

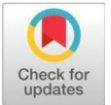
Review Article

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The Revival of Millets in Indian Thali: A Sustainable and Nutritional Revolution: A Review

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ABSTRACT

Millets, ancient grains once central to the Indian diet, have seen a sharp decline due to the rise of more refined cereals. However, their reintroduction into the Indian thali addresses critical health, nutritional, and environmental issues. Unfortunately, the potential of millet to address burning issues like food and nutritional security is never realized properly. India, the largest producer of millets, has taken several steps in recent years to revive millets as the plate staple. This paper delves into their historical background, nutritional and ecological benefits, economic relevance, and strategies for mainstreaming millets in modern diets. It also explores the challenges faced in promoting millet consumption and offers solutions for their sustainable integration into public food systems. Globally, there has been a notable surge in the prevalence of diabetes cases as a result of factors such as population growth, aging, urbanization, rising obesity rates, and declining physical activity. Diabetes can be controlled in large part by diet, and millets having low-glycemic index (GI) have become more significant as they release glucose into the bloodstream at a very slow rate. Dietary changes, particularly the addition of millet, can help prevent and manage diabetes mellitus. Eating practices have long been acknowledged for their important role in promoting health and wellness through the consumption of nutrient-dense meals

Keywords: Millets, historical importance, nutritional value, value-added millets, diabetes, environment sustainability, policies

Introduction

Millets, often dismissed as "coarse grains," are small-seeded cereals that have been cultivated for thousands of years. These grains include sorghum (jowar), pearl millet (bajra), and finger millet (ragi), which are highly regarded for their nutritional content and their minimal environmental footprint. Millets are major energy source and staple food for people living in the dry and arid regions of the world. The stover after harvest of grains is a source of nutritive fodder to animals apart from its industrial use as bird feed, brewing, potable alcohol etc. Millets had been the lifeline of dry regions of Asia and Africa for food and fodder. In the face of modern challenges such as climate change, water scarcity, and increasing health problems like diabetes and obesity, millets present a sustainable solution. Their revival in the Indian thali represents more than just a return to traditional eating but is part of a broader movement towards a healthier, more resilient food system [5].

A healthy diet is one of the lifestyle-based therapies that are most important for treating diabetes, and many nations have set their dietary guidelines regarding this. Every nation shares a commitment to provide personalized nutrition therapy based on individual preferences and treatment objectives. Unfortunately, due to national and even regional differences within a single country, as well as variations in body size, age, lifestyle and cuisine, nutritional therapy cannot be standardized. Nowadays, with technology being so easily available, people are leading highly sedentary, stressful lives devoid of adequate sleep and a well-balanced diet.

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Among the top 10 causes of death, along with cancer, respiratory diseases, and cardiovascular diseases, diabetes mellitus (DM) is one of the most crucial health issues of the twenty-first century. India is now a hub for conditions like obesity, atherosclerosis, DM, hypertension (HTN), and heart disease. One of the global epicenters of the DM pandemic is India. The past 40 years have seen an exponential rise in the prevalence of DM in India due to rapid socioeconomic development, demographic shifts, and greater susceptibility for Indians. A study by the Indian Council of Medical Research (ICMR) estimates that over 101 million Indians have diabetes, which is much higher than earlier reported figures. A minimum of 136 million individuals, or 15.3% of the populace, suffer from prediabetes.

Dietary changes, particularly the addition of millet, can help prevent and manage diabetes mellitus. Eating practices have long been acknowledged for their important role in promoting health and wellness through the consumption of nutrient-dense meals. The health benefits of millet, an underappreciated food crop, are numerous and include low GI, high-fiber content, non-acid-forming potential, polyunsaturated fatty acids (PUFAs), and gluten-free status. Apart from staple crops like wheat and rice, millets are also very healthy and useful, and they have an immense amount of opportunity to aid in the global fight against food insecurity, which is a problem that many countries now confront. Millets are high on the list of recommended foods because of their many health advantages and antioxidant characteristics. Diets that are low in carbohydrates, low in GI, Mediterranean, and very low in calories are now popular.

Historical Context and the Green Revolution

Millets have a deep connection to the Indian subcontinent, with evidence of their use dating back to the Indus Valley civilization (circa 2500 BCE). They are also mentioned in ancient texts like the Yajurveda. For centuries, millets formed a critical part of diets in drought-prone and resource-scarce regions, playing a

vital role in food security. However, post-Green Revolution, the government's focus shifted towards promoting rice and wheat, which were seen as high-yield, staple crops. As a result, millet production plummeted, from 44.34 million hectares in 1965-66 to just 22.65 million hectares in 2021-22 [4] and [13].

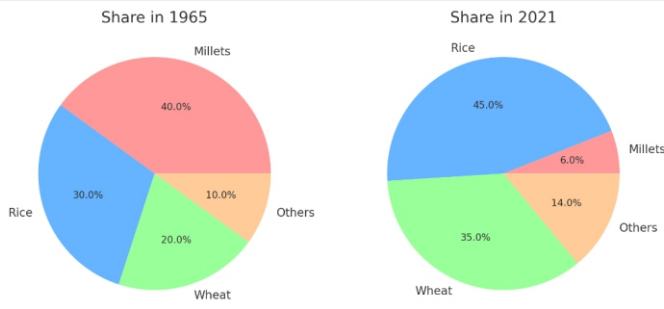


Fig.1 Share of Millets production in India over the time

Millets are resilient grains that thrive in semi-arid environments, making them an ideal crop for locations where water management is a priority. Most cultivars provide more protein than rice and are higher in iron content than both rice and wheat. Despite India's long history of eating millets, consumption of pearl millet or bajra declined by 67% in urban regions and 59% in rural areas between 1972-1973 and 2004-2005. According to another research, jowar, bajra, maize, and ragi contributed 23% of Indians' grain requirements in 1983 but just 6% in 2011. In order to reverse the trend of decreasing millet consumption, India designated 2018 the National Year of Millets in order to encourage the production and consumption of millet or nutri-cereals. Millet's production climbed from 14.52 million tons in 2015-2016 to 17.96 million tons in 2020-21. The three millets, Jowar, Bajra, and Ragi, are known as neutral, and Brown top, Kodu, Proso, Barnyard, and Foxtail are the positive millets. These five millets are becoming more and more popular because of their incredibly beneficial to the digestive system and can heal chronic conditions like diabetes.

Nutritional and Environmental Benefits of Millets

Millets are powerhouses of nutrition, offering essential vitamins and minerals. Sorghum (jowar) is gluten-free and helps regulate blood sugar and cholesterol levels, while pearl millet (bajra) is high in protein, fiber, and calcium, aiding in the prevention of anemia and enhancing digestion [12]. Finger millet (ragi) is renowned for its calcium content, making it ideal for bone health. Additionally, foxtail millet and kodo millet are rich in antioxidants and have low glycemic indices, making them beneficial for diabetics. Millets were the oldest foods known to humans but their importance and cultivation reduced due to large-scale cultivation of rice and wheat because of urbanization and industrialization. With diabetes, hypertension and cardiovascular disease becoming more prevalent, as gifts of newly acquired life-styles and food habits, millets have returned as a viable option to live healthy life and can reduce the incidence of these lifestyle diseases.

The world diabetic population is estimated to increase from 537 million in 2021 to 643 million by 2030, and 783 million by 2045 [9]. Three in four diabetic adults live in low- and middle-income countries. Millets are traditional food crops in Asia and Africa, which contain dense nutrition and have multiple health benefits. The nutritional benefits vary by type and variety of millet and growing conditions. For example, finger millets are high in calcium [1], and millets in general help in the growth of children [2].

The meta-analysis indicated that regular consumption of millets helps manage FBS and PPBS levels, thereby reducing the risks of developing type 2 diabetes. This would inform the design of dietary guidelines for populations at risk of diabetes, given the prevalence of diabetes in all regions across the globe. As the Asian population largely consumes diets based on rice and wheat, millet-based interventions can be applied to diversify staples and reduce the risk of diabetes. Governments, development agencies, and dieticians should design programs to diversify staples using millets through awareness-raising, recipe and product development, and marketing campaigns to ensure millet-based diets are accepted in the specific sociocultural environment.

Millets have many nutritional, nutraceutical and health-promoting properties especially the high fibre content, nature of starch has major role in reducing the risk of diabetes related diseases. Indeed millets act as a prebiotic feeding micro-flora in our inner ecosystem. Millet will hydrate our colon to keep us from being constipated. The high levels of tryptophan in millet produce serotonin, which is calming to our moods. Niacin in millet can help lower cholesterol. Millet consumption decreases triglycerides and C-reactive protein, thereby preventing cardiovascular disease. All millet varieties show high antioxidant activity. Millet is gluten-free and non-allergenic.

Millets are incredibly nutrient-dense food crops that are high in iron, calcium, magnesium, zinc, potassium, fatty acids, protein, and dietary fiber. They are also especially rich in vitamins, particularly the B complex. Dietary fibers from millet serve as prebiotics, promoting the growth of a balanced gut microbiota. Millets include dietary fiber, which can aid with blood glucose management, slow down the rate at which glucose is absorbed in the small intestine, and lower the food's GI.

Table 1: Nutritional value of minormiltes (per 100 g of edible portion)

Crop	Protein (gram)	Fiber (gram)	Minerals (gram)	Iron (Mg)	Calcium (mg)
Pearl Millet	10.6	1.3	2.3	16.9	38
Finger Millet	7.3	3.6	2.7	3.9	344
Foxtail Millet	12.3	8	3.3	2.8	31
Proso Millet	12.5	2.2	1.9	0.8	14
Kodo Millet	8.3	9	2.6	0.5	27
Little Millet	7.7	7.6	1.5	9.3	17
Barnyard Millet	11.2	10.1	4.4	15.2	11
Sorghum	10.4	1.6	1.6	4.1	25
Wheat	11.8	1.2	1.5	5.3	41
Rice	6.8	0.2	0.6	0.7	10

Most of the millets are kharif season crops (sown during May-June) and come to maturity in September to October. Most of these crops give good yields during rabi season (October-March) and summer season (January-April). Millets require very less water as compared to rice and wheat and considered drought-tolerant crops. These crops are majorly grown in regions receiving less than 450 mm rainfall (compared to about 700 mm minimum for maize). About 50% of sorghum and 80% of millet production is used for human consumption while the rest is used for poultry feed, potable alcohol and other industrial purposes. Millets are sometimes referred to as famine crops since they are the only crops that assure yields in famine situations. Earlier, these crops were also called as orphan crops since they are the last option for cultivation as they had less demand in the market and profits earned are also lower than other crops. However, these neglected crops are important by virtue of their contribution to the means of livelihood, food and nutritional security of the poor in various parts of the world and they diversify our food basket. Millets also offer environmental advantages—they are drought-resistant, require minimal

water, and thrive in poor soils without the need for synthetic fertilizers [15]. Thus, they are ideal for cultivation in India's arid regions and provide a sustainable alternative to water-intensive crops like rice.

In rice production, temperature increases are predicted to reduce rice yields. So, there is a need to consider adaptive measures to cope with changing agricultural patterns. Due to climate change, there is a decline in yield leading to food insecurity, more attacks of pests and diseases, soil degradation, change in crop schedules, and desertification. Considering millets as an alternative crop is a better choice and we can say it is the future crop [17].

Millets are drought resistant, requiring a very low amount of water; approximately 200-300 litres of water is required to produce 1 kg of millet, whereas a whopping 8,000-12,000 litres of water is required to produce 1 kg of rice and wheat. One of the reasons for the contamination of water, soil, and air is the intensive use of pesticides and fertilizers to grow crops that require them – like rice and wheat. Not only is the environment affected, this contamination also affects the health of humans, animals, and plants. Health issues such as leukemia, brain cancer, and asthma are a few examples of illnesses linked to pesticides and fertilizers. All of this can be reduced by growing millets, since these crops can be grown without much use of pesticides and fertilizers. Millets have a much smaller environmental footprint than that of rice or wheat; millets conserve water, benefit the health of the soil, and prevent pollution through their limited need for agrochemicals, making millets the most environmentally friendly choice of grain.

The cultivation of millets demands fewer resources, showcases higher resistance to diseases and insects, and requires reduced application of synthetic fertilizers and pesticides. Their adaptability to climate change further establishes millets as a sustainable choice, capable of improving livelihoods for small-scale farmers while diversifying the food chain.

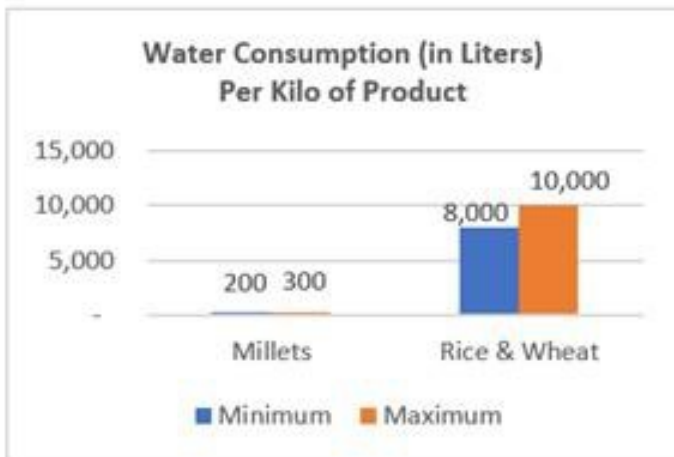


Fig 2: Water consumption by millets

Economic Importance and Current Status of Millets

The Indian government has recognized the importance of millets for addressing food security and nutritional deficiencies. In 2018, millets were rebranded as "nutri-cereals" and incorporated into the National Food Security Mission [11]. Policies have been introduced to encourage millet cultivation through an increased Minimum Support Price (MSP), and India aims to become a top exporter of millets by 2025. However, despite these efforts, millets currently account for only 5-6% of the national food basket, down from 40% during pre-Green Revolution times [6].

India is the highest producer of millets in the globe and the 5th largest exporter of millets. Its exports are increasing exponentially as the demand for millets is increasing at a faster rate. Millets are addressing the need for fuel and feeds. It has the potential to produce biofuel. As the demand for millets is increasing, it is creating more business opportunities for entrepreneurs. Millet Market size was over USD 9 billion in 2018 and will witness more than 4.5% CAGR during the forecast timespan (2018-2025) and the value projected is more than USD 12 billion.

These days, millets are grains that fit into a diet quite readily. Millet should be added to the diet gradually over time, starting with a small amount at first. Millet was traditionally eaten in diets as puffed, flaked, and popped grains. In recent years, millet-based noodles, vermicelli, pasta, baked goods, and sweets, particularly finger millet, have become more widely available. Several tactics that enhance soil fertility, optimize cultivation practices, make optimal use of water resources, and support sustainable farming practices can all be used to increase millet production. Production of millet is important from an economic, environmental, and nutritional standpoint, and it is essential to world agriculture and food security.

Food and beverage producers in India are adopting millets in a big way. You can find millets in a range of products, from biscuits to beer. From packaged foods to breweries to restaurants, large companies including Nestle, ITC, Britannia, HUL, Tata Consumer, Bira 91 and Slurrp Farm are putting up ambitious plans to introduce millet-based packaged foods, beers and restaurant menus or boost their existing millet portfolios. "We are innovating on functional ingredients by incorporating more of super grains, seeds, nuts and fruits with whole grains in our foods, actively engaging with partners and also looking for appropriate opportunities in this evolving space," Sudhir Nema, Chief development and quality officer at India's largest biscuits maker Britannia, told ET recently. Nema said Britannia, which already makes packaged foods with millets, oats, seeds and herbs fortified products under its flagship NutriChoice biscuits. India's largest packaged foods maker Nestle, which makes Maggi noodles and KitKat chocolate, has already inked a tie-up to integrate millets in its foods. A Nestle R&D Centre India spokesperson told ET recently that an MoU has been signed between millets incubator startup Nutrihub, ICAR-Institute of Millets Research and Nestle's R&D Centre, a subsidiary of the Swiss foods maker's parent company Nestle SAUL has signed an MoU with Indian Institute of Millets Research (IIMR), which has been named as a Centre of Excellence by the Government, to make millet-based drinks under its Horlicks brand, executives aware of the developments told ET. ITC has already introduced a number of millet-based products under the Aashirvaad Nature Superfoods brand including ragi flour, gluten-free atta and multi-millet mix. Aashirvaad Soul Creations, as part of ITC's Food Tech Initiative, offers millet-based khichdi that can be ordered at home. ITC Hotels has included millet-based dishes in their buffets — from risotto, jowar kebab, and jowar tur dal tadka to kutkikhaosuey and kodohalwa. TajMahal Palace in Mumbai sources various kinds of millets for risotto, tehri and khichd [7].

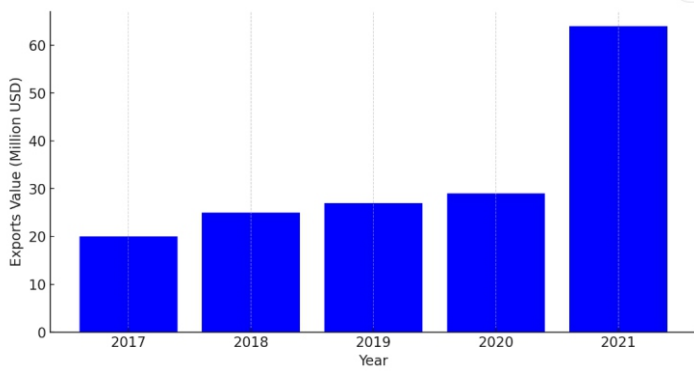


Fig 3 : Millets export from India during time

Challenges in Promoting Millets

Despite the growing awareness of millet's benefits, several barriers remain to their widespread acceptance. Consumer perception, marketing, and taste preferences are major issues. Many still associate millet with poverty or consider it less appealing compared to more refined cereals [8]. Additionally, the food industry has been slow to develop millet-based products that appeal to modern tastes and convenience-driven lifestyles. The lack of effective marketing strategies and innovation in millet-based products has resulted in limited market visibility. Moreover, the agricultural infrastructure for millet cultivation is underdeveloped compared to that for rice and wheat.

Beside this, low productivity of millets, lack of awareness about millets benefits, high cost (millets often come with a higher price tag compared to traditional cereals, posing accessibility challenges for low-income consumers), limited availability of retail market, Agricultural hurdles (millet cultivation is frequently associated with low yield and limited profitability, discouraging farmers from cultivating them), competition with rice and wheat, decentralized processing (processing millets poses several challenges, mainly due to the differences in size among various millet types and the low shelf life of processed millets. The grains vary in shape, grain surface nature, hardness, and husk-grain bonding. Additionally, there can be variations within the same small millet crop due to differences in varieties, cultivation practices, and microclimate across production regions), poor marketing and market linkage due to inconsistent supply and demand, which is hampering its commercial viability, low crop productivity is a result of the lack of access to high-yielding (HYV) seeds, while limited awareness about the nutritional benefits of millets has contributed to their low adoption as a ready-to-cook cereal. Furthermore, sub-optimal reach, lower price realization, and wastage are the consequences of limited distribution and market knowledge, short shelf life due to their intrinsic enzyme activity, make suitable for rapid rancidity and bitterness, as well as lipid oxidation.

To overcome these barriers, a multi-faceted approach is required [16]:

1. Collaboration with the Food Industry: Partnering with food manufacturers and retailers can help expand the range of millet-based products. Innovation in flavors, packaging, and product development will make millets more attractive to diverse consumer segments.

2. Integration into Public Nutrition Programs: Incorporating millets into school feeding programs, community initiatives, and the public distribution system can enhance their accessibility and acceptance.

This strategy can also help address malnutrition, particularly among children and women.

3. Consumer Engagement and Education: Educating consumers about the health benefits of millets through campaigns, cooking workshops, and social media can drive demand. Encouraging consumers to share recipes and experiences can create a community-driven movement towards millet consumption.

4. Support from Healthcare Professionals: Collaboration with dietitians, nutritionists, and healthcare providers can help incorporate millets into dietary recommendations and treatment plans, building trust and credibility among consumers.

Future scope of Millets

Food security exists when every individual has consistent and equitable access—both economic and social—to sufficient, safe, and nutritious food to meet their daily dietary needs, enabling a healthy, active, and fulfilling life. However, in today's world, climate change and the resulting rise in global temperatures (global warming) are posing significant challenges to crop production and the sustainability of food systems. Addressing these challenges requires a collective effort to reduce greenhouse gas (GHG) emissions, a critical step toward achieving food security.

Among agricultural practices, the cultivation of commonly grown cereals significantly contributes to GHG emissions. For instance wheat cultivation releases the highest amount of CO₂—approximately 4.0 tons CO₂ equivalent per hectare (eq/ha) whereas Rice and maize cultivation follow, emitting nearly 3.4 tons CO₂ eq/ha. These crops, while essential as staple food sources and primary providers of nutrients for the global population, have a substantial potential to exacerbate global warming.

In contrast, millet cultivation demonstrates a significantly lower global warming potential compared to these major cereals. This characteristic makes millets a sustainable alternative that aligns with efforts to mitigate climate change. Promoting millet cultivation not only addresses environmental concerns but also supports climate-resilient food systems, paving the way for sustainable food security [18].

Conclusion

The revival of millets in the Indian thali represents an opportunity to reconnect with traditional dietary practices while addressing contemporary challenges such as food security, nutritional deficiencies, and environmental sustainability. With coordinated efforts from government bodies, private enterprises, and civil society, millets can regain their status as a staple grain in India, fostering a more resilient and healthy food system. Balanced, healthful, and affordable meals can be served by including millet in a regular diet. People with diabetes can improve their general health and better regulate their blood sugar levels by using millets in their diet. Millets have been demonstrated to be an excellent blood sugar regulator due to their high fiber content and low GI. For those who have diabetes, the complex carbs in millet must break down slowly to avoid sharp rises in blood sugar. Moreover, millets have a well-rounded nutritional profile because they're an excellent source of important nutrients like minerals, vitamins, and antioxidants.

These nutrients not only promote general health but also lessen the chance of problems from diabetes. Consumer awareness of nutrition is increasing, creating pressure on the food industry to develop new products with unique features that can enhance people's health. Being a highly nutritious superfood, millet is the most powerful weapon to defeat malnutrition in poor populations of India.

Conflict of interest: The authors declare that the very less research, promotion and awareness work was available that could be construed as a potential conflict of interest.

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