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MILLETS: HISTORY AND DEMAND OF THE TIME

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ABSTRACT: Millets are ancient small-seeded cereal crops that have sustained human populations for thousands of years, particularly in the arid and semi-arid regions of Asia and Africa. This review highlights the historical importance, domestication, cultural relevance, agro-biodiversity, nutritional value, and contemporary significance of millets and pseudo-millets in food systems. Millets are recognized for their drought tolerance, climate resilience, and suitability for low-input agricultural systems, making them valuable crops under changing environmental conditions. The review also discusses their superior nutritional profile, including dietary fibre, essential minerals, bioactive compounds, and low glycemic index, which support their role in addressing malnutrition, hidden hunger, and lifestyle-related disorders. In addition, the article examines the applications of millets in food technology and nutraceutical product development, such as bakery products, fermented foods, gluten-free formulations, dietary supplements, and fortified foods. Policy support, value-chain development, and renewed global attention, especially during the International Year of Millets 2023, have further strengthened the relevance of these crops. Overall, the review emphasizes that millets represent not only a link to traditional agriculture and culture but also a promising pathway toward sustainable, nutritious, and climate-resilient food systems.

INTRODUCTION:

History and Traditional Uses: Millets are small-seeded, drought-resistant cereal crops of the grass family. They are grown in African and Asian countries for thousands of years. They are some of the oldest domesticated crops [6].

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Among the important domesticated millets are *Pennisetum glaucum* (pearl millet), *Eleusine coracana* (finger millet), *Setaria italica* (foxtail millet), and *Panicum miliaceum* (proso millet). Being drought-resistant crops, millets are of prime importance in the drylands of the Afro-Asian countries with marginal or low rainfall, even when crops like wheat and rice are not easy [1].

Archaeobotanical evidence revealed that millets were significant ancient cereals of early Indus Valley Civilization (3000–1500 BCE), and these were also extensively grown across the Yellow River Basin of China during the Neolithic period [7].

Finger millet and barnyard millet (Echinochloa spp.) were found to make significant contributions to regional agriculture before the advent of rice and wheat farming in the Indian sub-continent. Millet was found to spread extensively across East and West Africa too, where pearl millet and sorghum acted as major food cereals underpinning regional complexity [13].

Millet was found to play an important role in regional systems of food production and social life in West Africa, where pearl millet is argued to have acted as a major food cereal for greater than 4,000 years [8]. Similarly, archaeological evidence found from Mediterranean and European Bronze Age regions revealed that millets had become ubiquitous throughout regions of Africa and Asia and had become significant food cereals [2].

From a botanical and agronomic point of view, millets appear well-suited for cultivation in low-input conditions and environments where stress is rife. For instance, many types of millet show high water-use efficiency, high-temperature tolerance, and short growth periods, allowing them to go through reproduction even under uncertain rainfall patterns.

It is certain, therefore, that it is such physiological capabilities that could also have enabled our ancestral farming populations to provide stable supplies of foodstuffs despite climatic in certainties.

Indeed, it is asserted by more contemporary studies on the comparative physiology of different types of food crops, such as those conducted by Hegde *et al.* (2023) [5], that it is possible for these types of food crops, such as millets, to continue yielding stable harvests even in stressful conditions of drought and high environmental temperatures, such as in competitiveness with cereals such as rice, wheat, and maize.

Millets also have cultural significance beyond their role as staple grains. In many societies, they form part of ritual life, seasonal festivals, and regional cuisines. For instance, finger millet in Karnataka and Tamil Nadu is processed into a variety of foods porridges, fermented products, sweets, beverages, among others and forms a kind of cultural narrative around health, vitality, and longevity [10]. In parts of both West and East Africa, sorghum and pearl millet are staples in everyday and ceremonial foods and act as markers of cultural identity while providing significant dietary energy and micronutrients [16].

Nutritionally millets can often be distinguished from major cereals with respect to their content of dietary fibers as well as a variety of micronutrients, besides providing some contributions to important amino acids and B vitamins. Millets also provide some significant contributions to essential minerals like iron, calcium, and magnesium [22].

All of these factors explain why millets have typically acted as staple foods of communities where such micronutrient deficiencies already exist. Recent research focused on investigating the nutritional value of millets has further underlined developing millet-based diets to “treat the crisis of hidden hunger,” for deficiencies of iron and calcium being persistent public health issues [14].

The Green Revolution of the 1960s and 1970s transformed India's cropping pattern by promoting high-yielding wheat and rice varieties. While this transformation enhanced national calorie security, this also was constituted by a significant decline in millet cultivation and consumption, alongside a decline in agrobiodiversity and dietary diversity in general remind us.

Policy incentives further calcified this trend: procurement systems and public distribution mechanisms were largely oriented around rice and wheat, thereby eclipsing market visibility and farm-level incentives for millet crops that had long been produced by smallholders in India's vast rainfed areas.

More recently, millets have again entered policy and public discourses because of their climate resilience, nutritional value, and cultural resonance. To be sure, India's celebration of 2018 as the National Year of Millets and its leadership in the process that ultimately led the United Nations General Assembly to declare 2023 the International Year of Millets reflect this renewed positioning of millets in contemporary food-system strategies [2, 4].

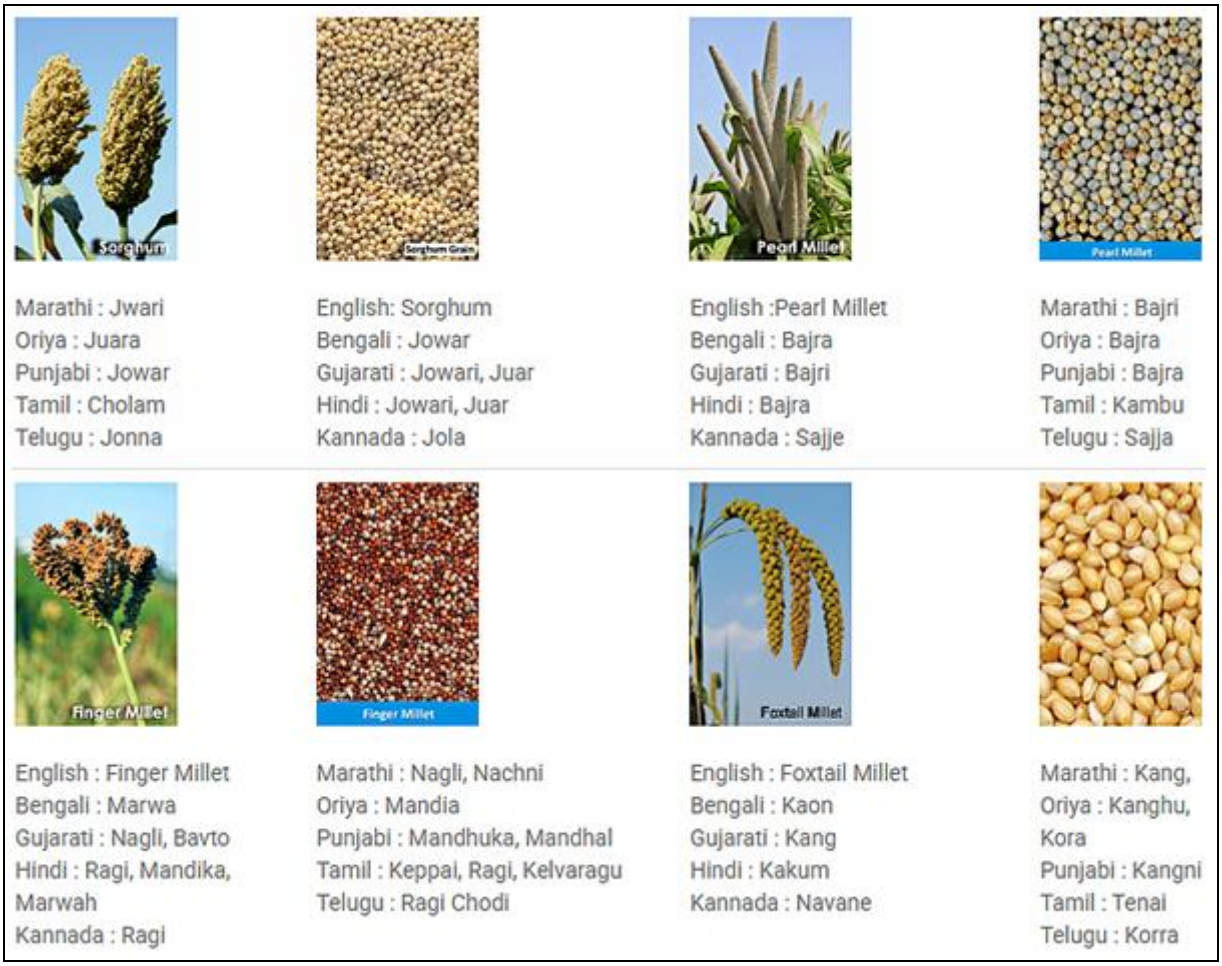

FIG. 1: DIFFERENT TYPE OF MILLETS USED IN INDIA

Millets in Historical Agriculture and Human Diets:

Domestication and Spread: Millets are among the earliest domesticated crops in the world. Archaeobotanical studies have traced evidence of foxtail and proso millet cultivation to China's Yellow River basin as early as 6000 BP. This underlines their importance regarding the origins of agriculture. Similarly, in the Indian subcontinent, millets such as finger millet, barnyard millet, and little millet appear in archaeological contexts that predate the widespread cultivation of rice. This suggests a deep history in South Asian agro-ecosystems. For example, pearl millet was domesticated in the West African Sahel and became a staple for Neolithic pastoralist and farming communities.

Cultural Embeddedness: Historical studies prove that millets were not just sources of food but also played an important role in shaping culture and religious activities. Research on ancient Telugu and Karnataka cultures indicates that finger millet, also called ragi, was related to rites and seasonal celebrations. This points to the fact that there is an important link between agriculture and culture. In Africa, pearl millet continues to be an important part of cultural practices and has influenced marriage and seasonal celebrations. This has been documented in the literature on culture and food history [16].

Millets and Agrobiodiversity:

Genetic Diversity: Millets possess a remarkable level of genetic diversity that has significant impacts on breeding adaptive traits. Recent genomic studies on finger millet and pearl millet reveal a considerable amount of allelic diversity associated with drought tolerance and micronutrient content [20]. These studies emphasize the need to retain traditional landraces, usually preserved by smallholder farming communities, for future crop resilience.

Agroecological Roles: Studies about agroecological systems indicate that using millets

aids in crop diversification. Diversification stores up crops and minimizes pests in rain-fed farming systems [5]. Mixed cropping systems of legumes and millets have been proven to enhance fertility and reduce erosion in dry land farming, both in India and East Africa.

Nutritional Value and Human Health:

Macronutrients and Micronutrients: Nutritional studies show that many nutritional studies confirm the nutritional potential of millets as they are rich in nutrients and also a source of calories. For example, iron and zinc concentrations are much higher in pearl millets than in other cereal grains. They can be used to reduce the risk of anemia [12, 20, 22]. Finger millets are very rich in plant-available calcium. The nutritional intervention studies also show the potential for the management of diabetes through millets because they can improve glycemic index levels.

TABLE 1: NUTRITIVE VALUES OF DIFFERENT TYPE OF MILLETS

Millet (common name)	Protein (g/100g)	Fiber (g/100g)	Minerals (g/100g)	Iron (mg/100g)	Calcium (mg/100g)
Barnyard millet	11.2	10.1	4.4	15.2	11
Brown top millet	11.5	12.5	4.2	0.65	0.01
Finger millet (Ragi)	7.3	3.6	2.7	3.9	344
Foxtail millet	12.3	8	3.3	2.8	31
Kodo millet	8.3	9	2.6	0.5	27
Little millet	7.7	7.6	1.5	9.3	17
Pearl millet (Bajra)	10.6	1.3	2.3	16.9	38
Proso millet	12.5	2.2	1.9	0.8	14
Sorghum (Jowar)	10	4	1.6	2.6	54

Source: https://www.millets.res.in/millets_info.php

Functional Properties: In addition to basic nutrition, there is now emerging research on millet-based bioactive compounds, polyphenols, dietary fiber fractions, and antioxidants, which have beneficial efficacy for heart and gastrointestinal well-being [14, 21]. These beneficial attributes show potential for developing health-focused food products.

Food Distribution, Value Chains, and Policy:

Market Integration: Though millets have linkages for local demand, their linkages at the national or global value chain level are less prominent compared to rice and wheat. A study conducted on Indian public distribution systems (PDS) found that adding millets to public distribution systems will increase food security [11]. A study carried out on markets for millets in Africa found the need to enhance post-harvest management, from clean threshing to storage, to enhance the value chain for millets and minimize loss of millets.

Policy Support: Other studies are specific to specific policies, revealing the role of such policies in enhancing production and consumption of millet. For instance, studies on Millet Mission and its purchase policies adopted by India during its International Year of Millets (2023) can provide lessons for other countries on how to promote MMs in national food systems [2]. These studies also link MMs to national nutrition targets, diversity of agriculture, and response measures to climate change.

Millets and Pseudo Millets in the Daily Diet: Millets and pseudo millets are becoming widely known for their nutritional value. The use of millets has become widely recognized, especially for their nutritional value in our food products. These millets were traditionally cultivated in Asia and Africa, but they have gained acceptance in relation to their role in food science and technology.

Definition and Classification:

True Millets: Millets are small-seeded grasses cultivated for fodder and food. More commonly, they are found in arid and semi-arid regions. Common varieties include pearl millet, or *Pennisetum glaucum*; finger millet or *Eleusine coracana*; foxtail millet or *Setaria italica*; and little millet or *Panicum sumatrense*. These grains are categorized as true cereals.

Pseudo Millets: Pseudo millets have similar uses and nutritional values, although these crops do not belong to the family Poaceae (grass family). The

common pseudo millets used are amaranth, buckwheat, and quinoa. They have been called pseudo-cereals because of their use and composition, which is similar to that of cereals.

Nutritional and Functional Properties: They are rich in nutrients, gluten-free, and good sources of dietary fiber; they also contain minerals, including iron, calcium, and magnesium. In addition, this millet and pseudo millet crops contain essential amino acids and bioactive compounds, including polyphenols and flavonoids. For example, finger millet contains a significant amount of calcium, amounting to as much as 344 mg/100g. Pseudo millets, such as quinoa, contain a balanced amino acid profile and a high concentration of the amino acid lysine [24].

These kinds of grains also have low glycemic indices, making them ideal for consumption by those suffering from diabetes and heart-related conditions. They also contain antioxidants that assist in protecting against chronic diseases, mainly by controlling inflammation and oxidative stress [23].

Applications in Food Technology: The millets and pseudo millets form the base for preparation of different functional and health foods like:

Bakery Products: Composite flours from finger millet, foxtail millet, and quinoa make bread, cookies, and muffins more nutritious.

Fermented Foods: Millets are good substrates for various traditional and novel fermented products, such as dosa, idli, and probiotic beverages.

Extruded Snacks: Their starch composition helps with puffing and texturization, thereby making it appropriate for ready-to-eat products.

Gluten-free Products: Pseudo millets like amaranth and buckwheat play a crucial role in gluten-free recipes.

Applications of Millets in Nutraceutical Products: Due to the growing demand for functional foods/nutraceuticals, millets have gained attention as a key option to improve healthy foods since they possess strong bioactive compounds, are gluten-free, and can be transformed using various processes. These qualities make millets critical inputs for the development of value-added nutraceuticals to manage metabolic disorders.

Functional Flours & Mixes: Composite flours containing millet are marketed as diabetic baking products, protein-enriching flours, and high-fiber-containing flours.

Examples: Finger millet flour blends for low glycemic index rotis or porridges, multigrain blends, etc.

Fermented Nutraceutical Beverages*:* Fermented drinks prepared from millets involve the use of probiotic cultures like Lactobacillus. These products may be non-dairy probiotic drinks, functional smoothies, and millet-based symbiotic drinks, as discussed in Anukiruthika *et al.* (2020)

Dietary Supplements and Capsules: Extracts with high amounts of polyphenols, peptides, and resistant starch are processed into supplements. Finger millet-based polyphenolic capsule preparations have proven effective in managing blood glucose levels and lipid profiles.

High-Fiber Snack Bars and Biscuits: Nutraceutical snacks utilise millets, which increase satiety and decrease cholesterol levels. They are used in protein bars, meal replacement cookies, and anti-diabetic snacks containing millet, legume, and herbal mixtures.

Ready-to-Drink (RTD) Products: Pearl millet and sorghum grains are used as ingredients in RTD forms of energy drinks, which are used as supplements due to their slow-digesting carbohydrates and electrolyte content.

Nutraceutical Porridges and Infant Formulas: Fortified millet porridge is being developed for nutritional supplements for infants, the elderly, and for clinical nutrition by virtue of its high bioavailability of calcium, iron, and protein.

CONCLUSION: Traditionally, millets were an integral part of central as well as traditional agriculture systems. Today, they once again find an important place as an integral part of a robust and diverse food system. Being able to thrive in challenging climatic conditions, as well as being good from a nutritional as well as cultural point of

view, makes millets an important part of modern food security and public health. The biological diversity of millets makes them an important tool in the development of climate-resilient as well as nutrient-rich food varieties, which would become even more important in the face of environmental challenges. In terms of food technology, millets as well as pseudo millets find an important place as part of potential foods and supplements with positive implications for health. Similarly, policies and interventions like India's Millet Mission and global support during the UN-designated International Year of Millets (2023) speak to the rising awareness about these crops. Moving further and ensuring these crops are integrated into value chains and ensuring better procurement mechanisms, as well as enhanced awareness and knowledge regarding processing techniques and nutrient as well as consumer acceptance, would also enhance the contribution these crops make to sustainable and consumer-centric nutrition. In all these respects, the introduction and reintroduction of millets and pseudo-millets to our food plate do not just signal a trip back into our past. Rather, it speaks to a highly sustainable food future.

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