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13. Revitalizing Millets: Nourishment for Health and Sustainability

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Abstract:

Millets, ancient grains cultivated for millennia, have played pivotal roles in human diets, cultural traditions, and agricultural practices. Despite facing challenges such as declining popularity and limited accessibility, there is a growing movement to revitalize millets driven by their nutritional richness, environmental sustainability, and cultural heritage. Strategies for promoting millets in the modern food system include awareness campaigns, research and development initiatives, policy support, supply chain development, culinary innovation, and consumer education. Embracing millets not only fosters better health outcomes and environmental sustainability but also preserves cultural heritage, supports smallholder farmers, and builds resilient food systems for the future. This comprehensive exploration delves into the multifaceted aspects of millets, encompassing their historical significance, health benefits, environmental sustainability, challenges, opportunities, culinary versatility, and promotion in the modern food system.

Keywords:

nutri-cereals, nutraceuticals, phytochemicals, food security and nutritional security.

13.1 Introduction:

13.1.1 Millets and Their Historical Significance:

Millets are a group of small-seeded grasses that have been cultivated for thousands of years, primarily in semi-arid tropical regions of Asia and Africa. These resilient grains have been a staple food for many cultures, providing sustenance and nutrition in regions where other crops struggle to thrive.

Millets includes foxtail millet, finger millet, brown top millet, little millet, pearl millet, sorghum and proso-millet. More than 90 million people in Africa and Asia depend on millets for food. Over 500 million people in more than 30 countries depend on sorghum as staple food. Millets including sorghum are grown in 131 countries and are more important for food and nutritional security. The historical significance of millets spans thousands of years and is deeply intertwined with the development of human civilization, agriculture, and dietary practices.

Millets have been cultivated and consumed by diverse cultures across the globe, leaving a rich historical legacy that is documented in archaeological findings, historical texts, and cultural traditions. Here's a detailed exploration of the historical significance of millets.

A. Early Cultivation and Domestication of millets:

Millets are among the earliest domesticated crops, with evidence of their cultivation dating back to Neolithic times. Archaeological excavations have uncovered millet grains at sites such as Jiahu in China, Mehrgarh in Pakistan, and Hacilar in Turkey, providing insights into their role in early agricultural societies (Crawford, 1992).

The domestication of millets played a pivotal role in the transition from nomadic hunter-gatherer lifestyles to settled agricultural communities, laying the foundation for the development of civilization.

B. Millets in ancient civilizations:

Millets were staple foods in many ancient civilizations, where they served as dietary staples for millions of people. In India, for example, the cultivation of millets dates back to the Harappan civilization, as evidenced by archaeological remains at sites such as Rakhigarhi and Banawali (Fuller, 2006). Millets such as pearl millet and finger millet were widely cultivated and consumed by ancient Indian societies, forming the basis of their culinary traditions and agricultural practices.

Similarly, in Africa, millets were integral to the diets of ancient civilizations such as those in Egypt, Ethiopia, and Sudan. The ancient Egyptian hieroglyph for "bread" depicted a loaf made from millet, highlighting its importance as a staple food (D'Andrea et al., 2007). Millets were also cultivated by ancient civilizations in the Middle East, including the Sumerians, Babylonians, and Assyrians, who used them to make bread, porridge, and fermented beverages (Miller, 2014).

C. Trade and Exchange OF millets:

Millets played a crucial role in ancient trade networks, facilitating cultural exchange and economic development. The Silk Road, for example, served as a major conduit for the exchange of goods between East and West, including millets and other agricultural products (Hansen, 2012). Millets were valued commodities in ancient trade routes, prized for their nutritional value, long shelf life, and versatility in culinary preparations.

D. Cultural Significance of millets:

Millets hold significant cultural importance in many societies, where they are revered as symbols of sustenance, resilience, and tradition. In India, millets are associated with cultural festivals, rituals, and ceremonies, where they are used to prepare traditional dishes such as bajra roti, ragi mudde, and jowar bhakri (Shobana et al., 2013). Similarly, in Africa, millets are central to cultural celebrations and communal gatherings, where they are used to prepare dishes like millet couscous, sorghum porridge, and fermented beverages (Berg, 2015).

Despite their historical significance, the cultivation and consumption of millets declined in many regions with the advent of modern agricultural practices and the promotion of high-yielding cereal crops such as wheat and rice. However, there has been a recent resurgence of interest in millets due to their nutritional richness, environmental sustainability, and potential to address food security challenges (Padulosi et al., 2009). Governments, NGOs, and international organizations are promoting millet cultivation as part of efforts to promote sustainable agriculture, enhance nutrition, and support smallholder farmers.

13.2 Environmental Sustainability of Millets:

The cultivation of millets offers several advantages over conventional cereal crops like wheat and rice. Millets require significantly less water, fertilizer, and pesticides to grow, making them more sustainable and environmentally friendly. Their deep root systems help prevent soil erosion and improve soil fertility, making them ideal for different agroecological conditions. Furthermore, millets are well-adapted to climate change, thrives under hot and dry conditions where other crops fail to survive. Millets are also high yielding, having high shelf life, short duration and fast growing and having high seed multiplication ratio. They also have varied adaptability/combining ability,highly nutritious and having high fodder value.

A. Millets are adaptable to small-scale farmers' production systems:

Millets exemplify agricultural adaptability, making them valuable assets to small-scale farming systems worldwide. These millets show extraordinary flexibility to a varied of agroecological situations, whereas other crops struggle with. Confined by limited resources and unpredictable weather, millets are dependable companions in their quest for sustainable livelihoods. Whereas millet crops grow quickly and complete the life cycle; some millets need 60-75 days to mature against 100-140 days for fine cereals. Their ability to grow in poor soils with minimal water requirements makes them ideal for smallholder farmers facing challenges like land scarcity and water scarcity. Additionally, millets are resilient to pests and diseases, reducing the need for expensive pesticides. Their short growing seasons also offer flexibility, allowing farmers to intercrop or rotate with other crops to maximize land use and soil fertility. Overall, millets play a crucial role in enhancing food security and livelihoods for small-scale farmers around the world.

B. Millets are good contingency crops:

Unique traits in addition to their short duration nature and photo insensitivity, early maturity, low water requirement, and good drought resistance millets are ideal for contingency crop planning. For example, proso millet is the earliest of the small millets, maturing in 60 to 70 days. Foxtail, little millet and barnyard millets mature around 75 to 85 days. Pearl millet and sorghum mature between 80 and 120 days. Kodo and finger millets mature in 100 to 130 days.

C. Millets for combating water scarcity:

Most of the millets are kharif season crops (sown during May-June) and come to maturity during September to October.

Most of these crops give good yields during rabi season (October-March) and summer season (January-April). These crops are majorly grown in regions receiving less than 450 mm rainfall (compared to about 700 mm minimum for maize). Millets require very less water as compared to rice and wheat and considered drought tolerant crops. This is the main advantage of millet crops over all other cereals as they resilient to climate change and required significantly less water to grow. Due to less water requirement millets, mainly cultivated for both food and fodder by small/marginal farmers in rain-fed areas and providing stable source of livelihood.

Table 13.1 Water requirement, fertilizer use and plant protection requirements for millet crops compared with other cereals.

Crop	Water requirement to produce 1 kg yield (Litre)	Amount of fertilizer used (kg/ha)				No. of plant protection sprays
		Nitrogen	Phosphorus	Potassium	Total	
Rice	5000	75-100	50-75	20	145-195	4-7
Wheat	750	50-100	25-75	50	125-225	1-3
Maize	750	100-150	50-65	25-65	175-280	3-4
Sorghum	833	50-100	25-75	25-40	100-215	0-2
Pearl millet	667	50-100	25-50	25	100-175	0-1
Finger millet	1000	50-100	40-50	25-50	115-200	0-2
Other millets	1111	25	15	15	55	0

Millets have several advantages over other cereal crops as they are resilient to climate change and require significantly less water to grow. Millets are small.

D. Millets for good soil health:

Millets can also help to reduce soil erosion due to their short growth cycle and better root systems. The short growth cycle means that the crop can be harvested quickly, reducing the amount of time that the soil is exposed to the elements and reducing the amount of topsoil that is washed away. The root systems of millets also allow them to absorb more water and nutrients from the soil, reducing the need for irrigation and helping to maintain soil structure and fertility. Millets are also more efficient in terms of nutrient use. They are able to capture nitrogen from the atmosphere and convert it into usable nitrogen for plant growth.

This means that less fertilizer is required for millet production and fewer pollutants are released into the environment.

E. Millets helps for reducing greenhouse gas emission:

Millets also have the potential to reduce greenhouse gas emissions. Millets are a C4 crop, meaning that they are able to capture more carbon from the atmosphere than other cereal crops. This increases the amount of carbon that is stored in the soil and reduces the amount of carbon dioxide that is released into the atmosphere.

F. Millets are climate resilient crops:

Millets are more resilient to climate change than other cereal crops. They are able to withstand higher temperatures and are less likely to be damaged by extreme weather events such as droughts and floods. This means that they are more likely to produce a good yield even in difficult conditions, reducing the risk of crop failure and increasing food security. Millets have the potential to reduce environmental impact due to their low water, fertilizer and pesticide requirements, their deep root systems and their resilience to climate change. They are an important crop for increasing food security and reducing environmental pollution.

13.3 Millets For Nutritional, Food Security And Sustainability:

Millets are ‘nutri-cereals’ and modern research has revealed the numerous health benefits of inclusion of millets in the diet. Integrating millets into our diets can offer an array of nutritional benefits that range from addressing under-nutrition and micronutrient deficiency to controlling over-nutrition (Tripathi and Vyas 2023).

The four pillars of food security are the availability of food, access to food, utilization of food, and food stability. The term "food security" does not explicitly define the nutrition aspect of food of adequate sanitation, health care, and services, allowing for a healthy and active lifestyle." (Tiwari, et al. 2023).

Millets are gluten-free and have a low glycemic index, making them suitable for people with celiac disease or those looking to manage blood sugar levels. They are also rich in dietary fiber, which promotes digestive health and helps prevent constipation. Additionally, millets contain significant amounts of essential nutrients such as magnesium, phosphorus, manganese, and antioxidants, which contribute to overall health and well-being. Millets offer a plethora of health benefits due to their nutrient-rich composition and unique biochemical properties. Here's an elaboration on the health benefits of millets, supported by suitable references:

A. Heart Health:

Millets are rich in antioxidants, including phenolic compounds and flavonoids, which help reduce oxidative stress and inflammation in the body, thus lowering the risk of cardiovascular diseases (Saleh et al., 2013).

Additionally, the dietary fiber content of millets helps regulate cholesterol levels by binding to cholesterol in the digestive tract and facilitating its excretion, thereby reducing the risk of atherosclerosis and heart disease (Sharma et al., 2020).

B. Digestive Health:

The high dietary fiber content of millets promotes digestive health by enhancing bowel regularity, preventing constipation, and reducing the risk of gastrointestinal disorders such as diverticulosis and colon cancer (Devareddy et al., 2010). Furthermore, millets contain prebiotic compounds that nourish beneficial gut bacteria, promoting a healthy gut microbiota and enhancing overall digestive function (Sekhon et al., 2020).

C. Weight Management:

Millets are low in calories and have a low glycemic index, meaning they are digested slowly and cause gradual increases in blood sugar levels, helping to regulate appetite and prevent overeating (Vetrani et al., 2016).

The high fiber content of millets also contributes to satiety and feelings of fullness, making them a valuable addition to weight management diets (Bamgbose et al., 2020).

D. Bone Health:

Millets are excellent sources of calcium, magnesium, phosphorus, and other minerals that are essential for maintaining bone health and preventing osteoporosis (Kim et al., 2016). Consuming millets regularly can help strengthen bones, reduce the risk of fractures, and promote overall skeletal health, especially in populations at risk of calcium deficiency (Sharma et al., 2016).

E. Management of Diabetes:

The complex carbohydrates in millets are digested slowly, resulting in gradual release of glucose into the bloodstream and preventing rapid spikes in blood sugar levels (Shobana et al., 2013).

This property of millets makes them suitable for individuals with diabetes or insulin resistance, as they help stabilize blood sugar levels and improve glycemic control (Mohan et al., 2014).

F. Anti-inflammatory Properties:

Millets contain bioactive compounds such as lignans, phytosterols, and polyphenols, which exhibit anti-inflammatory properties and help reduce inflammation in the body (Chandrasekara & Shahidi, 2010).

Regular consumption of millets may therefore help alleviate symptoms of inflammatory conditions such as arthritis, asthma, and inflammatory bowel disease (Singh et al., 2019).

G. Millets and aging:

One of the main causes of the difficulties associated with diabetes and aging is a chemical process known as nonenzymatic glycosylation, which occurs when the amino group of proteins reacts with the aldehyde group of reducing sugars. Millets are abundant in phenolics and antioxidants, such as tannins, phenols, and phytates, which can support antioxidant activity, which is crucial for aging, health, and the metabolic syndrome (Hegde et al., 2002).

H. Millets and phytochemicals:

Millets are an excellent source of vitamins and phytochemicals. Millets include a variety of phytochemicals, including phenolics, lignans, βglucan, inulin, resistant starch, phytates, sterols, tocopherol, dietary fiber, and carotenoids. Phenolic acids and tannins are the principal types of polyphenols; flavonoids, which are found in trace amounts and have a variety of functions in the immune system, are antioxidants.

I. Millets as nutraceutical:

The ideas around food consumption have evolved from earlier periods to the current ones. Prioritization has been placed on surviving, satiating hunger. The present focus is on promoting the use of nutraceutical foods, which promise to promote improved health and well-being and so help to minimize the risk of chronic diseases like obesity, diabetes, and cancer.

Health maintenance and the absence of adverse health effects are also important considerations. Millets provide nutrient-dense qualities called antioxidants that guard against degeneration in human health.

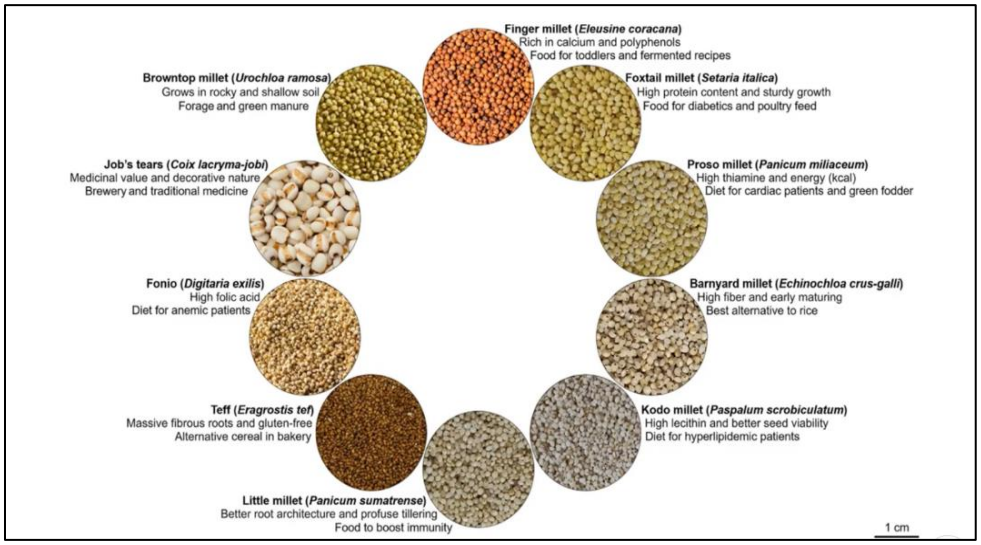

Figure 13.1: Important Health Benefits of Different Millets

Table 13.2: Nutrition composition of millets per 100g of edible portion

Parameter	Protein (g)	Fat (g)	Mineral (g)	Total dietary fiber (g)	Insoluble dietary fiber (g)	Soluble dietary fiber (g)	CHO (g)
Sorghum	10.00	1.70	1.40	10.20	8.50	1.70	67.70
Pearl millet	11.0	5.40	1.40	11.50	9.10	2.30	61.80
Finger millet	7.20	1.90	2.00	11.20	9.50	1.70	66.80
Proso millet	12.50	1.10	1.90	-	-	-	70.40
Foxtail millet	12.30	4.30	3.30		--	-	60.90
Little millet	10.40	3.90	1.30	7.70	5.50	2.30	65.60
Kodo millet	8.90	2.60	1.70	6.40	4.30	2.10	66.20
Barnyard millet	6.20	4.40	2.20	-	-	-	65.50

Source: Indian food consumption table 2017, NIN 2007, IIMR

13.4 Challenges and Opportunities in Revitalizing Millets:

Despite their many benefits, millets have faced challenges such as declining popularity, limited availability, and lack of awareness among consumers. However, there is a growing movement to revitalize millets and promote their consumption both locally and globally. Governments, NGOs, and farmers' associations are working together to raise awareness about the nutritional and environmental benefits of millets and to promote their cultivation and consumption through policy support, research, and marketing initiatives.

A. Challenges in Revitalizing Millets:

a. Lack of Awareness: One of the primary challenges is the lack of awareness among consumers about the nutritional and environmental benefits of millets. Many people are unfamiliar with millets or perceive them as inferior grains compared to rice and wheat.

b. Changing Dietary Preferences: In many regions, there has been a shift towards Western diets, which often prioritize refined grains over whole grains like millets. Convincing consumers to adopt millets as part of their regular diet requires changing perceptions and habits.

c. Limited Availability and Accessibility: Millets are often not readily available in mainstream grocery stores, and when they are, they may be more expensive than other grains. Improving the availability and accessibility of millets in local markets is crucial for their widespread adoption.

d. Lack of Research and Development: Compared to major cereal crops like wheat and rice, there has been relatively less research and development focused on millets. This includes breeding for improved varieties, developing value-added products, and optimizing cultivation techniques.

e. Infrastructural Challenges: In many regions, the infrastructure for millet cultivation, processing, and distribution may be inadequate or outdated. Investing in infrastructure such as storage facilities, processing mills, and transportation networks is essential for scaling up millet production.

B. Opportunities in Revitalizing Millets:

a. **Nutritional Benefits:** Millets are nutritious, gluten-free, and have a low glycemic index, making them suitable for people with dietary restrictions and those looking to improve their health. Promoting millets as a nutritious alternative to refined grains can attract health-conscious consumers.
b. **Environmental Sustainability:** Millets are well-suited to agroecological farming practices and require fewer inputs such as water, fertilizer, and pesticides compared to other cereal crops. Positioning millets as a sustainable food option can appeal to environmentally conscious consumers.
c. **Cultural Heritage:** Millets have deep cultural significance in many regions, where they are an integral part of traditional cuisines and rituals. Highlighting the cultural heritage associated with millets can foster a sense of pride and identity among communities and contribute to their revitalization.
d. **Diverse Culinary Applications:** Millets are versatile ingredients that can be used in a variety of culinary applications, from savory dishes like pilafs and salads to sweet treats like porridges and desserts. Exploring and promoting the diverse culinary potential of millets can attract food enthusiasts and chefs interested in innovative cooking.
e. **Policy Support and Advocacy:** Governments, NGOs, and international organizations are increasingly recognizing the importance of millets for food security, nutrition, and sustainable agriculture. Policy support, financial incentives, and advocacy efforts can help create an enabling environment for the revitalization of millets.

Addressing these challenges and seizing the opportunities presented by millets requires a multi-stakeholder approach involving farmers, researchers, policymakers, the private sector, and civil society. By working together to raise awareness, improve accessibility, invest in research and development, and promote culinary innovation, we can revitalize millets and harness their potential for health and sustainability.

13.5 Promotion of Millets in The Modern Food System:

Promoting millets in the modern food system involves various strategies aimed at raising awareness, enhancing accessibility, and integrating millets into mainstream food production, distribution, and consumption. Here's an elaboration on promoting millets in the modern food system, supported by references:

A. Awareness Campaigns:

Raising awareness about the nutritional benefits, environmental sustainability, and cultural significance of millets is crucial for promoting their consumption. Governments, NGOs, and advocacy groups can organize awareness campaigns through media channels, social

media platforms, educational programs, and community events to educate consumers about the value of including millets in their diets (Sobhana et al., 2016).

B. Research and Development:

Investing in research and development initiatives to improve millet varieties, enhance agronomic practices, and develop innovative millet-based food products can help expand their market potential. Collaborative efforts between research institutions, agricultural organizations, and food companies can lead to the development of value-added millet products that cater to consumer preferences and nutritional needs (Kumar et al., 2021).

C. Policy Support:

Formulating policies that incentivize millet cultivation, processing, and marketing can create a conducive environment for the growth of the millet sector. Policy measures such as subsidies, procurement support, quality standards, and market linkages can encourage farmers to adopt millet cultivation practices and facilitate the integration of millets into government nutrition programs and food policies (FAO, 2019).

D. Supply Chain Development:

Strengthening the millet supply chain from farm to fork is essential for ensuring consistent availability and quality of millet products in the market. Investments in infrastructure, storage facilities, transportation networks, and market linkages can help reduce post-harvest losses, improve market access for farmers, and streamline the distribution of millet products to consumers (Nandi et al., 2020).

E. Culinary Innovation:

Promoting culinary innovation and culinary tourism centered around millets can enhance their appeal among consumers and contribute to the diversification of the food industry. Chefs, food entrepreneurs, and culinary institutes can collaborate to create innovative millet-based recipes, menu options, and culinary experiences that showcase the versatility and culinary potential of millets (Hegde et al., 2020).

F. Consumer Education:

Educating consumers about the various ways to incorporate millets into their diets and highlighting their nutritional benefits can stimulate demand for millet products. Cooking demonstrations, recipe contests, nutrition workshops, and consumer outreach programs can empower consumers to make informed choices and adopt healthier eating habits that include millets as a staple ingredient (Khaskheli et al., 2021).

Promoting millets in the modern food system requires a multi-faceted approach that addresses awareness, research, policy, supply chain, culinary innovation, and consumer education.

By leveraging these strategies in a coordinated manner, stakeholders can harness the potential of millets to contribute to sustainable food systems, improve nutrition outcomes, and enhance food security for future generations.

13.6 Culinary Versatility of Millets:

The culinary versatility of millets stems from their adaptability to various cooking methods and their ability to complement a wide range of flavors and ingredients. Here's an elaboration on the culinary versatility of millets, supported by suitable references:

A. Whole Grain Dishes:

Millets can be cooked and served as whole grains, similar to rice or quinoa, providing a nutritious base for a variety of dishes. Whole millets such as pearl millet, finger millet, and sorghum can be boiled, steamed, or simmered to create fluffy, tender grains that can be enjoyed on their own or paired with savory or sweet accompaniments (Vetrani et al., 2020).

B. Porridges and Congees:

Millets are commonly used to prepare hearty porridges and congees, especially in regions where they are staple foods. Millet porridges can be made by simmering millet grains in water or milk until they reach a creamy consistency, often flavored with spices, fruits, nuts, or sweeteners for added taste and nutrition (Sharma et al., 2016).

C. Flatbreads and Breads:

Millets can be ground into flour and used to make a variety of flatbreads and breads, including rotis, chapatis, dosas, and pancakes. Millet flours can be combined with wheat flour, rice flour, or other gluten-free flours to create versatile doughs that can be rolled out and cooked on a griddle or skillet, resulting in soft and flavorful breads (Hegde & Vivek, 2020).

D. Fermented Foods:

Millets are often used to prepare fermented foods such as idlis, dosas, and injera, which are popular in South Asian, East African, and Ethiopian cuisines, respectively. Fermenting millet batter enhances its nutritional value, digestibility, and flavor, resulting in light and fluffy dishes with a pleasant tanginess (Hegde & Vivek, 2020).

E. Salads and Pilafs:

Millets can be incorporated into salads and pilafs (pulav) to add texture, flavor, and nutritional value. Cooked millet grains can be tossed with fresh vegetables, herbs, nuts, and dressings to create refreshing salads with a satisfying crunch. Similarly, millets can be cooked with aromatics and spices to make flavorful pilafs (pulav)or grain-based salads (Bamgbose et al., 2020).

F. Snacks and Desserts:

Millets can be used to prepare a variety of snacks and desserts, ranging from savory snacks like crispy millet chips and roasted millet mixtures to sweet treats like millet puddings, cakes, and cookies. Millet flour, flakes, and puffed millets can be incorporated into baked goods, granola bars, and energy bites for added nutrition and texture (Vetrani et al., 2020).

The culinary versatility of millets offers endless possibilities for creative and nutritious cooking. Whether used in whole grain dishes, porridges, flatbreads, fermented foods, salads, pilafs, snacks, or desserts, millets add a unique flavor, texture, and nutritional value to a wide range of culinary creations.

13.7 Conclusion:

In conclusion, revitalizing millets is not just about promoting a nutritious and sustainable food source but also about preserving cultural heritage, biodiversity, and traditional farming practices. By embracing millets and incorporating them into our diets and food systems, we can promote better health outcomes, support smallholder farmers, conserve natural resources, and build more resilient and sustainable food systems for future generations. It is time to recognize the value of millets as a nourishing and environmentally friendly food option and to work together to ensure their widespread cultivation, consumption, and appreciation.

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