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The international year of millets-2023, millets as a smart food: Food that is good for you, the planet and the farmer

Anerao KK, Deshpande HW, Katakhade RP and Mane RP

Abstract
Millet is a group of small-seeded grasses that have been cultivated as a staple food over thousands of years in many parts of the world. Millets are nutri cereals comprising of sorghum, pearl millet, finger millet (major millets) foxtail, little, kodo, proso and barnyard millet (minor millets). These are one of the ancient foods known to humanity. millet grains are highly nourishing, non-glutinous and non-acid forming foods. Hence, they are soothing and easy to digest. This paper provides a comprehensive review of the nutritional composition, production statistics, health benefits, processing and value addition of millet grains. Effect of processing on the nutritional quality of millet grains, new generation RTE products from millet grains and potential health benefits of millets are also discussed in this review. It can be concluded that millets have a huge potential for its utilization into different value-added products. Millets, such as sorghum, foxtail millet, and pearl millet, are nutrient-rich grains high in dietary fiber, B-complex vitamins, essential amino acids, and vitamin E. They also provide significant minerals like iron, magnesium, phosphorous, and potassium. With a slow glucose release, millets promote satiety, potentially reducing the risk of diabetes. These grains are carbohydrate-rich, containing 6 to 11 percent protein and 1.5 to 5 percent fat. Considering a nutritious alternative to common grains, incorporating millets into your diet can contribute to overall health. In order to increase the production of nutrient-rich millets and create awareness among people the year 2023 is declared the "International Year of Millets". There are continuous efforts of GOI for improving the consumption and the level of production of millets in India by providing various schemes and policies such as MSPs for major millets, mid-day meal program etc. To explore the potential health benefits of millet consumption further research is needed and to develop new processing and preparation methods to improve its nutritional quality and sensory properties.

Keywords: Smart food, nutri-cereals, gluten-free, staple food, health benefits, production, processing, value addition

Introduction
Millets, a group of small-grained cereal crops, thrive in marginal and low-fertility soils with minimal inputs like fertilizers and pesticides. These crops play a crucial role in ensuring food and nutritional security, especially in India, where most millets are native. Often referred to as Nutri-cereals, millets are rich in nutrients essential for human health. Cultivated in rain-fed regions with low rainfall, millets are vital for sustainable agriculture and food security. They are classified into major millets like sorghum (jowar) and pearl millet (bajra), and minor millets including finger millet (ragi/mandua), foxtail millet (kangni/Italian millet), little millet (kutki), kodo millet, barnyard millet (sawan/jhangora), proso millet (cheena/common millet), and brown top millet (korale) are categorized under minor millets (Котлер, 2008) [21].
India is the sixth largest producer of sorghum globally (*www.smartfood.org*, N.D.). Traditionally, many kinds of foods and beverages were made from these grains in different regions, which played an important role as a staple food in the local food culture. However, their presence in the Indian food basket has been declining over the years largely due to government policies favouring the production and consumption of fine cereals, such as rice and wheat (State of India's Livelihoods Report 2019, 2019) [17].
In the 21st century, global challenges such as climate change, water scarcity, a growing world population, and escalating food prices pose a significant threat to agriculture and food security, particularly impacting the poorest communities in arid and sub arid regions. Addressing these challenges requires scientists and nutritionists to explore alternative food sources to alleviate hunger and poverty.

Cereal grains play a crucial role in the global food supply, but the changing landscape prompts the need for diversification. Millet, recognized as a vital drought-resistant crop, is extensively cultivated in the semiarid tropics of Africa and Asia, serving as a primary source of carbohydrates and proteins for local populations. Given its resilience and nutritional value, millet is gaining increased attention from food scientists, technologists, and nutritionists due to its potential contributions to national food security and health benefits. The exploration of alternative food sources like millet becomes imperative in the quest for sustainable solutions to ensure global food security (Saleh *et al.*, 2013) [16].

Dating back to some of the earliest known civilizations around the world, like Dadiwan in China which settled about 8000 years ago, contained some fossilized fragments of millet. Signatures of C4 plants were found in the bones of dogs suggest that, these dogs were probably domesticated and fed with millets by the community. Another millet influenced civilization of north-central China is Yangshao culture. These findings highly suggest that early Chinese may have eaten millets before they got used to eating the very common rice (Baruah *et al.*, 2023) [2].

Government policies, specifically in the form of distribution of subsidised rice and wheat through public distribution system (PDS), are primarily responsible for the dietary shift among the rural and urban poor. In populations with higher disposable incomes, millets are often seen as ‘coarse’ grains and are not preferred for daily consumption. The predominance of rice and wheat rather than in processed and convenient foods produced by the industry compounds the problem in this socioeconomic group. Dietary patterns in India have shifted away from traditional staple food grains, which were largely millets, towards the post-green revolution staples such as wheat and rice. This dietary shift from traditional to ‘modern’ foods is considered to be one of the main reasons for diet-related non-communicable illnesses as well as malnutrition in India (*https://nuffoodsspectrum.in*, N.D.).

Let's explore how we can achieve nutrition and food security with a conscious millet rich diet adoption. It is noteworthy that all socioeconomic groups have exhibited a marked shift in grain consumption from a predominantly millet-based diet to a rice and wheat-based diet, though it is more pronounced in urban areas.

Smart Food movement

Under the Smart Food movement, ICRISAT has prioritized millets and sorghum as key smart foods, aiming to expand the traditional "Big 3" staples into the "Big 5." Millets and sorghum, once staple foods in many African countries, India, China, and other parts of Asia, are now labelled as 'nutri-cereals' in India and align with the Smart Food criteria. For instance, finger millet stands out with three times the calcium content found in milk, making it a significant nutritional resource. Moreover, three millet varieties are rich in iron and zinc, addressing widespread micronutrient deficiencies globally. Given the increasing prevalence of anaemia, especially among pregnant women, the incorporation of iron-rich millets into diets becomes crucial for the well-being of current and future generations. The Smart Food movement underscores the importance of these nutrient-dense cereals in addressing nutritional gaps and promoting sustainable food choices (Fund & House, 2018) [3].

India, with one of the world's fastest-growing economies, still grapples with issues of hunger and malnutrition despite its remarkable economic progress. Global concerns include food security, livelihood security, and natural resources conservation. The Global Hunger Index Report 2022 ranked India 107th out of 121 countries, categorizing it as 'serious' with a score of 29.1.

A major contributor to malnutrition is the lack of dietary diversity. Recognizing this, the Government of India is actively promoting millet production to enhance nutritional awareness among consumers and increase farmers' income. In 2020, India accounted for over 41% of the world's millet production. The United Nations General Assembly (UNGA) has designated 2023 as the International Year of Millets, highlighting their significance. Millets, considered as nutritional powerhouses, are particularly valued by vegans for their rich nutrient content. Encouraging millet consumption plays a crucial role in addressing malnutrition and fostering sustainable agricultural practices in India (Pattanaik & Priyadarshini, 2023) [12].

Production statistics

Table 1: Production of millets in India (MT)

Sr. No.	Grains	Production in million tones					
		2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
1	Sorghum	4.24	4.57	4.8	3.48	4.73	5.01
2	Bajra	8.07	9.73	9.21	8.66	10.28	9.57
3	Ragi	1.82	1.39	1.99	1.24	1.74	2.35
4	Small Millets	0.39	0.44	0.44	0.33	0.4	0.65
Total Nutri-cereals		14.52	16.12	16.44	13.71	17.15	17.58

Source: Ministry of Agriculture and Farmers Welfare, GOI. (Government of India, 2015) [4]

The production of Nutri-cereals (All India) has increased from 14.52 million tonnes to 17.58 million tonnes during the last five years (Table 1). Despite the many benefits of growing small millets and its health advantages, the cultivation of small millets is confined to a few pockets of India. The current small millet production in the country is 0.65 million tonnes during 2020-21 (GOI). However, the production of sorghum in Maharashtra during 2019-20 was 2.19 (Million Hectares) contributing (46.48%) to all India production with an average yield of 823 kg/hectare (Government of India, 2015) [4].

Major millets producing states in India

Globally, India is the largest producer with 41.04% market share and the fifth largest exporter of millets. India holds a dominant position globally as the largest producer of millets, claiming a substantial 41.04% market share. Despite a historical decline in consumption and cultivation due to the preference for commercial crops supported by policies like subsidized inputs, the government recognized the nutritional significance of millets and declared them as "Nutri-cereals" in April 2018. According to the 4th Advance estimate for 2021-22, Pearl millet (60%), Sorghum (27%), and Finger millet (11%) are the primary millets produced in India, contributing to a 27% increase in total millet output compared to the previous year. The top five millet-producing states are Rajasthan (39%), Uttar Pradesh (20%), Haryana (12%),

Gujarat (11%), and Madhya Pradesh (9%), followed by Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, and Telangana India's millet exports have shown a steady increase over the past decade, with a Compound Annual Growth Rate (CAGR) of approximately 3% from 2010 to 2020. This data highlights the renewed focus on millets as a crucial component of India's agricultural landscape, aligning with both nutritional and economic goals (*White Paper on Millets*, N.D.).

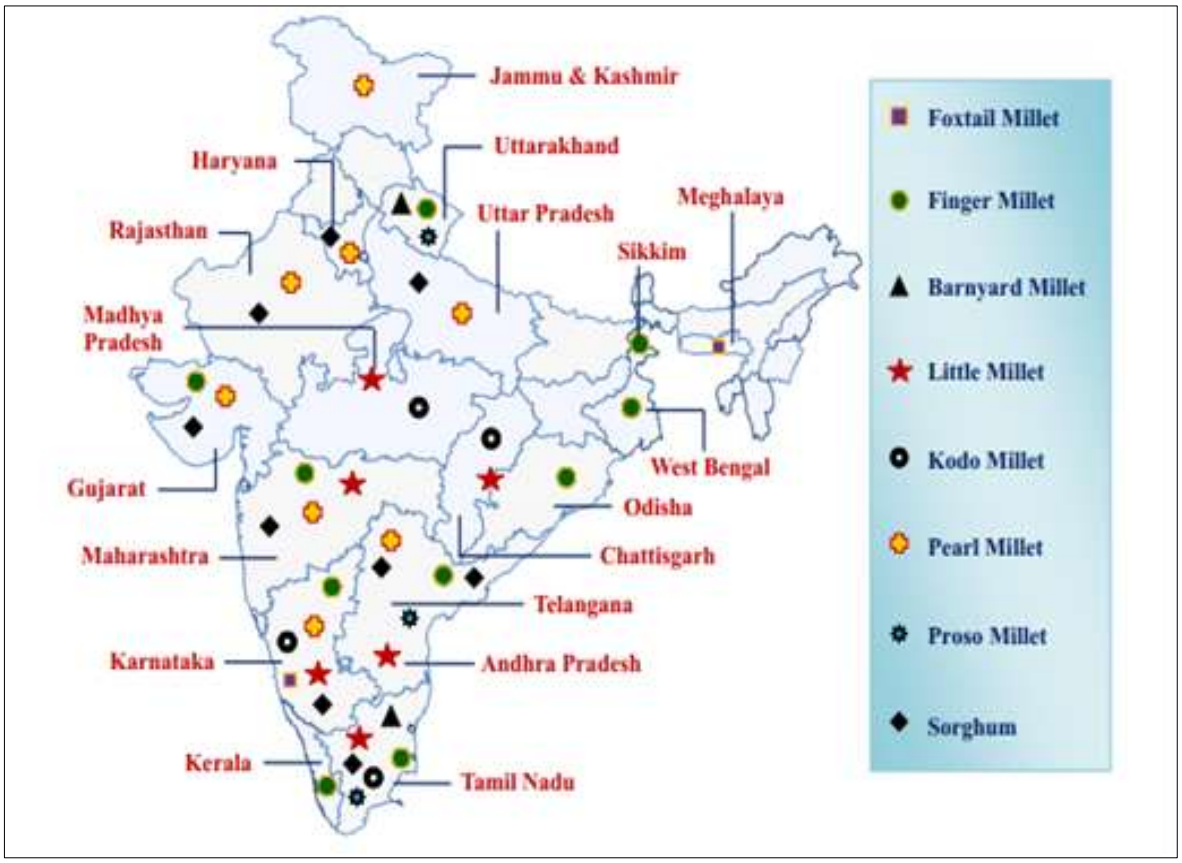
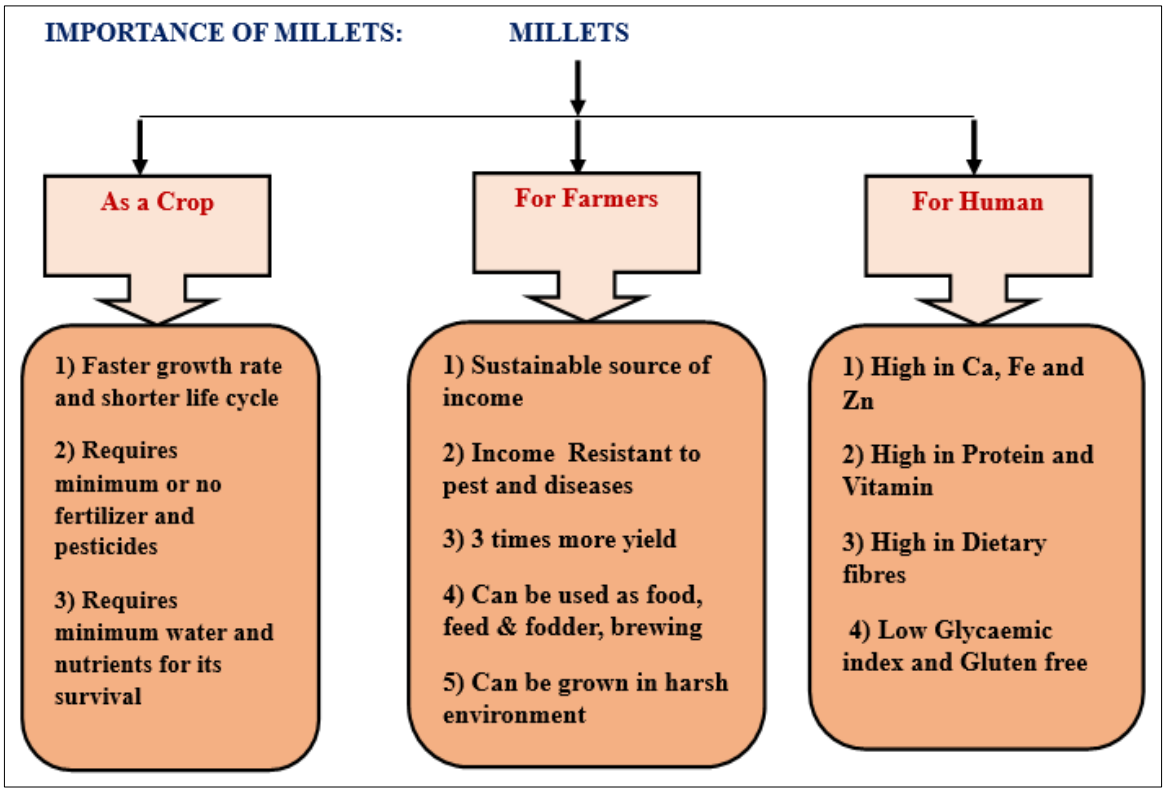


Fig 1: Major millets producing states in India



Nutritional composition of nutri-cereals

Table 2: Nutritional composition of nutri-cereals

Crop	Protein (g)	Fat (g)	Fiber (g)	CHO (g)	Minerals (g)	Iron (mg)	Calcium (mg)
Sorghum	10.4	1.9	1.6	72.6	1.6	4.1	25
Wheat	11.8	1.5	1.2	71.2	1.5	5.3	41
Foxtail Millet	12.3	4.3	8.0	60.9	3.3	2.8	31
Pearl Millet	11.6	5.0	1.2	67.5	2.3	8.0	42
Finger Millet	7.3	1.3	3.6	72.0	2.7	3.9	344
Kodo Millet	11.0	3.6	10.0	66.6	1.9	0.5	27
Little Millet	7.7	-	7.6	-	1.5	9.3	27
Proso Millet	12.5	4.2	2.2	73.0	1.9	0.8	14
Barnyard Millet	12.2	3.85	10.1	55.8	3.2	1.4	24

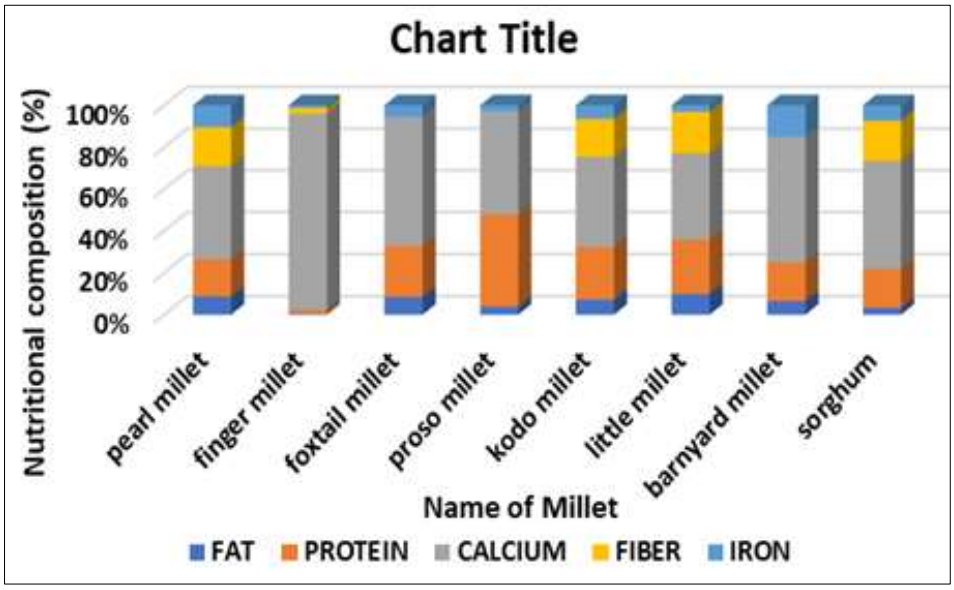
Longvah *et al.*, 2017 [10]

The average carbohydrate content of sorghum varies from 60-70 g/100 g, protein content from 9.57 to 11.57% and lipid content ranges between 1.39 and 1.90 g/100 g (KK *et al.*, 2022) [7]. Millets are a rich source of calcium, especially finger millet or ragi (364 mg/100 g) contains 10 times more than that wheat or rice. The iron content of Pearl millet or Bajra (6.42 mg/100 g) and Barnyard millet (5.0 mg/100 g) is also higher compared to other staple cereals. They are also rich sources of crude fiber as well as dietary fiber and rich in vitamins and minerals (Poshadri *et al.*, 2019) [13].

Millets offer a nutritional boon for populations heavily reliant on cereal-based diets lacking essential micronutrients. Rich in proteins, essential amino acids, minerals, and vitamins, millets are predominantly used for human consumption in developing countries. In contrast, developed nations have traditionally limited their use to animal feed. Nutritionally comparable to major cereals in terms of carbohydrates and energy, millets provide a substantial source of protein, micronutrients, and phytochemicals. With a nutrient profile encompassing 7-12% protein, 2-5% fat 65-75% carbohydrates and 15-20% dietary fiber, millets play a crucial role in addressing nutritional deficiencies worldwide (Котлер, 2008) [21].

Millets exhibit unique nutritional characteristics, featuring complex carbohydrates, abundant dietary fiber, and distinctive phenolic compounds and phytochemicals with medicinal properties. Serving as a natural source of iron, zinc, calcium, and other essential nutrients, millets play a crucial role in combating malnutrition in India. They boast higher levels of niacin, B6, folic acid, calcium, iron, potassium, magnesium, and zinc. Notably, finger millet stands out as the richest calcium source (300-350 mg/100 g), while other small millets contribute to phosphorus and iron intake. Millets are easily digestible, contain significant lecithin, and excel in fortifying the nervous system.

Nutrient content of millet grains



Source: Indian Food Composition Tables, NIN-2017; *Nutritive value of Indian Foods, NIN-2007

Fig 2: Nutrient Content of Millet Grains

Health benefits of millets

Treasure trove of nutrients

Millets are rich sources of nutrients like carbohydrate, protein, dietary fibre, good quality fat and have substantially higher amounts of minerals like calcium, potassium, magnesium, iron, manganese, zinc and B complex vitamins making them a preferable choice over the cereal grains. It also contains several bioactive phytochemicals including furoxans, lignans, β-glucan, inulin, resistant starch, sterols and phenolic compounds (e.g., ferulic acid, caffeic acid and quercetin). Studies have supported the role of polyphenols in antioxidant, anti-carcinogenic, anti-inflammatory, antiviral and neuroprotective activities which in all has shown to be beneficial against diseases like cancer and cardiovascular disease, diabetes, high blood pressure, high cholesterol, inflammatory diseases, metabolic syndrome and Parkinson's disease. Millets are also regarded to have antimicrobial and DNA damage protection activities due to their phytochemical content. A very high proportion of the millet grain comprises dietary fibre and non-starch polysaccharides which help in weight regulation. Due to high fibre content and the slow release of glucose, millets are an excellent choice of food for diabetics.

Millet grains hold a good quantity of bio-active compounds that involve polyphenols- (vanillic acid, sinapic acid, coumaric acid), Flavonoids- (quercitin, luteolin, catechin, myricetin), tannins, photosterols. These components possess numerous health benefits for sustaining a healthy life (Priya *et*

al., 2023) [12].

Scientific evidence indicates that incorporating millets into diets can lead to better growth in children. Studies reveal that these 'smart foods' can enhance growth by 26-39% in children and adolescents when they replace rice in standard meals, offering a promising solution to combat malnutrition. Among children fed millet-based meals, a relative increase of 28.2% in mean height, 26% in weight, 39% in mid-upper arm circumference, and 37% in chest circumference was observed compared to those on regular rice-based diets. The duration of millet consumption ranged from 3 months to 4.5 years.

These findings underscore the potential of nutrition intervention programs that promote millet consumption, enhancing meal diversity and nutritional content. Millets not only address child under nutrition but also contribute to managing Type 2 Diabetes, overcoming iron deficiency anaemia, reducing total cholesterol levels, managing obesity, and mitigating the risk of cardiovascular disease. Incorporating millets into school feeding and mother and child programs offers a valuable strategy to meet diverse nutrition and health needs (https://nuffoodsspectrum.in, N.D.).

Millets confer good health and protection against non-communicative diseases

Indeed, scientific evidence supporting the nutritional and health benefits of millets has become increasingly available. Consumers are recognizing millets as superior and nutritious cereals that contribute to human health. Millets are recommended for various demographic groups, including infants, lactating mothers, the elderly, and convalescents, due to their suitability and positive impact on well-being. The rich nutritional profile of millets, encompassing essential nutrients and unique health-promoting compounds, makes them a valuable dietary choice for diverse populations, supporting overall health and addressing specific nutritional needs.

Absolutely, the low glycaemic index of millets, leading to a slow release of glucose, is a crucial factor in addressing the global challenge of diabetes. Areas where millets are dietary staples tend to have lower rates of diabetes mellitus and gastrointestinal tract disorders. The high fiber content in millets plays a dual role, aiding in preventing constipation and potentially reducing the risk of various bowel disorders, including those affecting the bowel and colon. These qualities make millets a valuable dietary option for individuals aiming to manage blood sugar levels and enhance digestive health.

The major portion of sorghum protein is comprised of prolamin (kafirin), which exhibits a unique characteristic of reduced digestibility upon cooking. In contrast, millets have a more favourable amino acid profile. Upon cooking, sorghum proteins become significantly less digestible compared to other cereal proteins, potentially offering health benefits for specific dietary groups. Millets, in contrast, contain fewer cross-linked prolamins, contributing to higher protein digestibility.

Moreover, sorghum starch is gluten-free, making sorghum a suitable alternative to wheat flour for individuals dealing with celiac disease. This characteristic positions sorghum as a valuable option for those with gluten sensitivities, expanding the range of dietary choices for individuals with specific health requirements (Котлер, 2008) [21].

Kodo millet stands out with lower phosphorus content compared to other millets, while its antioxidant potential surpasses that of both other millets and major cereals. Being gluten-free, kodo millet is particularly advantageous for individuals with gluten intolerance. Its consumption is associated with benefits such as controlling blood sugar levels and promoting strength in dermal wound healing, by the virtue of its antioxidant properties.

Additionally, kodo millet undergoes fermentation in the intestinal gut by bacteria, leading to the conversion of its components into animal lignans. These animal lignans have demonstrated protective effects against certain chronic diseases. This highlights the multifaceted health benefits of incorporating kodo millet into one's diet, offering nutritional advantages and potential protection against chronic health conditions. (Kumar *et al.*, 2022) [9].

Proso millet offers a resilient, nutritious crop in the face of climate change. Nutritional analyses of proso millet varieties and other minor crops are tools to encourage farmers and growers to cultivate them and for consumers to integrate these crops in the diet. Without nutritional studies, many minor crops will be overlooked and will soon be forgotten. The inclusion and consumption of ancient grains like “kabog millet” as staple food can help address the challenge of food insecurity by providing more balanced diets, and biodiversity loss by encouraging cultivation of overlooked and often forgotten plant varieties (Narciso & Nyström, 2023) [11].

Pearl millet contains 5.6-7.1% free lipids and 0.57-0.90% bound lipids, including phospholipids like lecithins and cephalins. These compounds play a crucial role in general metabolism, supporting brain function and addressing behavioural disorders and stress. Additionally, they contribute to membrane regeneration, providing protection to organs like the liver, lungs, kidneys, and gastrointestinal tract. Phospholipids in pearl millet also enhance the bioavailability of nutrients and medicines, making it a valuable dietary choice for overall health and well-being.

Properties of dietary fibre in millets and their health consequences

Function	Health consequences	Millet (e.g.)
Water absorbing and bulking property	Energy diluents to formulate low calorie diets	All Millets
Increased transit time of food in the gut	Reduced risk of inflammatory bowel disease.	Sorghum and Finger Millet
Bile acid and steroid binding	Hypocholesterolaemia activity and reducing the risk of cardiovascular diseases	Pearl Millet, Sorghum and Finger Millet
Retardation of carbohydrate absorption and impaired glucose tolerance	Management of certain type of diabetes	Management of certain type of diabetes
Binding of toxins	As a detoxifying agent	Sorghum

Котлер, 2008 [21]

Anti-nutrients in millets – challenges and solutions

Millets, despite being rich sources of nutrients and minerals, also contain anti-nutrients (phytochemicals) that can reduce digestibility and mineral absorption. These compounds, including phytates, polyphenols, oxalic acids, tannins, and digestive enzyme inhibitors, contribute to properties like 'slow glucose release' and 'anti-oxidant' effects. For example, phytic acid, found in other grains like rice, can bind to minerals such

as calcium, iron, magnesium, and zinc, inhibiting their absorption in the body. Despite these considerations, the overall nutritional benefits of millets often outweigh these drawbacks, and various cooking and processing methods can help mitigate the impact of anti-nutrients. (Котлер, 2008) [21].

The anti-nutrients interact negatively with the bio accessibility of essential elements in the digestive tract particularly iron and zinc; moreover, tannins further reduce the digestibility of sorghum proteins. The general mechanism involves the formation of insoluble complexes at physiological pH, due to the ability of phytic acid and tannins to bind proteins and divalent captions (Anerao *et al.*, 2022) [1].

The presence of anti-nutrients in millets can be mitigated through common household food processing techniques. Methods such as decortications, milling, soaking, malting, germination, fermentation, popping, and cooking effectively reduce phytates, phenols, tannins, and trypsin inhibitor activity. These processes not only enhance the digestibility of millets but also improve the bioavailability of minerals, making millets a more nutritionally advantageous dietary choice.

How millets and sorghum are good for you, the planet and the farmer?

Considering the challenges posed by climate change and water scarcity, it is crucial to equip the Indian agriculture sector with climate-resilient approaches and crops capable of thriving in stressful environments. This is essential to sustain food production and meet the rising demand. Simultaneously, there is a global trend towards integrating agriculture and nutrition to effectively address issues related to health and nutrition. This underscores the need to prioritize crops that can meet current environmental challenges, nutritional requirements, and provide a sustainable livelihood for farmers.

A holistic approach is required to align agricultural practices with nutritional needs, environmental sustainability, and the well-being of farming communities. This encapsulates the definition of Smart Food, which refers to food that meets three key criteria: being good for you (nutritious and healthy), Good for the Planet (with a low carbon footprint), and Good for the Farmer (climate-resilient and requiring less water). A focus on Smart Food contributes to addressing major global and Indian challenges simultaneously: poor diets (from malnutrition to obesity), environmental issues (including water scarcity and degradation), and rural poverty. It represents a holistic approach to food production and consumption that aligns with health, sustainability, and the well-being of farming (Kane-Potaka & Kumar, 2019) [5].

Millets and sorghum emerge as highly nutritious options, addressing significant nutrition and health needs:

- Finger millet contains three times the calcium found in milk.
- Certain types of millets boast high iron and zinc content, surpassing that in meat. While plant-based iron may have lower bioavailability, these millets can still provide a substantial amount of iron, comparable to red meat and close to the recommended daily allowance.
- Millets and sorghum have a low glycaemic index (GI), making them important in the context of the increasing incidence of diabetes.
- They are also rich in fiber, contributing to overall digestive health.

These nutritional attributes position millets and sorghum as valuable components of a well-balanced diet, offering benefits for bone health, iron intake, diabetes management, and overall dietary fiber.

In this context, it's crucial to note that

- Iron and zinc deficiencies rank among the top three global micronutrient deficiencies, with anaemia being a major concern.
- Calcium and protein deficiencies are prevalent in Asia and Africa, particularly impacting children and women.
- Given the rising prevalence of diabetes, the need for food with a low glycaemic index is critical.
- On-farm diversification with millets and sorghum serves as a robust risk management strategy for farmers due to the crop's resilience to harsh conditions.
- These crops offer multiple, largely untapped uses for food, feed, fodder, brewing, and biofuels, creating parallel markets for their produce.
- Millets and sorghum have a low carbon footprint.
- They thrive in high temperatures and can survive with minimal water, with pearl millet often referred to as the last crop standing in times of drought.
- Embracing millets and sorghum serves as an adaptation and mitigation strategy for climate change.

Processing and value addition of millet grains

Processing Technology of Millets

A) Primary Processing

Millets are usually processed before consumption to make dried grains palatable and digestible. The processing increases the shelf life, enhances aroma, texture, and appearance in order to fulfil the demands of consumers. Ready to eat (RTE) food products can also be developed by processing. Several studies show that processed millets are at par with wheat-based products in terms of nutritional composition, biological and sensory characteristics values. It inactivates natural toxins, prevents bacterial growth and food spoilage. The Processing of Millets is helpful in creating their greater demand, fetching good price of the production, increasing self-life and taste. After harvesting, nutri-cereals are not eaten as uncooked whole seeds in any human society. Processing millets is necessary to make it digestible. Millets are an excellent grain for processing. Primary processing of millets mainly involves De-stoning, Cleaning, Dehusking, De-cortication, Parboiling and Milling (Yadav Khan, N.D.).

1. **Destoning:** It is the process of removing stones/mud or contamination from various crops of different sizes and colors which come along with the harvested crop.
2. **Cleaning:** Cleaning is the method of removing impurities such as stems, leaves, soil lumps and moldy particles from unprocessed grains.
3. **Dehusking/Hulling:** It is the process of removing the outer most layer of millets to bring it to form so that it can provide maximum nutrition. This process of removing the husk is called de-husking.
4. **Decortication or Dehulling:** The millet grain's outer coat is partially removed during decortication or pounding. The process is carried out by manual pounding and abrasive dehullers, such as those used for dehulling rice. Pounding Grain is often crushed with a wooden pestle in a wooden or stone mortar whether it is dry, moistened, or wet. The biological availability of nutrients

and consumer acceptability are both enhanced by de-cortication. It reduces protein, dietary fiber, vitamins and mineral contents of the grains to some extent. The overall mineral contents of the grains are known to decrease with de-hulling or de-cortication, while the bioavailability of calcium, iron, and zinc is known to increase by 15, 26, and 24 g/100g, respectively (Krishnan *et al.*, 2012) [8].

5. **Parboiling:** This is basically the process of partial cooking of grain together with its husk and bran. The raw grain is briefly steam-cooked. The finished product is dried, de-husked and decorticated.
6. **Milling:** It is the process of separating germ and bran from the starchy endosperm so that the endosperm can be granulates into flour or rawa by using various types of sieves in a hammer mill. To enable consumer acceptance, higher nutrient bioavailability, and improved product-making capabilities. The main limiting criteria for the use of millets are the coarse grains, pigmented seeds, hard seed coat, acidic or bitter taste, and poor shelf life of the processed goods. Therefore, for the value addition and commercialization of millet-based products, appropriate milling technologies are needed.

B) Secondary Processing

Secondary processing is a process converting primary processed raw material into product which is suitable for food usage or consumption, such as ready-to-eat (RTE), ready-to-cook (RTC) goods, puffed products, extruded products, value added, fermented weaning food products.

1. **Ready-to-Eat (RTE) Products:** Instantly ready-to-eat (RTE) items can be made, reducing the cumbersome time for fermentation. It is low in calories, rich in phenolic compounds, gluten free, induces satiety, slows digestion, and reduces oxidative stress.
2. **Ready-to-Cook (RTC) Products:** Ready-to-cook (RTC) products require minimum cooking time and make it convenient foods or handy. RTCs are viable option for working women.
3. **Puffed Products:** Millet puffs are a byproduct of explosive or cannon puffing, in which the millets (sorghum pearl millet, and foxtail millet) grain is inflated to its greatest extent while maintaining their identity (same grain form). The RTE (ready-to-eat) snack was created with the use of a puff gun machine. Different processing methods, particularly the thermal treatment of grains induces the physicochemical and structural changes in starch-protein matrix which ultimately leads to the expansion of the grains to produce a puffed product.
4. **Extruded Products:** Extrusion cooking is the technique of cooking which is utilized for the post-harvest processing of starchy and protein versatility of processed food items. It is carried out either by direct application of heat through a steam injection or indirectly through a jacket by the dissipation of mechanical energy through shearing that takes place within the matrix.
5. **Value Added Products:** People in both developed and developing nations use a lot of functional wheat food products such cakes, pasta, macaroni, vermicelli, noodles, spaghetti, and flakes. Semolina or refined wheat flour is the major ingredients in all these baked goods. The nutritional and functional quality of these goods is improved, and the physicochemical characteristics will alter when millet flour is added in certain amounts (S. Thorats & Kulthe, 2017) [15]. Noodles and pasta are the most popular food items across all age groups. Noodles and pasta have a longer shelf life and greater economic value when compared to other items. Millets can also be used to make a variety of pasta and noodles. It comprises noodles produced entirely from finger millet flour, noodles created in a 1:1 ratio of finger millet and wheat flour, and noodles made in a 5:4:1 ratio of finger millet to wheat and soy flour.
6. **Bakery Products:** Baked goods are favoured by people of all age groups owing to their prolonged shelf life, simple marketing, and attractive packaging. These goods are not favoured by celiac disease patients due to the high gluten content, especially in developed countries. Millet-based bakery products not only are superior in terms of nutritive value but will also fetch the higher price in the market (Verma & Patel, 2013) [18]. Common bakery products such as biscuits, cakes and bread were prepared and tested using dehulled sorghum or millet grain and milled flour of finer particle size is most amenable for production of these products. Incorporation of 20-30% refined wheat flour produces a product acceptable on par with wheat biscuits.
7. **Weaning food products:** Traditionally, millet malt is used to feed infants. Finger millet has effective malting qualities, and its malt is popular in tribal communities. According (Anerao *et al.*, 2022) [1]**,** malting significantly improves the health benefits content of grains, including mineral, fiber, crude fat, vitamin B, the bioavailability of nutrients, and sensory attributes of the millet grains as well as it also reduces the antinutritional factors present in millets such as phytic acid tannins etc.

Conclusion

India is known for producing numerous traditional coarse cereal crops such as Sorghum, Pearl Millet, Finger Millet, Foxtail Millet, Proso Millet, Little Millet, Barnyard Millet, Millet, kodo millet etc. Millets are small, round-shaped coarse grains which is an indigenous crop to India that comes with an impressive nutrient profile. They are famed as “poor man’s food grain” due to its affordability. Millet grains have one in thing common – ample amounts of nutrition. Millets are staple foods, and are important sources of nutrients. Millet grains are rich sources of fibre, vitamins, minerals, and Phyto chemicals. Though millets have a huge potential for its utilization into different value-added products however, it has yet to reach communities or processing industry. Based on above literature review it can be concluded that Millets are Smart Foods by virtue of its nutritional composition, Good for the planet as a result of Low Water & Zero carbon foot print and also, Good for the farmer as long as Short Crop Duration, Resource Efficient & Climate Resilience.

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