



Importance of Millet in Nutrition, Health and Value added Products: A Review

Gunjan Sanadhya* and Dolly Mogra**

Department of Home Science College of Social Science and Humanities
MLS University of Udaipur (Raj.)

*Ph.D. Scholar Department of Home Science College of Social Science and Humanities
MLS University of Udaipur (Raj)

**Assistant Professor, Department of Home Science College of Social Science and Humanities
MLS University of Udaipur (Raj)

Abstract

The first crops that humans ever cultivated were millets, which were once a vital source of nourishment for human society. While post-green revolution staples took precedence over these ancient grains, there is an urgent need to bring these superfood millets back to life throughout the due to their high nutritional value and capacity for growth in a variety of challenging environments. India, the world's biggest producer, is leading the charge to revive millets, which are beneficial to farmers, the environment, and human health. Millets can be used in both routine and exploratory cuisines. Millets are a noteworthy dietary bio-source due to their plenitude in carbohydrates, protein, and fiber, as well as niacin, magnesium, phosphorus, manganese, potassium, iron and imperative amino acids. Millets moreover offer therapeutic focal points such as avoiding heart infection, dia the later betes, headaches, and early mortality. Millets is useful for nourishments and nutraceuticals. Millets may be brought back to ubiquity with the assistance of facilitated investigation, showcasing, and entrepreneurial exercises.

This review looks at the various types of millets, their distribution across cultures. The research emphasizes millets' high nutrient content, which includes proteins, dietary fibers, vitamins, and minerals, making them an important part of a balanced diet. Furthermore, it investigates the gluten-free nature of millets, catering to people with special dietary needs. The health benefits of millet consumption are explored, with a focus on its ability to prevent and manage chronic diseases such as diabetes and cardiovascular ailments. Antioxidants and polyphenols are examples of bioactive chemicals.

Key Words:

Millets, Nourishments, Nutraceuticals, Antioxidants, Health, Gluten-free, Anti-Obesity, Cardiovascular disease

Introduction

India is a nation of traditional cuisine, and each region has its own culinary history. Millet, contrary to rice and wheat, can be grown almost anywhere; therefore, growing millet should be encouraged to increase our food self-sufficiency. Millets in Indian diets are classified as coarse cereals with small grains having 2.1 – 7.1 g/1000 grain weight. Well-filled grains have 1.4 – 5.1 ml/1000 grain volume. They have spherical to oval shapes with colored seed coats Millets are a staple in any local cuisine. *Roti, Rabadi, Katt, Laddu, Khichada* made from pearl millet are staple dish for farmers in western Rajasthan (FAO. 2009) Millets are termed as “yesterday’s coarse grains and today’s *Nutri-cereals*.” Millets are “future crops” as they are resistant to most pests and diseases and adapt well to the harsh environment. It is also termed as small seeded grass, which includes pearl millet, finger millet, foxtail millet, proso millet, barnyard millet, kodo millet,

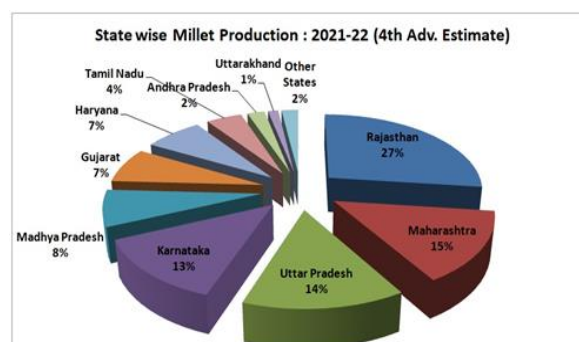
and small millet, of Asia and It is typically found in dry regions Africa. The importance of millets by designating 2023 as the **International Year of Millets**. Millets, an old crop with a long history of cultivation, have been an important source of nutrition for many cultures worldwide. Millets are one of the oldest foods known to humans, maybe the first cereal grain used for domestic use. It is used in a variety of African and Indian dishes. Although millet is one of the world's most important food crops, it is grown primarily in the Eastern hemisphere, in areas with rudimentary farming practices and high population density. Millets are the primary food supply for millions of people, particularly those living in hot, dry regions of the world.

Global Scenario in Millet

The global millet production was estimated 31.72 MMT, India is the world's leading producer of millets and has the largest global share of around 42percent with the production13.20 MMT (USDA-2022) India is among the top 5 exporters of millets in world. World export of millet has increased from \$400 million in 2020 to \$470 million in 2021 (ITC trade map) India exported millets worth \$64.28 million in the year 2021-22, against \$59.75 million in 2020-21. But the share of Millet based value added products is negligible. As the largest producer of millets, India has taken leadership initiative in reviving millets across the globe. In the year 2021, India ranked 7th in global millet export in terms of value - witnessing exports rising from USD 55.22 Mn in 2011 to USD 65.10Mn in 2021, registering a decadal CAGR of 1.66%.(APEDA Report,2023)

.In India and Africa, pearl millet grains are mostly used for food purposes. It is one of the important nutricereals and is a source of staple food for rural population. Pearl millet is a rich source of proteins, minerals and fibers (Singh and Shurpalekar 1989). India is a major producer and supplier of millet, with a number of millet sourcing centers spread around the country. India's key millet-growing states include Rajasthan, Maharashtra, Karnataka, Andhra Pradesh, and Madhya Pradesh. These states have a considerable number of millet growers who produce grain for domestic and international markets. These traditional grains, have resurfaced as nutritious and ecological alternatives to conventional cereals. Their versatility and health benefits have led to their use in diverse culinary, agricultural, and industrial applications. There are various uses of millets. Millets, including pearl millet (bajra), finger millet (ragi), and foxtail millet, are widely consumed due to their high nutritional value(Sivakumar,2017)These foods are high in fiber, vitamins, and minerals, making them beneficial for a healthy diet and addressing malnutrition in underdeveloped nations

Rajasthan is the top millet-producing state; accounting for more than 36 percent of the nation's total production, Rajasthan has a vast variety of Thar deserts, so its farmers always favor this climatically resilient dryland crop. Compared to rice, sugarcane, and wheat, millet requires less water, making it a good crop for small and marginal farmers of Rajasthan.



<https://apeda.gov.in/milletportal/Production.htm>

Types of millet and their nutritional Profile

Millets are nutrient-dense, non-glutinous, and non-acidic. Starch is the primary carbohydrate component, with a greater proportion of non-starchy polysaccharides (dietary fiber). Prolamines and glutelins make up the majority of their proteins. Millets' fats are rich in unsaturated and necessary fatty acids. While the seed coat contains a significant amount of nutrients, endosperm nutrients are more bioavailable (Liu, 2007). In terms of mineral content, millets have more fibre when compared to rice and wheat. Each one of the millets has more fibre than rice and wheat. Some millets have more than fifty times of fibre than of rice. Finger millet is having thirty times more Calcium than rice while all other millets have at least double amount of Calcium compared to rice (Amir Gull, *et al*, 2014). They include anti-nutritional elements such phytate and polyphenols, however these are primarily found in the seed coat. Milled millets are normally free of these components (Kumar *et al.*, 2010).

Pearl Millet

Though its consumption is limited to lower socioeconomic groups, pearl millet is a very nutritious grain that is even more so than other major cereals in terms of calories, protein, vitamins, and minerals. Phenolic chemicals found in pearl millet have anti-diabetic properties. As a result, it can be utilized to make a range of dietary items for people with diabetes. Additionally, it reduces the risk of diabetes mellitus, cancer, cardiovascular diseases, tumor incidence, blood pressure, heart disease, cholesterol, and fat absorption rate, among many other health benefits. Gall stone incidence is decreased by the fiber content of pearl millet. Because gallstones are caused by an excess of bile in the body, the insoluble fiber found in pearl millet aids in lowering this level (Shweta, 2015).

Nutrient per 100g

Nutrient per 100g		Primary Uses
Energy (Kcal)	361	Staple food
Protein	11.6 g	-porridges and flatbreads - Livestock feed
Carbohydrate	65.5 g	- Traditional alcoholic beverage
Crude Fibre	1.2 g	
Calcium	42mg	
Iron	8.0 mg	

Source: Nutritive value of Indian food, NIN, ICMR 2018

Sorghum

It has also been demonstrated that jowar, or sorghum, aids in weight loss. Jowar has a higher calcium content than major cereals like wheat and rice. It is also a great source of fiber, protein, and iron. Scientists have discovered that policosanols, which are abundant in sorghum wax, have the ability to lower cholesterol levels. Because it is a gluten-free grain, people who are intolerant to wheat-based items also really appreciate it. (O.S.K. Reddy, 2017)

Nutrient Per 100g

Nutrient per 100g		Primary Uses
Energy (Kcal)	349	Human consumption
Protein	10.4 g	- Animal feed - Biofuels and industrial applications
Carbohydrate	72.6g	
Crude Fibre	1.2 g	
Calcium	42mg	
Iron	8.0 mg	

Source: Nutritive value of Indian food, NIN, ICMR 2018

Finger Millet

Finger millet provides the greatest percentages of potassium (408 mg%) and calcium (344 mg) in all grains . It is higher in dietary fiber, minerals, and sulfur-containing amino acids than white rice, which is the country's current main grain. Recent studies show that urban Indians consume less finger millet, despite its nutritious advantages. Processing steps for finger millet include milling, popping, fermentation, malting, and decortication. Finger millet is used to make noodles, vermicelli, pasta, Indian sweet papads (halwa), soups, and baked goods.

Nutrient per 100g

Nutrient per 100g		Primary Uses
Energy (Kcal)	328	Porridges and malted beverages - Baked goods and snacks - Nutritional supplements
Protein	7.3 g	
Carbohydrate	72 g	
Crude Fibre	2.6 g	
Calcium	344 mg	
Iron	8.9 mg	

Source: Nutritive value of Indian food, NIN, ICMR 2018

Foxtail Millet

Foxtail millet facilitates the constant release of glucose without interfering with the body's metabolism. Because foxtail millet is a high source of magnesium, eating it lowers the prevalence of diabetes and makes it a heart-healthy food (O.S.K. Reddy, 2017). Significant amounts of protein, fiber, minerals, and phytochemicals can be found in foxtail millet. With the right processing techniques, anti-nutrients like tannin and phytic acid found in this millet can be significantly decreased. It has also been observed that millet has antioxidant, low-glycemic index, and hypolipidemic properties. The review comes to the conclusion that foxtail millet is still underutilized as a food source, much like most other millet kinds. Nonetheless, it is attracting more scientific and economic interest, particularly because to its ability to grow in challenging environments and its very low input requirements during growth. One could reasonably assume that foxtail millet holds promise for improving food and nutritional security (Nitya Sharma & Keshavan Niranjana, 2018)

Nutrient per 100g

Nutrient per 100g		Primary Uses
Energy (Kcal)	331	Staple food Idlis and dosas Bird feed
Protein	12.30	
Carbohydrate	60.9 g	
Crude Fibre	14.0 mg	
Calcium	31 mg	
Iron	3.6 mg	

Source: Nutritive value of Indian food, NIN, ICMR 2018

Kodo Millet

Kodo millet also aids in lowering knee and joint discomfort and assists women in regulating their menstrual cycles (Deshpande et al., 2015)

Nutrient per 100g

Nutrient per 100g		Primary Uses
Energy (Kcal)	302	- Human consumption
Protein	8.03 g	- Traditional dishes
Carbohydrate	69.9 g	- Crop rotation and soil
Crude Fibre	8.5 mg	
Calcium	22.0mg	
Iron	9.9mg	

Source: Nutritive value of Indian food, NIN, ICMR 2018

Proso Millet

Pellagra is a skin condition that leaves the skin rough, scaly, and dry. Niacin (Vitamin B3) and protein make up proso millet. It has historically been used as a healing food, particularly after childbirth or illness (Jana Kalinova, 2007)

Nutrient per 100g

Nutrient per 100g		Primary Uses
Energy (Kcal)	309	Human consumption
Protein	8.3	- Bird and poultry feed
Carbohydrate	65.9	- Soil improvement
Crude Fibre	9.0	
Calcium	27	
Iron	0.5	

Source: Nutritive value of Indian food, NIN, ICMR 2018

Little Millet

Little millet gives the body the necessary fats that aid in weight loss. Another benefit is its high fiber content, which makes it perfect for kheer or pongal in place of rice. (2017) O.S.K. Reddy.

Nutrient per 100g

Nutrient per 100g		Primary Uses
Energy (Kcal)	314	Staple food
Protein	10.13	Porridges rice dishes
Carbohydrate	65.55	
Crude Fibre	7.72	
Calcium	32.0	
Iron	1.3	

Source: Nutritive value of Indian food, NIN, ICMR 2018

MILLETS AS FOODS WITH A PURPOSE

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 (Gujral *et.al.*,2011) Millets, which contain a wealth of phytochemicals that promote health, have drawn a lot of interest because of their potential as functional foods. Millets are safe for those with celiac disease and gluten allergies since they are non-glutinous. They don't produce acids, making them simple to digest. They do not cause allergies either.

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Health benefits of millets

Cardiovascular Health	Millets are rich in antioxidants, fiber, and phytochemicals that promote heart health and may lower the risk of cardiovascular disease. (Ganesan.2018) Millets are also a good source of magnesium which is known for the reducing of heart attack. Millets which are known to be rich in phyto-chemicals which contains phytic acid helping in lowering cholesterol and preventing cardiovascular disease by reducing plasma triglycerides (Lee, et al., 2010).
Diabetes Management	Millets have a lower glycemic index than other grains, making them beneficial for managing blood sugar levels and lowering the risk of type 2 diabetes (Shobha <i>et.al.</i> ,2021) The enzymes like aldose reductase which helps in prevention of accumulation of sorbitol and reduces the risk of diabetes induced cataract diseases. Hence consuming millets helps controlling the blood glucose level and also helps in dermal wound healing process with the help of antioxidants (Rajasekaran NS, et al., 2004). Millets help in prevention of Type II Diabetes due to their significant levels of magnesium. Magnesium is an important mineral which helps in increasing the efficiency of Insulin and glucose receptors by producing many carbohydrate digesting enzymes, which manages insulin action. (O.S.K.Reddy, 2017)
Digestive Health	Millets' dietary fiber promotes proper digestion and may prevent constipation (Saleh et al., 2013).
Weight Management	Millets' high fiber content promotes fullness, aiding weight management and appetite control (Ganesan.2018) Millets are an excellent choice for weight loss diets due to their high nutritional density and low calorie content (Shobha <i>et.al.</i> ,2020)
Cancer prevention	According to research, millets are a good source of phenolic acids, phytates, and tannins—antinutrients that lower the risk of breast and colon cancer. It has been demonstrated that millets' phenolics can effectively stop cancer from starting and spreading in vitro (Chandrasekara A, et al., 2011).
Gluten-Free Alternative	Millets are naturally gluten-free, making them suitable for individuals with celiac disease or gluten sensitivity (Bhullar <i>et.al.</i> , 2018) .
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 (Chethan <i>et.al.</i> , 2018).

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 (Shobha *et.al.*, 2020) 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 (Franzluebber *et.al.*, 1995) Millets are valuable components in animal feed formulations. They provide essential nutrients to livestock and poultry, contributing to animal health and quality product outcomes (Haldhar *et.al.* 2013)Millets are also more reliable and produce a harvest even under adverse growing conditions..

Importance of millets for Indians

In the *Poshan Abhiyan* Report 2019, it is clearly mentioned that India is the home to one-third of its population which is malnourished, every second woman is anemic and every third of women is undernourished. There are 927,606 severely acute malnourished children in India. In 2016, 51.4 percent of women of reproductive age in India were suffering from anemia. Around 60 million children are underweight, 45 percent are stunted and 21 percent are wasted (Malnutrition in India report -2021). Millets can offer nutritional security and serve as a barrier against nutritional deficiencies, particularly in children and women. Its high iron content can help India's newborns and women of reproductive age combat the country's high prevalence of anemia. Millets would be the part of iron and protein diets of rural communities due to their ease of availability, low cost, and dense nutrition content. Further, these millets contribute to diversifying our food basket, which is at present very narrow because of excessive dependence on major cereals like rice and wheat among all millets, bajra is the cultivar that is farmed the most in India. It is very nutrient-dense and ideal for growing in semi-arid regions. Millet is attracting the world's attention as a key crop to overcome population explosion and food crisis. Hence, the pressing need to improve livelihoods and well-being through improved use of biodiversity has been augmented envisaged. Thus, the focus in India is to be on small-grain cereals, notably millets.

Millets' position in the food chain for Indians

Where millets are grown and produced, there is a decline in consumption of millets and its products. This is because of changes in consumer habits, the rapid urbanization rate, the time and effort needed to prepare millet-based foods, inadequate domestic structures, subpar marketing facilities, processing methods, a lack of staple supplies, and the relative scarcity of millets and its products, including flour, when compared to other foods. The millets do not need any fumigants. Millets have relatively a lower position in India, among feed crops in agriculture, but they are very important from food security point at regional and farm level, (Stanley Joseph, et al., 2013). Although mechanical pearling or polishing is well-known for grains like wheat, rice, and corn, it is largely unknown for millet. For instance, the production of millet was significantly harmed by big imports of wheat and rice as well as laws that subsidized those crops' production in various nations. Cereals and millets are typically blended with pulses in varying proportions, as cereals are low in lysine and high in methionine, while pulses are low in methionine and high in lysine. Mutual supplementation can enhance protein quality by balancing the amino acid profile (Gahlwat and Sehgal, 1994). Adding pulses and legumes like Bengal gram, green gram, pea, and soybean boosts the product's protein level. Millets can be substituted for cereals in composite mixes to increase micronutrients and fiber content (Kurahatti, 2010).

Millets contain phytate and polyphenols, however these are mostly found in the seed coat. Milled millets are often free of these anti-nutritional elements. Millet consumption is low in India due to these reasons

- Lack of technical know-how on processing methods among farmers and processors related to proprietary old processing methods.
- Cultural issues related to food introduction and diversification.
- Lack of public awareness of the nutritional value of millet and the general belief that millet is a poor man's crop.
- Consumer resistance to purchase and consumption

Annual Per Capita Consumption of Millets in India (Kg)

1960-1966	26.22
1981-1987	18.49
1988-1994	11.92
1995-2001	3.87
2009-2015	5.63
2016-2022	4.03

(APEDA REPORT-2023)

Production has mostly remained static while the domestic population kept on increasing, thereby explaining the decline in per capita consumption. Exhibit 9 shows the per capita consumption trend of millets in India.

Value Addition technologies The scope for value addition in millets starts from primary processing wherein the glumes and various foreign materials are separated to get desirable, fine edible grains with optimum quality and consumer acceptability. 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. Millet is typically ingested in India along with legumes, which promotes mutual with legumes, which creates mutual supplementation of protein, increases the amino acid content, and enhances the overall digestibility of protein. The phytate content of millets can be reduced by germination as during the germination the hydrolysis of phytate phosphorus into inositol monophosphate takes place which contributes to the decrease in phytic acid. The tannins are also leached during soaking and germination of grains, and hence it results in the reduction in tannins (Hussain 2011). Millet's fermentation where a particular bacterial/or yeast strain is grown over the mineral grain under optimized conditions. By applying fermentation as a processing method a lowering in the bio accessibility of the nutrient has been found whereas an increase in the total phenolic content was observed (Yano, et.al, 2017). Malting is another method of processing that includes a combination of a series of steps like germination, drying, toasting, and sieving it has been observed that during malting the antioxidant properties and total phenolic content increase in the millet while the tannin content decreases (Yang, et.al, 2020).

Primary Processing



Secondary Processing (Millet Flour, etc.)



Tertiary Processing



RTE snacks (Ready to Eat)

RTC (Ready to Cook)

Puffs, extruded

Instant Food (Noodles, Pasta)

Bakery (Bread, Biscuits)

Mixes (Idli, Dosa, Upma)

(APEDA,2023)

- Energy bar- By Tertiary Processing flaking and binding
- Breakfast cereals- By roasting, grinding, milling, and extrusion
- Puffed and expanded- Milling and extrusion
- Millet biscuit- Milling and baking
- Health drinks (weaning foods)- Roasting/Malting and grinding

Conclusion-

Powerhouses of nutrients, millets have numerous health advantages. Whilst a grain called millets has legacy honour in India, still more emphasis has been given to rice, wheat and maize production. These ancient grains provide a priceless supply of vital ingredients that support better digestion, strong bones, and the prevention of disease, such as fiber, minerals, and antioxidants. They are the best choice for controlling diabetes and preserving stable blood sugar levels due to their low glycaemic index because of their nutritional makeup, millets can be used to treat dietary deficits and malnutrition. , particularly in areas with limited resources. In order to achieve goals for food and nutrition security, millet can be extremely important. Growing efforts in invention and product development have produced a variety of millet-based culinary products that suit different consumer tastes. Moreover, the integration of millet-based foods into global, national, and state feeding initiatives will significantly contribute to mitigating the persistent nutrient deficits in poor countries. The growing popularity of these grains as a gluten-free alternative, benefit to farmers, and way to preserve natural resources makes it imperative to create processing technology that will extend millets' shelf life. In addition, enlightening people about the benefits of eating these grains for a long, disease-free life. Improvements in these wholesome, high-value grains will improve people's health, immunity, and socioeconomic standing.

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