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Millets a Pathway to Nutrition Security for Sustainable Agriculture

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Authors' contributions

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

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Review Article

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ABSTRACT

Millets, a group of small-seeded grasses, have been cultivated for thousands of years and are an integral part of traditional diets in many regions of the world. The nutritional value, resilience to harsh environmental conditions, and potential for sustainable agriculture, millets have been largely overlooked and underutilized in modern food systems, the nutritional benefits of millets, their role in ensuring food security, and strategies for promoting their cultivation and consumption. Millets are rich in essential nutrients, including protein, fiber, vitamins, and minerals, and offer numerous health benefits, such as reducing the risk of chronic diseases like diabetes and heart disease. Additionally, millets are well-suited to climate-resilient agriculture, requiring less water and fertilizer than many other cereal crops. By promoting the cultivation and consumption of millet, policymakers, researchers, and agricultural stakeholders can enhance food security, support small-scale farmers, and promote sustainable food systems and the need for increased investment in millet research, the development of value chains, and consumer education to realize the full potential of millets in addressing global food security challenges.

Keywords: Millets; food security; nutrition; sustainable agriculture; climate resilience.

1. INTRODUCTION

Millets, a group of small-seeded grains, have been cultivated for centuries and have served as staple foods for millions of people around the world [1-3]. Despite their nutritional richness and adaptability to diverse agro-climatic conditions, millets have often been overlooked in favor of more widely cultivated cereals like rice, wheat, and maize. However, with the increasing challenges posed by climate change, water scarcity, and food insecurity, there is a growing recognition of the potential of millets to play a significant role in ensuring global food security. Millets, including varieties such as pearl millet, finger millet, sorghum, and foxtail millet, have been fundamental to the diets of diverse cultures across Asia, Africa, and parts of Europe for centuries. Historically, they have been cultivated in regions with challenging growing conditions, such as arid and semi-arid environments, where other crops struggle to thrive. This resilience to harsh climates has made millets a reliable source of sustenance for communities facing environmental challenges, including drought and soil degradation [4-6].

Nutritional benefits and adaptability, millets have often been marginalized in modern agricultural systems, overshadowed by more widely cultivated crops like rice and wheat. This trend has been driven in part by agricultural policies and market dynamics that prioritize the production of staple grains over traditional and locally adapted crops. As a result, millet cultivation has declined in many regions, leading to a loss of biodiversity and cultural heritage associated with these ancient grains. there has been a resurgence of interest in millets as a sustainable and nutritious food source. Researchers, policymakers, and farmers are recognizing the potential of millet to address contemporary challenges such as food insecurity, malnutrition, and climate change. Millets are known for their high nutritional value, containing essential nutrients such as protein, fiber, vitamins, and minerals. They are also gluten-free, making them suitable for individuals with celiac disease or gluten intolerance, millets require fewer inputs such as water and fertilizer compared to other cereal crops, making them well-suited to sustainable agricultural practices [7-12]. Their deep root systems help improve soil structure and fertility, making them valuable components of agroecological farming systems. By promoting millet cultivation, farmers can diversify their crop portfolios, reduce dependence on external inputs, and enhance resilience to climate variability, millets contribute to cultural diversity and food sovereignty, preserving traditional knowledge and culinary heritage. In many communities, millets are not just a source of nutrition but also play important roles in rituals, festivals, and social gatherings. Revitalizing millet production and consumption can thus contribute to the preservation of cultural identity and the promotion of local food systems, the resurgence of interest in millets presents an opportunity to promote sustainable agriculture, improve nutrition, and enhance food security for communities around the world. By harnessing the nutritional and ecological benefits of millets, we can build more resilient and inclusive food systems that nourish both people and the planet [13-15].

2. NUTRITIONAL VALUE OF MILLETS

Millets are nutritional powerhouses, rich in protein, dietary fiber, vitamins, and minerals. They are particularly high in iron, calcium, magnesium, and antioxidants, making them an excellent dietary choice for combating malnutrition and addressing micronutrient deficiencies, especially in vulnerable populations. Additionally, millets are gluten-free, making them suitable for individuals with celiac disease or gluten intolerance. Incorporating millets into the diet can help diversify nutrient intake and improve overall health outcomes [16-21].

This table provides a comparison of the nutritional composition of pearl millet, finger millet, sorghum, and foxtail millet. It includes information on energy content, macronutrients (carbohydrates, protein, fat, fiber), micronutrients (calcium, iron, magnesium, phosphorus, potassium, zinc), and vitamins (B1, B2, B3, B6, folate). These values are approximate and may vary depending on factors such as variety, growing conditions, and processing methods. Millets are increasingly recognized as a key component in achieving nutrition security and promoting sustainable agriculture. These ancient grains are exceptionally nutrient-dense, offering high levels of proteins, dietary fiber, and essential minerals such as iron and calcium, while also boasting a low glycemic index that supports better metabolic health. Their ability to thrive in arid and semi-arid environments with minimal water and input requirements positions millets as a resilient crop option, especially valuable in the face of climate change and resource scarcity. Moreover, millets contribute positively to soil health, enhancing soil structure and fertility, which can reduce the reliance on chemical fertilizers. Economically, millets present a viable option for smallholder farmers, with lower production costs and potential for increased income through growing market demand. However, challenges such as gaps in cultivation knowledge and consumer acceptance need to be addressed through continued research and effective policy support to fully realize their benefits.

3. RESILIENCE TO ENVIRONMENTAL STRESSES

One of the key attributes of millets is their resilience to environmental stresses such as drought, heat, and poor soil fertility. Unlike many other cereal crops, millets require minimal water and fertilizer inputs, making them well-suited to regions prone to erratic rainfall and soil degradation. Their short growing seasons and ability to thrive in marginal lands further enhance their adaptability to challenging growing conditions [22-25]. By promoting the cultivation of millets, farmers can mitigate the risks associated with climate variability and ensure stable food production even in the face of environmental uncertainties.

Table 1. Nutritional value of millets

Nutrient	Pearl Millet	Finger Millet	Foxtail Millet	Proso Millet	Little Millet
Calories (kcal)	378	336	357	365	361
Protein (g)	11.6	7.3	12.3	11.0	7.7
Fat (g)	4.4	1.5	4.3	3.3	4.1
Carbohydrates (g)	67.0	72.0	60.0	69.0	65.0
Fiber (g)	8.5	3.6	7.6	8.5	7.6
Calcium (mg)	42	344	31	8	17
Iron (mg)	8.0	3.9	2.8	2.7	7.2
Magnesium (mg)	140	137	110	115	138
Phosphorus (mg)	296	283	268	340	266
Potassium (mg)	508	408	268	256	284
Vitamin B1 (mg)	0.35	0.27	0.36	0.31	0.36
Vitamin B2 (mg)	0.10	0.26	0.14	0.16	0.19

Note*: Values are approximate and can vary based on cultivation practices, processing methods, and variety*

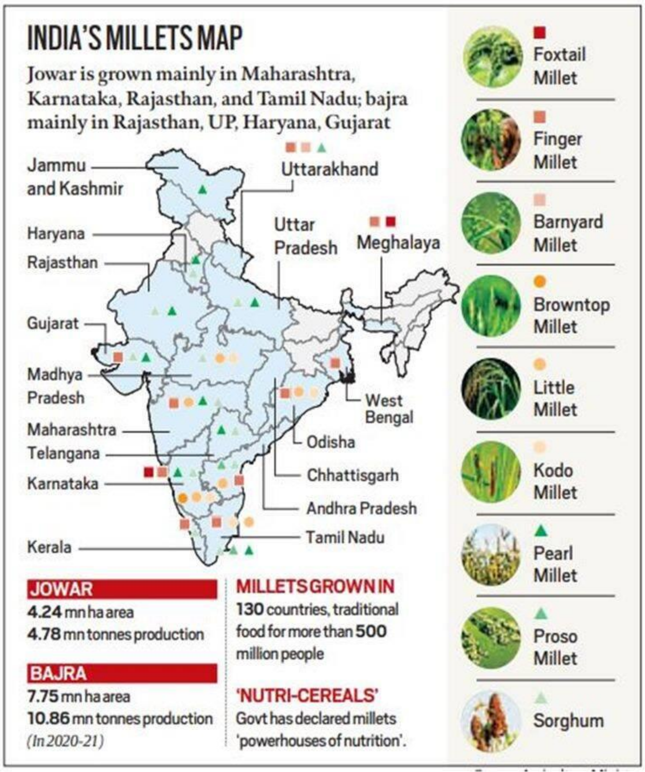

Fig. 1. India's millet map

Source:https://vajiramandravi.com/upsc-daily-current-affairs/mains-articles/the-international-year-of-millets/

4. PROMOTING SUSTAINABLE AGRICULTURE AND FOOD SYSTEMS

The cultivation of millets aligns with the principles of sustainable agriculture, as it promotes biodiversity, conserves water and soil resources, and reduces greenhouse gas emissions. Millets are often grown using traditional farming practices, such as intercropping, agroforestry, and organic farming, which contribute to ecosystem resilience and agroecological diversity, millet-based cropping systems provide opportunities for smallholder farmers to diversify their income sources and improve their livelihoods [16-34]. By integrating millets into cropping rotations and promoting agroecological approaches, policymakers and agricultural stakeholders can foster more sustainable and resilient food systems that benefit both people and the planet. Millet represent a valuable yet underutilized resource for ensuring food security, promoting nutrition, and enhancing resilience to climate change. Their nutritional richness, adaptability to diverse agro-climatic conditions, and contribution to sustainable agriculture make them a promising solution to the challenges facing global food systems. However, realizing the full potential of millets requires concerted efforts from policymakers, researchers, farmers, and consumers to promote their cultivation, consumption, and value addition [35-51]. By prioritizing millets in agricultural policies, research agendas, and dietary guidelines, we can harness the power of these ancient grains to build a more sustainable and equitable food future for all [52,53].

5. HEALTH BENEFITS

Millets, often referred to as "nutri-cereals," are a diverse group of small-seeded grasses that have been cultivated for thousands of years. They include varieties such as pearl millet, finger millet, foxtail millet, and sorghum. In recent years, millets have gained attention for their numerous health benefits and their role in promoting sustainable agriculture. Their resilience to harsh environmental conditions, minimal water requirements, and ability to grow in marginal soils make them an essential crop for food security, particularly in drought-prone regions. This review highlights the health benefits of millets and their role in ensuring nutrition security and promoting sustainable agricultural practices.

Fig. 2. Millets health benefit
Source: https://apeda.gov.in/milletportal/health_benefits.html

Millets are nutrient-dense, offering a rich source of essential vitamins and minerals, including iron, calcium, magnesium, phosphorus, and B-vitamins. They are gluten-free, making them an excellent dietary option for individuals with celiac disease or gluten intolerance. Their high fiber content contributes to improved digestion and helps prevent constipation, while their low glycemic index makes them suitable for managing blood sugar levels, especially for people with diabetes. Additionally, millets are known for their antioxidant properties, which can help reduce inflammation and protect against chronic diseases like heart disease and cancer.

The health benefits of millets extend beyond their nutritional value. Several studies have shown that regular consumption of millets can contribute to the prevention of lifestyle-related diseases. For instance, their high fiber and complex carbohydrate content help in weight management by promoting satiety and reducing the likelihood of overeating. Furthermore, millets are rich in phytochemicals, such as polyphenols and flavonoids, which have been associated with lower risks of cardiovascular diseases and certain cancers. Their high magnesium content also supports heart health by helping regulate blood pressure and reducing the risk of stroke.

Millets also play a crucial role in promoting sustainable agriculture. As climate change intensifies, the need for resilient crops that can withstand extreme weather conditions has become more urgent. Millets thrive in arid and semi-arid regions, requiring less water than conventional cereals like wheat and rice. Their ability to grow in poor soils with minimal inputs makes them a sustainable option for farmers, particularly in regions facing water scarcity and soil degradation. Furthermore, millet cultivation contributes to biodiversity, as it encourages the diversification of crops, thereby enhancing the resilience of agricultural ecosystems, millets offer numerous health benefits, from improving digestive health and managing blood sugar levels to reducing the risk of chronic diseases. Their cultivation not only supports nutrition security but also promotes sustainable agricultural practices that are essential for addressing the challenges posed by climate change and food insecurity. As the world looks for solutions to ensure food security and combat malnutrition, millets present a viable pathway to achieving both health and environmental sustainability.

Fig. 3. Health benefit of millets

Source: https://selliliar.live/product_details/20751228.html

6. CONCLUSION

Millets stand out as a valuable yet often overlooked resource with the potential to address multiple challenges facing global food systems. Their exceptional nutritional richness, adaptability to diverse agro-climatic conditions, and ability to contribute to sustainable agriculture make them a promising solution in the fight against hunger and malnutrition. However, realizing the full potential of millets requires collaborative efforts from various stakeholders. Firstly, policymakers play a crucial role in promoting millet cultivation by implementing supportive policies, providing incentives for farmers, and integrating millets into national agricultural strategies. By recognizing the importance of millets and prioritizing their production, policymakers can create an enabling environment for farmers to grow these crops sustainably. Secondly, researchers have a responsibility to conduct further studies on millets to enhance their agronomic performance, nutritional value, and resilience to climate change. This includes developing high-yielding and climate-resilient millet varieties, improving agronomic practices, and exploring innovative processing techniques to add value to millet-based products. Thirdly, farmers need support and access to resources to adopt millet cultivation practices and integrate them into their cropping systems. Extension services, training programs, and financial incentives can empower farmers to embrace millet cultivation and maximize its potential benefits, consumers play a vital role in driving demand for millet-based foods by raising awareness about their nutritional benefits, culinary versatility, and environmental sustainability. By incorporating millets into their diets and supporting local producers, consumers can contribute to the growth of the millet market and promote a more diverse and resilient food system prioritizing millets in agricultural policies, research agendas, and dietary guidelines can unlock their full potential to ensure food security, promote nutrition, and enhance resilience to climate change. By working together, we can harness the power of these ancient grains to build a more sustainable and equitable food future for all.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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