millet and Obesity**

In India, obesity is the most growing issue and is linked to several chronic ailments, such as diabetes and cardiovascular disease (CVD). According to recent studies consuming a high-fibre diet lowers the incidence of obesity (Alferi et al., 1995). Dietary fibre-rich foods enhance intestinal function and slow down the process of digestion and absorption, which lowers the risk of developing chronic diseases (Ali et al., 1982). Millets have a relatively greater dietary fibre content (22%) in comparison to cereals such as wheat (12.6%), rice (4.6%), and maize (13.4%). As reported by Chethan et al., (2007), finger millet grain contains 1.4% soluble dietary fibre and 15.7% insoluble dietary fibre. According to research by Shobana et al. (2007), finger millet contains 22.0% total dietary fibre, 19.7% insoluble dietary fibre, and 2.5% soluble dietary fibre.

Obesity is becoming a more common issue these days, and it's linked to a number of other illness like diabetes, high blood pressure, and heart issues. Research indicates that eating foods high in fibre can enhance colon health and lower the incidence of obesity by enhancing the body's ability to absorb and digest nutrients, which lowers the chance of developing chronic illness (Ambati et al., 2019).

### **Millet and Cancer**

Millets have been found to be rich in antinutrients such as phenolic acids, phytates, and tannins, which can lower the incidence of breast and colon cancer. Research has demonstrated that millets' phenolics can effectively prevent cancer from starting and spreading in vitro (Chandrasekara et al., 2011). Sorghum has well-established anti-carcinogenic properties. It contains tannins and polyphenols that have anti-mutagenic and anti-carcinogenic features (Grimmer et al., 1992) and can work against human melanoma cells and positive melanogenic activity.

As a result of their ability to neutralize free radicals, which have the potential to cause cancer, many of the antioxidants in millets can also help remove toxins from other parts of the body, including the liver and kidneys. By encouraging appropriate excretion and counteracting enzymatic activity in those organs, quercetin, curcumin, ellagic acid, and other advantageous catechins can assist in clearing the system of any foreign substances and poison (O.S.K.Reddy, 2017).

### **Millet and Celiac disease**

Gluten ingestion is what causes celiac disease, a genetically predisposed condition. Being gluten-free, millets lessen the sensitivity that regular cereal grains' gluten causes, thereby lowering the risk of celiac disease (Saleh et al., 2013). Controlling the digestive process can improve nutritional retention and lower the risk of developing more severe gastrointestinal disorders like colon cancer or gastric ulcers. Millets' high fibre content aids in the elimination of conditions like cramping, bloating, constipation, and excessive gas. Celiac disease is an immune-mediated enteropathic illness that typically develops in susceptible people after consuming gluten (Catassi and Fasano, 2008). Consumption of foods belonging to the grain food group is significantly impacted by a gluten-free diet. For those following a gluten-free diet, substituting gluten-free grains such as rice, corn, sorghum, millet, amaranth, buckwheat, quinoa, and wild rice for cereals like wheat, barley, and rye may be helpful (Thompson, 2009).

### **Millet and Diabetes**

By lowering  $\alpha$ -glucosidase and pancreatic amylase, millets decrease postprandial hyperglycemia by inhibiting the enzymatic degradation of complex carbs. Enzymes such as aldose reductase aid in preventing sorbitol formation and lower the incidence of cataract problems caused by diabetes. Due to the presence of antioxidants, eating millet helps to regulate blood sugar levels and also promotes the healing of skin wounds (Rajasekaran et al., 2004).

As we can see, millions of individuals worldwide suffer from diabetes. Because millets contain a significant amount of magnesium, they can help prevent Type II Diabetes. Magnesium is an essential element that produces a variety of enzymes that break down carbohydrates, which control the action of insulin. This serves to increase the efficiency of insulin and glucose receptors (O.S.K.Reddy, 2017)

### Millet and Cardiovascular disease

Millet is an excellent source of magnesium, which has been shown to lower the risk of heart attacks. Millets, which are well-known for being high in phytochemicals, include phytic acid, which lowers plasma triglycerides and cholesterol, preventing cardiovascular disease (Lee et al., 2010). Additionally, the plant lignans found in millets are prebiotic fibres that are fermented in our intestinal intestine by bacteria. The microflora in our digestive systems can change these prebiotic fibres into animal lignans, which have been demonstrated to offer protection against several chronic diseases. Once fermented, they produce enterolactone, a substance that has been shown to offer protection against certain types of breast cancer as well as heart disease (O.S.K.Reddy, 2017)

### Glycemic Index (GI) of millet

The GI is the degree to which a meal can alter blood glucose levels. Meals with lower GI raise blood sugar levels gradually or steadily, while meals with higher GI raise blood sugar levels quickly. On the GI chart, millets have a score between 40 and 70, which is lower than the GI values of maize, rice, wheat, and refined flour (Geetha et al., 2020). The protein composition and glycemic index of different types of millet is shown in the table below (Rao et al., 2017).

**Table 3:** GI and protein composition of different types of millet.

Name of millet	GI of millet	Content of protein(%)
Sorghum	70-85	10.4%
Pearl millet	70-85	10.6%
Foxtail millet	50-60	12.3%
Finger millet	70-80	7.3%
Little millet	50-65	7.7%
Barnyard millet	50-65	11.2%
Kodo millet	50-65	8.3%
Proso millet	50-65	11.5%

### Bioactive compounds present in millets

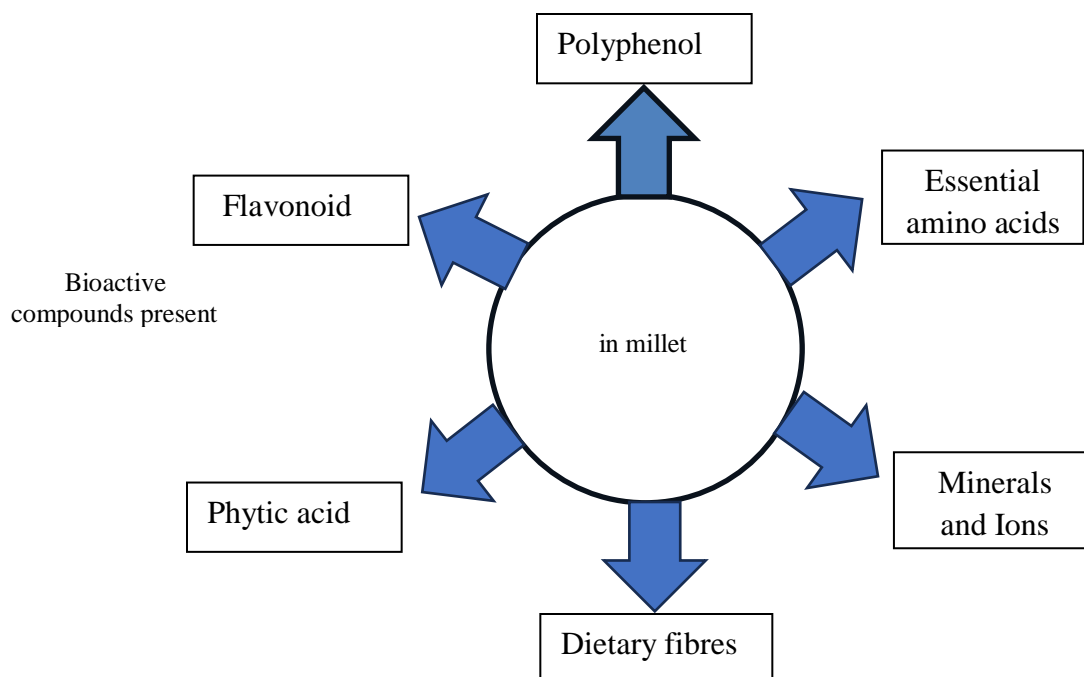
The seed coat of millet, or bran, has a high concentration of nutritionally important minerals, dietary fibres, and bioactive substances like tannins (Onipe and Ramashia, 2022). There are several health benefits associated with following a diet that includes a substantial amount of finger millet seed coat. These comprise decreasing inflammation, upholding a balanced plasma lipid profile, reducing oxidative stress, adjusting the expression level of multiple genes linked to obesity, and improving the population of advantageous bacteria in the gastrointestinal tracts, such as lactic acids and bifidobacteria, in a study conducted on mice (Murtaza et al., 2014). The mineral composition of the seed coat includes globulin, albumin, prolamin, calcium, magnesium, iron, zinc, and phosphorus. Millets are stores of abundant bioactive substances that nourish the body as shown in figure 2.

They are enhanced with antioxidant and anti-aspirin effects by the polyphenols found in the millet seed layer. Millets, especially finger millet (ragi), contain a significant quantity of phytic acid, which lowers the digestion of carbohydrates and lowers blood glucose levels after meals (Gupta et al., 2017). As a result, finger millet may be suitable for diabetics to eat. Finger millet has ten times more calcium than brown rice, wheat, and corn, and twice the calcium content of milk. Finger millet consumption can significantly improve mother and child bone health and prevent osteoporosis during and after pregnancy and nursing. The body needs calcium for structure and stiffness as well as for the transmission of nerve signals and the mediating of vascular and muscle contractions (Kumar et al., 2016, Shobana et al., 2016, Puranik et al., 2017). Consequently, since high calcium is associated with mortality and

vascular events in those taking calcium supplements, a balanced calcium diet is advised (Xiao et al., 2013, Bolland et al., 2008).

Resistant starch, which is abundant in foxtail millet, can slow down the emptying of the stomach and lower blood glucose levels after eating (Ren et al., 2018). Prolamin (kefirin) is added to sorghum, which is loaded with a protein that is less digestible when cooked compared to other grain proteins (Stonestreet et al., 2010). When ingested, pearl millet, also known as bajra, has antioxidant qualities due to its high content of zinc, iron, dietary fibre, and omega-3 fatty acids (Satyavathi et al., 2021).

**Figure 2:** Bioactive compounds and nutrients in millet.



## Conclusion

The high fibre content of millet makes them easier to digest, and their high lecithin content helps to support the development of the nervous system. Millets are also rich in minerals like calcium, magnesium, and potassium and have been linked to a number of health advantages, including regulating blood pressure, cholesterol, and blood sugar levels. People with celiac disease or those following a gluten-free diet may find millets to be a fantastic option because they are devoid of gluten. A healthy life can be achieved by regularly consuming millet. Nutrient deficiencies can be eliminated through the successful production of functional food through the fortification or supplementation of millet. The development of functional foods through fortification or supplementation should receive top priority because India leads the world in millet production.

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