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Millet: A therapeutic grain

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Abstract
Millets are highly nutritious and provide nutritional security hence there is a need to promote millets. These have been important staple foods throughout human history, especially in Asia and Africa. Millets consumption as direct food has increased significantly over the last decade. In the 21st century, climate change, water scarcity, world population growth, rising food prices and other socioeconomic impacts are expected to pose serious threats to agriculture and food security worldwide, especially for poorer people living in arid and border regions. These effects challenge researchers and nutritionists to explore ways to produce, process and use other potential food sources to end hunger and poverty. Cereals are the world's most important food source and play an important role in human nutrition worldwide. As one of the most important drought crops, millet is widely cultivated in the semi-arid tropics of Africa and Asia and is an important source of carbohydrates and proteins for people living in those regions. In addition, due to the significant impact of millet grains on national food security and potential health benefits, millet grains have attracted increasing interest among food scientists, technologists, and nutritionists.

Keywords: Millets, nutritional composition, therapeutic, nutrition, health, types of millets

Introduction
Millets are a type of small-grained cereal food crops that are drought resistant and require little in the way of chemical addition of fertilizers and pesticides to flourish. They are coarse grains that have been farmed and eaten for over 5000 years on the Indian landmass (Saleh *et al*., 2013) [30]. The majority of millet crops grown in India are known as Nutri-cereals since they contain maximum nutrients essential for regular main body function. Based on grain size, millets have been divided into two categories: Major and Minor. The term ‘Pseudo’ is also given to the millets because they are not the actual members of the Poaceae botanical family, but includes 'true' grains and behave like one as they are nutritionally excellent in nature (FSSAI, 2022.) They are extremely strong in proteins, vitamins, minerals, and fibers. Millets require little water and ground fertility in contrast to other grains. They are known as “poor man’s food grain” because they are extremely feasible for all the people and are available in the market at low cost (Sood *et al*., 2015) [35]. Millets are a competitive source of supplements also considered as a powerhouse of nutriments (Abioye *et al*., 2022) [1]. They have retrieved their place in the kitchen for those who are more fitness attentive. In addition to being gluten-free, they are good for human health and help in losing weight (Gupta *et al*., 2012) [12]. Millets are rich in all the dietary fibers and nutriments. Protein, vitamins, and phytochemicals are all abundant in them. Millets consist of a protein content of 7-12 percent, a lipid content of 2-5 percent, a carbohydrate content of 65-75 percent, and a dietary fiber content of 15-20 percent (Rao *et al*., 2016) [26]. Millet protein has a superior necessary amino acid profile than other grains. Millets have less cross-linked prolamins, which might be another factor that contributes to the millet proteins' improved digestibility and stability. Millets in general have a strong antioxidant activity (Rao *et al*., 2016) [26]. The millet proteins are low in lysine, but they work well in constitution with lysine-rich plants (leguminous) and animal proteins to create nutritionally balanced compounds with high biological value (Kaur *et al*., 2023) [17]. Millets are more nutrient-dense and phosphorus and iron are abundant in small millets. Millets consist of phytates, polyphenols, tannins, anthocyanins, phytosterols and phytostanols contributing to antioxidant activity which is responsible for aging and metabolic diseases (Gani *et al*., 2012) [10].

Therapeutic Foods
Therapeutic foods are dietary supplements that are created for targeted, typically nutrimental, therapeutic objectives.

These can also be ready-to-eat meals that give calories and nutrients in convenient packaging. These foods are used as a supplement to the diet for assertive people with appropriate and extraordinary nutritional requirements (Zhao, 2007) [39]. Nonetheless, such high-energy diets are also essentially used as a treatment for malnourished children where nutrient-dense foods are scarce or unavailable. In terms of grains, therapeutic foods/grains are the grains that provide sufficient amounts of nutrients to the population and are also considered the alternatives to various diet types such as gluten free diet, protein and energy rich diet, diet for diabetes, CVD, etc. (Singh and Sarita, 2016) [33]. In reference to millets, a sequence of germination and malting can be used to prepare some healthy and nutritious foods, such as infant formula, complementary foods and therapeutic foods to fight health problems (Singh and Sarita, 2016) [33]. For instance, finger millet is the main ingredient meal replacement for celiac patients due to its gluten-free properties. These can either be used in the form of composite flour for regular staple meals, baking etc. or as individual major raw materials. Composite flour is the blend or mixture of different proportions of more than one flour which can either be with or without wheat flour (Chandra *et al*., 2014) [8]. Usually the composite flours consist of the staple foods due to its nutritional properties and economic attainability. Like the addition of amaranth flour to any kind of flour, say, millet flour to increase once protein content as the amaranth is known for its protein-rich properties (Mendonca *et al*., 2009) [22].

Impact of involvement and negligence of millets in human diet

These days, consumer demand has been shifted towards healthier food options rather than opting for hunger-satisfying foods. As a result, there is an efficient need to create health-promoting foods that hold long-term large commercial potential. The development of diverse food items by combining various health-promoting foods has risen in popularity and drawn a lot of attention. Millets are an excellent source of dietary fiber, divalent minerals such as zinc, magnesium, and calcium, and have a low glycemic index, making them ideal for enriching foods (Kim *et al*., 2001; Anju & Sarita 2010) [18, 4]. Millets have a high polyphenolic content, which helps to stimulate the immune system and protect the heart. Equivalently, spinach is abundant in minerals, fiber, and antioxidants that reduces cholesterol and cholesterol levels while also providing several other health advantages (Sirisha, K. S. 2019) [34]. All types of millets are a rich source of dietary fiber, lipid content, and higher in essential amino acids (leucine, isoleucine, and lysine) in comparison to other conventional cereals. Hence, these grains have a great potential as human food (Gull *et al*., 2014) [11]. Besides, they are low-cost, low-maintenance and less sensitive to aflatoxins contamination. They are used to prepare flours, biscuits, pasta, snacks, and non-dairy probiotic drinks, millets can be milled, decorticated, germinated, fermented, cooked, and extruded (Anju & Sarita 2010) [4]. They have a low glycemic index (GI), making it a good choice for weight loss and lowering the risk of chronic illnesses like diabetes (Shukla and Srivastava, 2014) [32].

Lack of nutritional education and the use of imbalanced or processed meals is majorly responsible for long-term nutrient deficiencies. Long-term deficiency can result in slowed physical and cognitive development, which might have a negative impact on one's development (Gupta and Gupta, 2014) [13]. Several strategies are usually put forward to eliminate such conditions with short-term supplementation, moderate-term fortification, and long-term dietary diversity, etc. (Nair *et al*., 2016) [24]. Through successful supplementation and fortification programmes, higher success rates are seen in managing certain clinical manifestations of microelement deficiencies such as pellagra, beriberi, rickets, goiter, and others. Equivalently, the prevalence of iron deficiency anaemia has decreased, although the subclinical and clinical forms of the disease still account for more than 50% and 40% of cases (Meshram *et al*., 2012) [23].

As a result, an effective, adequate and comprehensive approach is needed to address the aforementioned issues and it is a major criterion requirement. Enrichment is one such method or approach that combines all three treatments, supplementation, and fortification (from natural sources) to provide dietary diversity (Olson *et al*., 2021) [25]. CODEX Alimentarius defines enrichment as the process of adding one or more nutrients to food in order to prevent or control deficiency in a population or a specific group of people (Mannar and Khan, 2016) [24].

Types of millets & their distribution in India

India is the largest producer of millets, followed by Nigeria in 2000 and 2009. There are 8 varieties of millets in India species that are grown under rain-fed conditions (Annbukani *et al*., 2018) [3].

1. Sorghum

Warm-season crops like sorghum (*Sorghum bicolor* (L.) Moench) are not tolerant of low temperatures but are generally resistant to harmful pests and diseases (Hossain *et al*., 2022) [15]. Animal feed is the primary application for the majority of the sorghum produced in North and Central America, South America, and Oceania. The grain is made up of a naked caryopsis that includes an embryo, endosperm, and pericarp. Sorghum is divided into four types despite the vast selection available owing to physical diversity: grain sorghum, forage sorghum, grass sorghum, and Sudan sorghums (Ananda *et al*., 2020) [2].

2. Finger Millet

Eleusine coracana (L.) Gaertn, also known as finger millet, is a cereal grass primarily produced for its grain. The name "finger millet" comes from the inflorescence, which is a panicle with 4–19 finger-like spikes that resemble a fist when ripe. Due to its ease of storage throughout years of famine, it is also regarded as a useful famine crop. In Ethiopia, finger millet is also used to manufacture beer and liquor, both of which produce byproducts that are fed to cattle. Although finger millet is predominantly utilized as a food grain, it is not frequently used for livestock since it is of lower quality for animals than maize, sorghum, and pearl millet. It is occasionally used in India to feed growing animals, ill and convalescing animals, as well as newborn calves (Yemets *et al*., 2020) [38].

3. Pearl Millet

Originating in Central Tropical Africa, Pearl Millet (*Pennisetum glaucum* (L.) R. Br.) is now widely grown in India and the drier tropics (Taylor., 2016) [36]. A significant grain, fodder, and stover crop historically, pearl millet is

largely grown in dry and subtropical areas of many developing nations. It works effectively on soils with low pH or excessive salt. It can be cultivated in regions where other cereal crops, such maize or wheat, would not thrive because of its resistance to challenging growth circumstances (Serba *et al*., 2020) [31].

4. Proso Millet

Annual grass proso millet (*Panicum miliaceum* (L.)) grows from seed annually. Proso millet is a crop with little requirements, and no known illnesses affect it. Proso millet is a useful intercrop between two crops that require a lot of water and pesticides because of its shallow root structure and tolerance to atrazine residue. Because the previous crop's stubbles release more heat into the soil, millet grows more quickly and early (Habiyaremye *et al*., 2017) [14].

5. Kodo Millet

The kodo millet plant, *Paspalum scrobiculatum* (L.), is extensively spread in wet environments across the world's tropics and subtropics (Duodu and Dowell, 2019) [9]. It is an ancient Indian crop and serves as the foundation for meeting dietary nutritional needs. It has a lot of fiber, little fat, and a lot of protein. Kodo millets are suitable for gluten-intolerant persons since they are free of gluten. For postmenopausal women exhibiting symptoms of cardiovascular disease, such as high blood pressure and high cholesterol levels, regular ingestion of kodo millet is particularly advantageous (Bunkar *et al*., 2021) [7].

6. Foxtail Millet

Considered a native of China, foxtail millet (*Setaria italica* (L.) P. Beauvois) is one of the oldest crops still grown today. Foxtail millet is the second most produced millet in the world and continues to play a significant role in global agriculture (Sachdev *et al*., 2020) [29]. It cannot stand standing water. Due to its early maturity, foxtail millet may sometimes avoid droughts despite its moderate drought tolerance. It may be planted as a short-term catch crop because of its rapid growth. It can thrive in a variety of soils, climates, and elevations. Its grain is fed to poultry and caged birds as well as utilized for human consumption (Saadat and Shukla, 2020) [28].

7. Barnyard Millets

Echinochloa crusgalli (L.) P. Beauvois, known as barnyard millet, is a crop grown for food and fodder. It is a rich source of highly digested protein and dietary fiber with a good balance of soluble and insoluble components, and it is very nutritious (Rao *et al*., 2016) [26]. Barnyard millet is a natural gift from nature for today's sedentary human population since it has a low and slowly digesting carbohydrate content. Linoleic acid is the main fatty acid in barnyard millet, followed by palmitic and oleic acid. Additionally, it exhibits a strong retrogradation of amylase, which promotes the creation of more resistant starches. The best results from barnyard millet come from lowering cholesterol and blood glucose levels (Renganathan *et al*., 2020) [27].

8. Little Millet

Panicum sumatrense, known as little millet, was domesticated in India. Little millet has smaller seeds than normal millet does. It is an annual herbaceous plant that can resist both dry conditions and standing water. Due to its early maturity and resilience to unfavorable agro climatic conditions, little millet is another trustworthy capture crop. Stover makes excellent cow feed (Anusha *et al*., 2020) [6].

Nutritional properties of millets

As nutritional well-being is a sustained force for health and development as well as the maximization of human genetic potential, it is essential for preserving human total physical well-being. Therefore, dietary quality should be taken into account to address the issue of pervasive food insecurity and malnutrition. Millets were discovered to have a high nutritional content that is equivalent to that of main grains like wheat and rice, in addition to its cultivation advantages (Kumar *et al*., 2018) [20]. Additionally, it has been noted that millet proteins, with the exception of lysine and threonine, are excellent sources of methionine. Millets are abundant in micronutrients and phytochemicals. A substantial percentage of the millet grain (65%) carbohydrate content comes in the form of non-starchy polysaccharides and dietary fiber, which decrease blood cholesterol, prevent constipation, and block the release of glucose into the bloodstream after digestion (Gull *et al*., 2014) [11]. Regular millet eaters have been found to have lower rates of cardiovascular disease, duodenal ulcers, and hyperglycemia (diabetes). Important vitamins including thiamine, riboflavin, folic acid, and niacin are also abundant in millet grains. They are also high in fatty acids and several minerals (Rao *et al*., 2016) [26].

Millions of people throughout the world depend on sorghum and millets including Pearl millet, Finger millet, Kodo millet, Proso millet, Foxtail millet, Little millet, and Barnyard millet as key staple foods (Singh and Sarita, 2016) [33]. These are often rain-fed crops cultivated in regions with little rainfall, which gives them more significance for sustaining agriculture and ensuring food security. In the majority of poor nations, millets are almost exclusively utilized for human food, but in wealthy nations, their usage has mostly been relegated to animal feed (Konapur *et al*., 2014) [19]. Millets are a rich source of protein, fibre, as depicted in Table (1) minerals, and phytochemicals and are nutritionally equivalent to other types of cereal. Prolamin (also known as kaffirin), which makes up a large amount of sorghum protein, has the unusual property of being less digestible when cooked, whereas millets have a superior amino acid profile. Sorghum proteins are said to be much less digestible after heating than other cereal proteins, which may be advantageous for some dietary groups (Taylor 2017) [37]. On the other hand, millets have lower levels of cross-linked prolamins, which may be another factor boosting the millet proteins' level of digestibility. Kodo millet is ideal for boosting the nervous system since it is very easy to digest, has a high lecithin content, and is also very easy to digest. Niacin, B6, folic acid, and other B vitamins, as well as minerals including calcium, iron, potassium, magnesium, and zinc, are abundant in kodo millets (Rao *et al*., 2016; Hrideek and Nampoothiri, 2017) [26, 16].

Table 1: Nutritional Composition of Different Types of Millets (in every 100 grams)

Millet Type	Protein Content(g)	Fat Content(g)	Fibre Content(g)	References
Sorghum Millets (Jowar)	10.4	3.1	2	Rao *et al*., 2016 [26]
Finger Millets (Ragi)	7.3	1.3	3.6	Yemets *et al*., 2020; Gull *et al*., 2014 [38, 11]
Pearl Millets (Bajra)	11.6	4.8	2.3	Ananda *et al*., 2020; Rao *et al*., 2016 [2, 26]
Proso Millets (Baragu)	12.5	1.1	5.2	(Habiyaremye *et al*., 2017) [14]
Kodo Millets (Araka)	8.3	1.4	5.2	Bunkar *et al*., 2021 [7]
Fox-tail Millets (Navane)	12.3	4.3	6.7	Sachdev *et al*., 2020; Rao *et al*., 2016 [29, 26]
Barnyard Millets (Sanwa)	6.2	4.8	13.6	Renganathan *et al*., 2020 [27]
Little Millets (Samai)	7.7	4.7	7.6	Rao *et al*., 2016 [26]

Conclusion

The literature review has shown that millets have the potential to be employed as an alternative energy source in poultry diets. Finger and pearl millets provide comparable nutrients to traditional cereals like maize, wheat, and rice, or even more in certain cases. Additionally, millets are given significant significance in terms of health benefits, particularly for humans, due to the existence of nutraceuticals in them. Millet grains contain a number of health-promoting nutrients such as dietary fiber, minerals, vitamins, and phytochemicals like phenolic compounds. They also have a number of possible health advantages. Millets are a basic food source that are abundant in vitamins and minerals in addition to important nutrients like protein, carbohydrate, and fat. Malnutrition and other health issues, such as obesity, diabetes, cardiovascular disease, skin conditions, cancer, celiac disease, etc., are more common in poor countries due to insufficient nutrition availability.

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