MILLETS: ANCIENT GRAINS WITH MODERN NUTRITIONAL VALUE AND SUSTAINABLE POTENTIAL

Abstract

Millets, a group of small-seeded grasses, hold a significant position as one of humanity's oldest crops. Despite their historical importance, these nutritious ancient grains have been overlooked in favor of more widely promoted cereals like rice and wheat. However, recent research has unveiled their exceptional nutritional value and sustainable potential, positioning them as valuable options for modern diets and agricultural practices.

Millets are a diverse group of crops that encompass major varieties such as sorghum, pearl millet, finger millet, foxtail millet, kodo millet, proso millet, barnyard millet, and little millet. They are highly resilient to drought and insect attacks, making them suitable for cultivation in various climatic and soil conditions, particularly in rain-fed or dry zones. Millets also exhibit the unique advantage of being gluten-free, making them a viable alternative for individuals with celiac disease and gluten allergies.

From a nutritional standpoint, millets stand out as nutrient-dense and easily digestible grains. They are rich sources of essential minerals like calcium, iron, zinc, magnesium, and potassium, as well as vitamins B6, folic acid, and niacin. Moreover, they contain beneficial phytochemicals like polyphenols, antioxidants, and phytosterols, which contribute to their health-promoting properties. Consuming millets has been associated with a reduced risk of cardiovascular disease, diabetes, and certain cancers.

The cultivation and consumption of millets hold considerable ecological and economic significance. As water scarcity and climate change continue to pose challenges to conventional agriculture, the cultivation of millets can help in sustaining local ecosystems and enhancing the resilience of farming systems. Emphasizing millets in

Authors

Rosamund Jyrwa
Pratiksha Institute of Pharmaceutical Sciences,
Panikhaiti, Guwahati.

Ananta Choudhury
Assam down town University,
Guwahati.

Freddy Teilang Nongkhlaw
Pratiksha Institute of Pharmaceutical Sciences,
Panikhaiti, Guwahati.

farming practices can also contribute to rural economic empowerment and promote more diversified and nutritious diets.

In conclusion, millets offer a sustainable and nutritionally potent solution for addressing the challenges of modern agriculture and nutrition. Recognizing their potential and incorporating them into global food systems can not only improve human health but also support environmental sustainability in an ever-changing world.

Keywords: Millets, Grains, Nutritional, Potential
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I. INTRODUCTION

1. What are Millets?

Cereals are a staple food for the majority of the world's population. Millets are a collection of small-seeded grasses that are one of humanity's oldest crops. Millet is one of the world's oldest grains. The Poaceae family, also known as the grass family, includes a variety of small seed grasses, round whole grain, and cereal crops. Humans are aware of them, and they were the first cereal grain to be used. They are the first cereal grain to be used for domestic purposes and are familiar to humans. Today, millet is the world's sixth most valuable crop, sustaining 1/3 of the world's population, and is a staple food in Africa, northern China, Japan, India, Manchuria, and parts of the former Soviet Union and Egypt.[1]

Small millets are unique to Indian agriculture, despite contributing only about 2.50 percent of the country's grain production. Millets are important because they fill an ecological niche where no other food crop can be grown profitably [2]. These crops, which have a much longer history of cultivation than major food grains, have historically been highly regarded, and have played an important role in our traditional food culture and farming systems. They are the most nutrient-dense and easily digestible grains on the planet. These crops are commonly consumed in East Asia because of their ability to compensate for nutrient shortages in rice, such as vitamins and minerals.[4,5,6]

Unlike temperate cereals such as wheat, barley, rye, rice, and oats, millets, like maize and sorghum, are C4 tropical grasses [7]. Maize and sorghum are both part of this subfamily. Millets, on the other hand, are only distantly related to temperate cereals (subfamily Pooideae) and rice (Bambisoideae subfamily). Polyphenols, phytoestrogens, phytocyanins, lignans, and phytosterols are among the health-promoting phytochemicals present in them. These antioxidants, immune modulators, detoxifying agents, and other compounds protect against age-related degenerative diseases such as diabetes, cancer, and cardiovascular disease (CVD), among others. Vitamins, minerals, and essential fatty acids are some of the well-known nutrients that can help prevent degenerative diseases. Millets are suitable for celiac disease and gluten allergy sufferers because they are gluten-free, non-acidifying, easy to absorb, and non-allergenic.[8,9,10]

Millets have been linked to a lower risk of cardiovascular disease, diabetes, and some cancers, according to epidemiological evidence [11,12,13]. Furthermore, economic restrictions make them unaffordable for local/rural citizens to use on a daily basis. On the other hand, millet crops classified as "underutilized/neglected" have a lot of untapped potential in terms of filling niches in local ecology, processing, and consumption systems. Despite their practical utility, they must continue to be poorly characterised and ignored by science. Exploration of such underutilized/neglected species contributes to the ecosystem's sustainability, restoration, and diversification, as well as rural people's economic empowerment and nutritional and health welfare, all of which are in higher demand in today's world [14, 15].

Millets have one distinct advantage in that they are drought and insect resistant crops [16].They are small to medium-sized crops that are grown in the tropics and

subtropics all over the world. Millets are high-energy-yielding, nutrient-dense foods that aid in the treatment of malnutrition. They're made into flour, rolled into balls, parboiled, and eaten as porridge with milk [20]. Traditional food processing methods, such as decortication, milling, fermentation, malting, germination, and roasting of millets, are recommended by the Food and Agriculture Organization (FAO) to avoid antinutritional properties and enhance their edible qualities. Water and oil holding capacity, viscosity, foaming action, and so on are all functional properties. The fundamental physicochemical properties of millets are functional properties such as water and oil holding ability, viscosity, foaming behaviour, and swelling strength, which reveal the intricate relationships between the structure, molecular components, composition, and physicochemical properties of food components.[18,19,20,21].

Millets could be processed and eaten as pop-up meals, porridges, chapati, dosa, pasta, and biscuits, among other typical local foods [22, 23, 24]. In most African countries, millet-based foods and beverages are a staple of the diet [25]. Millet crops have a range of health benefits due to the availability of natural bioactive compounds such as calcium, dietary fibre, polyphenols, and protein [26,27,28] . Millets are higher in fatty acids than sorghum, corn, and rice, and contain sulfur-containing amino acids (methionine and cysteine) [29,30] .

Millet-based foods are thought to be good sources of prebiotics and probiotics [31]. Millet crops' phytonutrients and vitamins can be responsible for a variety of activities, including antioxidant, anticancer, antiinflammatory, antifungal, and blood clot inhibition [32].

II. IMPORTANCE OF MILLET

- Millets are also non-glutinous, high-nutrient, non-acidifying, and easily digestible foods. Since it has a low glycaemic index (GI) and is gluten-free, it aids in the sustained release of glucose over a longer period of time, lowering the risk of diabetes mellitus. Celiac disease sufferers can easily integrate different millets into their diets.

- Minerals such as calcium, phosphorus, magnesium, iron, zinc, and potassium are abundant in millets. It also has a lot of dietary fibre and vitamins including vitamin B6, beta-carotene, folic acid, and niacin in it. According to study, high levels of lecithin are beneficial to the nervous system's strength. As a result, daily consumption of millets has several health benefits and can aid in the prevention of malnutrition.[12,13]

- Millets contain anti-nutritional factors that can be decreased by some processing treatments, despite their high content of phytochemicals such as polyphenols, tannins, phytosterols, and antioxidants.[21]

- Millets have a broad range of adaptability since they can expand from coastal Andhra Pradesh to moderately high altitudes in the North-eastern states and hilly areas of Uttarakhand. Millets can accommodate a wide variety of temperatures, moisture, and soil types, from heavy to sandy infertile lands.[29,31]

1. **History:** As can be seen, the history of some foods, especially in the Indian context, would be incomplete without the inclusion of millets. One piece of evidence is millet cultivation on the Korean Peninsula, which dates back to the Middle Jeulmun Pottery Period (around 3,500–2,000BC). Millets have been listed in some of the earliest Yajurveda texts in India. These are foxtail millet (priyangava), Barnyard millet (aanava), and black finger millet (shyaamaka), suggesting that millet consumption was widespread before the Indian Bronze Age (4,500BC). About 2000 B.P., pearl millet and finger millet were introduced to the Indian subcontinent. Millets were the most widely grown grain in India until around 50 years ago. Millets, which were once a staple food and an important part of local food cultures, have been demonised by modern urban consumers as "coarse grains" – something that their village ancestors might have eaten but had abandoned in favour of a more "refined" diet the number. [33].

   Following the western model of growth and pursuing standardisation, India and other developing countries have lost a lot of useful and important products, like our indigenous foods, which we are easily forgetting. One of the most significant shifts in today's generation has been in eating patterns. Millets were often discarded because they were too primitive to be used. Millets made up about 40% of all cultivated grains prior to the Green Revolution, as can be seen (contributing more than wheat and rice). After the revolution, however, rice production has doubled and wheat production has tripled. Rice and wheat promotion, which allows for large investments in machinery, hybrid seeds, fertilisers, pesticides, and other agricultural inputs, is a lucrative economic strategy. Millets, which grow well in a variety of small-scale, low-input farming systems and are beneficial to small farmers' livelihoods, are not profitable for agrochemical companies, large food companies, and so on.[2,3,21]

   Today, many efforts are being made in India and around the world to increase millet demand, development, and cultivation, including changing people's mindsets. Several groups are forming to support this cause. Farmers are being educated on how to grow millets in a more efficient manner. They are assigned a lot of weight because of their gluten-free proclivity. There have also been a lot of millets-based recipes floating around.[34,35]

   One example of a big boost for the cause is the Smart Food initiative. They will be carried out as collaboration, and several organisations have already teamed up to promote millets. The Indian Institute of Millet Research (IIMR), the National Institute of Nutrition (NIN), the MS Swaminathan Research Foundation (MSSRF), and the Self Employed Women's Association are among the organisations in India (SEWA) the number.[36,37].

III. TYPES OF MILLETS

Millets in India come in a variety of shapes and sizes.

Millets are divided into:

- **Major**
  - Jowar (sorghum)

- Bajra (pearl millet)
- Ragi (finger millet)
- Barri (Proso or common millet)
- Kangni (foxtail/ Italian millet)

- **Minor**
  - Kodra (Kodo millet)
  - Samai (Little Millet)
  - Jhangora (barnyard millet) [37,38]

Vernacular Names of Millets

Table 1: Vernacular Names of Millets in India

English	Sorghum	Pearl Millet	Finger millet	Little millet	Kodo millet	Foxtail/ Italian millet	Barnyard millet	Proso millet
Hindi	Jowar	Bajra	Mandua	Kutki	Kodon	Kangni, Kakum	Sanwa, Jhangon	Barre
Sanskrit	-	-	Nandimukhi, Madhuli	-	Kodara	Kanguni	Shyama	Chiná
Gujarati	Juar	Bajri	Nagli, Bavto	Gajro, Kuri	Kodra	Kodra Kang	Sama	Cheno
Kannada	Jola	Sajjai	Ragi	Same	Harka	Navane	Oodalu	Baragu
Tamil	Cholam	Kamboo	Kelvaragu	Samai	Varagu	Tenai	Kuthiravaali	Panivaragu
Telugu	Jonna	Sajjalu	Ragulu	Samalu	Arikelu, Arika	Korra, Korralu	Udalu, Kodisama	Varigulu, Varagalu
Malayalam	Cholam	Kamboo	Moothari	Chama	Varagu	Thina		Panivaragu
Marathi	Jcwari	Bajri	Nachni	Sava	Kodra	Kang, Rala	Shamul	Vari
Bengali	Juar	Bajra	Mandua	Kangani	Kodo	Kaon	Shamula	Cheena
Punjabi	-	Bajra	Mandhuka,	Mandhal	Kodra	Kangni	Swank	Cheena

Source: Millets network of India (http://milletindia.org); Himanshu, chauhan, sonawane and Arya (2018) protein,fiber,calcium,iron,minerals

1. **Sorghum Millet**
   - Subfamily: Panicoideae
   - Tribe: Andropogoneae
   - Sorghum bicolor (L.) Moench subsp. Bicolour [39,40]

Sorghum bicolor (L.) Moench is known by a number of different names, including great millet and guinea corn in West Africa, jowar in India, dura in Sudan, mtama in eastern Africa, kafir corn in South Africa, and kaoliang in China [40]. Sorghum is a grass that belongs to the Andropogonae tribe of the Poaceae family. Saceharum officinarum, also known as sugar cane, is a member of this tribe and a close relative of sorghum. Spikelets borne in pairs characterise the genus Sorghum. Sorghum is regarded as an annual, despite the fact that it is a perennial grass that can be harvested several times in

the tropics. Cultivated sorghum is a single species (Sorghum bicolor (L.) Moench [41,42]. The Sorghum bicolor species has multiple subspecies, with the bicolor subspecies accounting for all cultivated sorghums [42,43]. Grain sorghum, sweet sorghum (sweet-stalked, i.e., with sucrose-rich sap-like sugarcane), forage sorghum, and biomass (bioenergy or energy) sorghum are the four varieties of sorghum [44].

2. Pearl Millet

- Subfamily: Panicoideae
- Tribe: Paniceae
- Pennisetum glaucum (L.) R. Br. [39,40]

The current accepted species name for pearl millet is glaucum. However, in the past, two other species names were widely used: americanum and typhoides [45].

Like most millets, pearl millet (Fig.) belongs to the Panicoideae subfamily, which also includes sorghum (Fig. 1). Unlike sorghum, pearl millet and most other millet species belong to the Chloridoideae family. Pearl millet is self-pollinated, but it outcrosses a lot and has a lot of heterozygozygosity, typhoides, nigritarum, globusum, and leonis are the four basic races of cultivated pearl millet[46]. The pearl millet (Pennisetum glaucum (L.) R. Br.) (Fig. 4) is a tropical grain that originated in Central Africa and is now widely spread in the tropics and India. Drought, low soil fertility, and high temperatures are ideal growing conditions for pearl millet. It thrives in soils that are high in salinity or have a poor pH. It can be grown in areas where other cereal crops, such as maize or wheat, will not thrive due to its tolerance for difficult growing conditions.[47,48]

3. Foxtail Millet

- Subfamily: Panicoideae
- Tribe: Paniceae
- Setaria italica (L.) P. Beauv.
- subsp. Italic [39,40]

Setaria italica (L.) P. Beauvois, also known as foxtail millet, is a Chinese native and one of the world's oldest cultivated crops. It is thought to have been domesticated in eastern Asia, where it has been cultivated since antiquity. China is the primary producer, but S. italica is the most essential millet in Japan and is widely grown in India [40,50]. There are three or four races of foxtail millet: maxima, moharia, indica [46], and nana [47]. While foxtail millet is used for both grain and forage/fodder, there do not appear to be genetically distinct types used for each [49]. It can't bear being flooded. Foxtail millet is drought resistant, and because of its early growth, it can avoid certain droughts. It can be grown as a short-term catch crop due to its rapid growth. It can grow in a variety of elevations, soils, and temperatures. Its grain is used as human food as well as poultry and cage bird feed. NB[51,52]

4. Finger Millet

- Subfamily: Chloridoideae
- Tribe: Eragrostideae

- Eleusine coracana (L.) Gaertn. [39,40]

Eleusine coracana (L.) Gaertn (finger millet) is a cereal grass cultivated primarily for its grain (Fig. 3). Finger millet is a tufted, tillering annual grass that grows up to 170 cm tall [53,54]. In many African and South Asian nations, finger millet is a staple food. It is also regarded as a useful famine crop since it can be processed for lean years [50]. Eleusine coracana L., also known as African millet, koracan, ragi (India), wimbi (Swahili), bulo (Uganda), and telebun, is a type of finger millet (the Sudan). The grains are malted before being used to make beer. Finger millet can be stored for long periods of time without being harmed by insects [40], making it useful in times of famine. E. coracana is thought to have originated in Uganda or a neighbouring country, and it was introduced to India at a very early date, perhaps over 3000 years ago. Grain colour can range from white to orange-red, deep brown, purple, and almost black. [54]

5. Proso Millet

- Subfamily: Panicoideae
- Tribe: Paniceae
- Panicum miliaceum L.
- subsp. Miliaceum [39,40]

The annual grass Proso millet (Panicum miliaceum (L.)) grows from seed each year. Dry climates, such as Central Russia, the Middle East, Northern India, Africa, Manchuria, and the Great Plains region of North America, are suitable for this plant[55]. Proso millet was first introduced to Canada in the 17th century, and it was used as a forage crop in the early 1900s to a small extent. Proso millet is a relatively low-maintenance crop with no known diseases. As a result, Proso millet is often used in organic farming systems across Europe. It is sometimes used as an intercrop in the United States. As a result, Proso millet will help to prevent a summer fallow and allow for continuous crop rotation [56]. Proso millet is a successful intercrop between two water and pesticide-demanding crops because of its shallow root system and resistance to atrazine residue. Millet grows faster and earlier as a result of the previous crop's stubbles allowing more heat into the soil.[57]

6. Kodo Millet

- Subfamily: Panicoideae
- Tribe: Paniceae
- Paspalum scrobiculatum L. [39,40]

The kodo millet (Paspalum scrobiculatum (L.)) is found in moist environments all over the world's tropics and subtropics (Fig. 6). It is an indigenous Indian cereal that is currently grown in Uttar Pradesh in the north, as well as Kerala and Tamilnadu in the south. Varagu, haraka, and arakalu are some of the other names for this cereal. It serves as the mainstay of dietary nutritional needs.It has a high protein content (11%) and a low fat content (4.2%), as well as a high fibre content (14.3 %). Kodo millet is easy to digest, contains a lot of lecithin, and is perfect for improving the nervous system's strength. B vitamins, especially niacin, B6, and folic acid, as well as minerals like calcium and iron, potassium, magnesium and zinc are abundant in kodo millets. [57]Gluten-free Kodo

millets are ideal for gluten-intolerant individuals. Daily consumption of kodo millet is extremely beneficial for postmenopausal women with cardiovascular disease symptoms such as high blood pressure and cholesterol levels. Based on panicle characters, it is divided into four groups: Haria, Choudharia, Kodra, and Haria-Choudharia. Kodo is a tufted annual grass that reaches a height of 90 cm. Because of a fungus infecting the grain, some types have been confirmed to be toxic to humans and animals. Strong, corneous, and permanent husks encase the grain, making it difficult to extract. The colour of the grain can range from light red to dark grey. [40,57]

7. Little Millet

- Subfamily: Panicoideae
- Tribe: Paniceae
- Panicum sumatrense Roth [39,40]

In India, the little millet (Panicum sumatrense) was domesticated (Fig.9). It grows to a small extent in India up to 2100 m altitude, but is of little significance elsewhere. Little millet seeds are smaller than common millet seeds. The habit of this cereal is similar to that of proso millet, but it is smaller. It is an annual herbaceous plant that grows to a height of 30 cm to 1 m with straight or folded leaves. The leaves are linear, with a hairy lamina and membranous hairy ligules in some cases. The panicles range in length from 4 to 15 cm and have a 2 to 3.5 mm long awn. The grain is smooth and round, measuring 1.8 to 1.9 mm in length. It has the potential to survive both drought and flooding. It can be grown up to 2000 metres above sea level. Because of its early maturity and tolerance to adverse agro-climatic conditions, little millet is another reliable catch crop. Stover is an excellent cattle feed. Plant breeders have paid very little attention to it. The plant grows to a height of 30 to 90 cm, with an oblong panicle that measures 14 to 40 cm in length. Little millet seeds are smaller than common millet seeds. [40,57,58]

8. Barnyard Millet

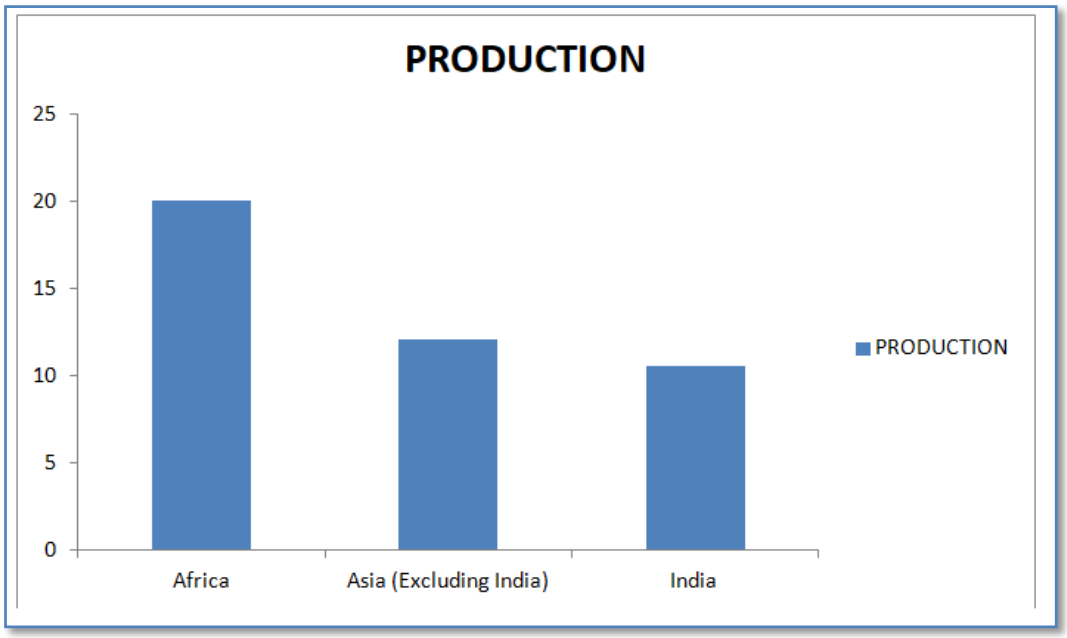
- Subfamily: Panicoideae
- Tribe: Paniceae
- Echinochloa frumentacea Link [39,40]

Echinochloa crusgalli (L.) P. Beauvois (barnyard millet) is a multi-purpose crop grown for food and fodder (Fig. 8). Japanese barnyard millet, ooda, oodalu, sawan, sanwa, and sanwank are some of the other names for it. It is also a good source of protein that is easily digestible, as well as a good source of dietary fibre with a good balance of soluble and insoluble fractions. Barnyard millet has a low carbohydrate content and is slow to digest, making it a natural gift for modern humans who are sedentary. Linoleic acid is the most abundant fatty acid in barnyard millet, followed by palmitic and oleic acids. It has a high degree of amylase retrogradation, which makes the formation of more resistant starches easier. As a result, patients with cardiovascular disease and diabetes mellitus can benefit from it. [57,58] The most powerful way to lower blood glucose and lipid levels is to eat barnyard millet. Japanese barnyard millet (Echinochloa esculenta) and Indian barnyard millet (Echinochloa frumentacea) are two cultivated species of barnyard millet (Fig. 1.3H). The two species vary morphologically, with E. esculenta having smaller spikelets and membranaceous type glumes (De Wet et al., 1983a).

Furthermore, their roots seem to be distinct, with E. esculenta deriving from E. crus-galli and E. frumentacea deriving from E. colona (Yabuno, 1983). The fastest growing of all millets, barnyard, Japanese barnyard, or sawa millet [Echinochloa crus-galli (L.) P.B. and Echinochloa colona (L.) Link] produces a crop in six weeks. It is grown as a rice replacement in India, Japan, and China when paddy fails. In the United States, it is grown as a forage crop and can yield up to eight harvests per year.[43,59]

IV. PORDUCTION AND CULTIVATIONS OF MILLETS

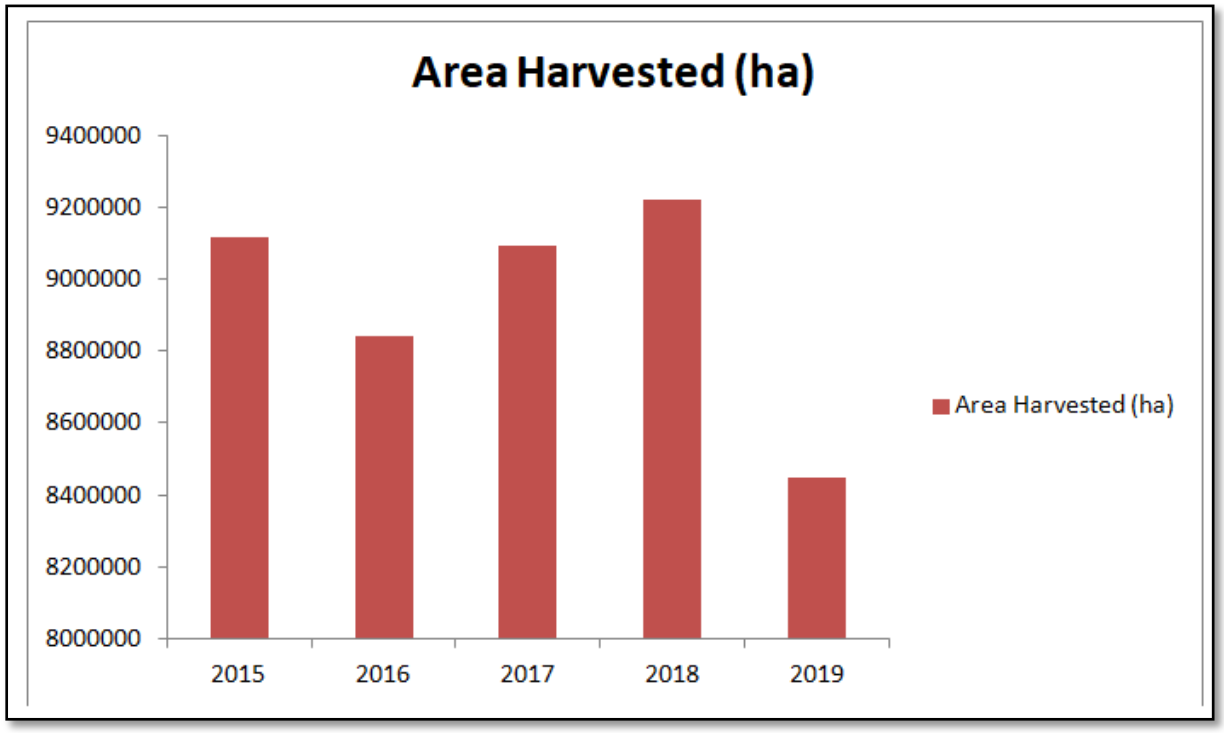
Millets were produced on a global scale of 26.7 million metric tonnes from an area of 33.6 million hectares (20). Millets were produced on a global scale of 23.3 million metric tonnes in 2002, down from 33.3 million hectares a decade earlier. According to the FAO, Africa produced the most millet (20.6 million metric tonnes) in 2009, followed by Asia (12.4 million metric tonnes) and India (10.5 million metric tonnes). In terms of production and area planted, sorghum ranks fifth in importance behind wheat, rice, maize, and barley, accounting for 5% of global cereal production [60,61] .



Source: FAOSTAT., 2014. Production: Crops. www.fao.org/faostat.

Graph 1: Global Production

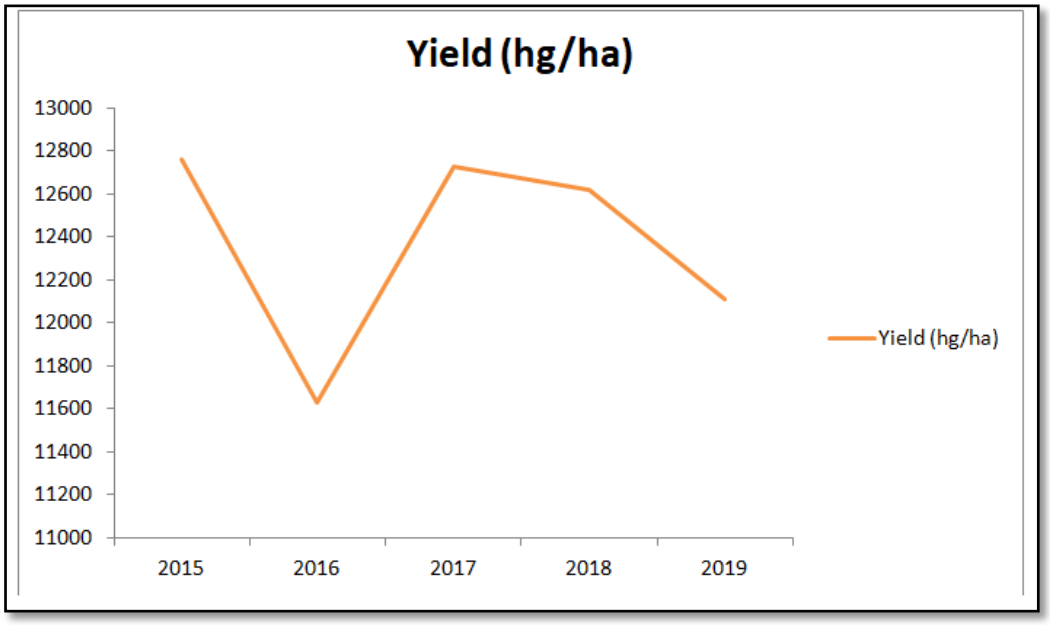
According to the Ministry of Agriculture and Farmers Welfare of India (2016–2017), the area under millet cultivation decreased by 60% (to 14.72 million hectares) due to irrigated land conversion for wheat and rice cultivation, shift in consumption patterns, low yield, dietary habits, unavailability of millets, and lower demand. This resulted in a drop in protein, iron, vitamin A, and iodine levels in children and women, resulting in malnutrition. The emphasis has been solely on the distribution of rice and wheat, although millets have long been overlooked.



Source: FAO: FAOSTAT. Food and Agriculture Organisation of the United Nations. FAOSTAT. http://www.fao.org/faostat/en/#data/QC

Graph 2: Area harvested of Millets in India

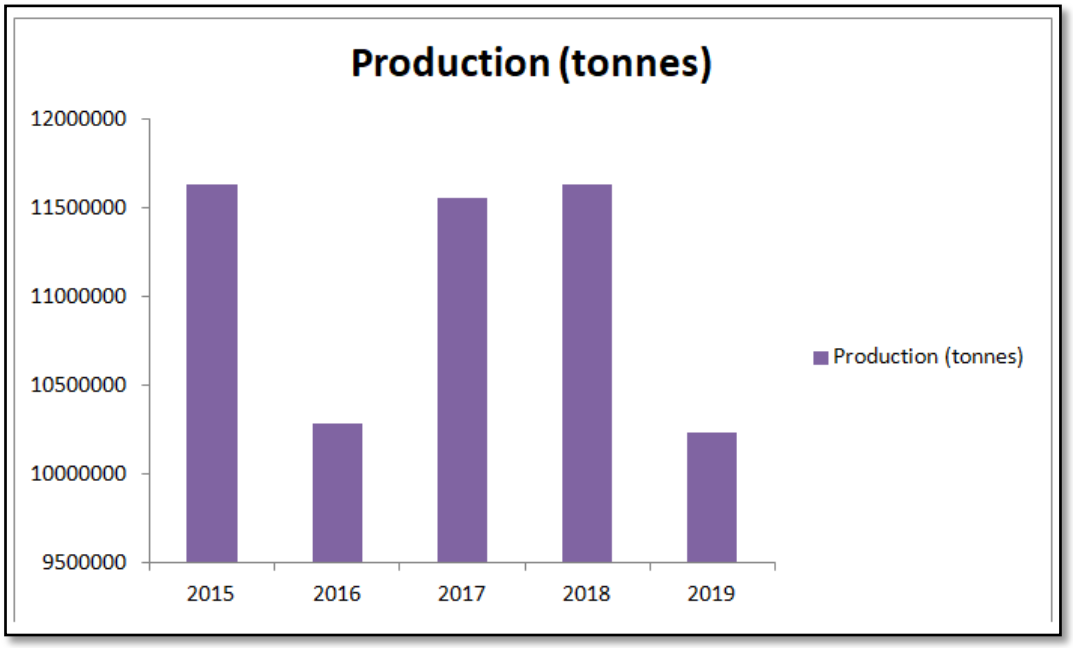
Between 2000 and 2009, India was the leading millet producer, followed by Nigeria. Sorghum, Pearl millet, Finger millet, Foxtail millet, Kodo millet, Proso millet, Barnyard millet, and Little millet are among the eight millets species commonly cultivated in India under rainfed conditions. In Rajasthan's desert regions, pearl millet and sorghum are the primary crop and allied crops, respectively, while in Rajasthan's eastern regions and Gujarat, the opposite is true. Sorghum is sown as a main crop in Telangana, Maharashtra, Andhra Pradesh, and parts of Central India, though it is considered a fodder crop in some Southern regions. [62,63,64]



Source: FAO: FAOSTAT. Food and Agriculture Organisation of the United Nations. FAOSTAT. http://www.fao.org/faostat/en/#data/QC

Graph 3: Yield of Millet in India

In the year 2019, the area planted with minor millet and small millet decreased dramatically (Graph no 2). In addition, between 2016 and 2019, the output of minor millet dropped (graph no 4). Minor millets, on the other hand, showed a small increase in yield (Graph no. 3), but this was minor in comparison to other crops. The tradeoff between rice and wheat with minor millet was a major reason for the reduction in area (graph no 2) and demand (graph no 4). [65]Finger millet, on the other hand, has a one-fold decrease in area but not as much of a decrease in output due to yield nearly doubling during this time span. Poor policy support for coarse cereals, on the one hand, and favourable policies for the cultivation of oilseeds like sunflower and soybeans, as well as cash crops like cotton, on the other hand, became more lucrative, thanks to higher yields and prices spurred by rising market demand (Status paper on coarse cereals, Directorate of Millets Development, Department of Agriculture and Cooperation). Millet consumption has decreased in 2019 due to the availability of subsidised rice and wheat through the Public Distribution System (PDS), the social status associated with fine cereals, the penetration of diversified value-added goods made from rice and wheat, and the ease of preparation and short cooking time for them (graph no 1)[66,67]



Source: FAO: FAOSTAT. Food and Agriculture Organisation of the United Nations. FAOSTAT. http://www.fao.org/faostat/en/#data/QC

Graph 4: Production of Millet in India

Finger millet (Ragi), foxtail millet (Kangni), kodo millet (Kodo), little millet (Kutki), barnyard millet (Sawan), and proso millet are all examples of small millets (Cheena). India is the world's leading producer of small millets, with around 20% of the country's land planted in these crops. The annual planting area for small millets is approximately 2.5 million hectares. Crops succumb to biotic and abiotic stresses as a result of inadequate management practises. Diseases like Blast, Cercospora leaf spot, Brown spot, Downy mildew/green ear, Smut, Rust, and many viral diseases can cause heavy yield losses under vulnerable conditions of biotic stresses, such as diseases like Blast, Cercospora leaf spot, Brown spot, Downy mildew/green ear, Smut, Rust, and many viral diseases [68,69,70]. Aside from these new diseases, the reappearance of previously prevalent diseases and the emergence of a minor disease that has become a major hindrance in the development of various millets have been identified and are posed as emerging problems for strengthening research needs.

These are the key reasons why millet production (Graph no. 4) and yields (Graph no. 3) have declined in 2016 and 2019 compared to previous years.

In Gujarat and Tamil Nadu, finger millet is a primary crop, though it is a minor crop in Telangana. As a result, the spatial distribution of millets as allied crops or primary crops is largely determined by the amount of rainfall received in the area and the growing habitat.[71,72,73] Though pearl millet competes with it in areas with annual rainfall of 350 mm, sorghum reigns supreme in areas with annual rainfall exceeding 400 mm. Small millets such as barnyard millet, little millet, finger millet, foxtail millet, and proso millet are also found in most of India's southern and central states, especially where annual rainfall is less than 350 mm, where no other cereal crop can grow under such moisture stress.[74,75,76]

Millets are grown in tribal areas with low fertility, as well as rain-fed and mountainous areas. Uttar Pradesh, Chhattisgarh, Haryana, Gujarat, Rajasthan, Madhya Pradesh, Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, and Telangana are among these states in India .[77,78]

Pearl millet is the most commonly grown millet, and it is a major crop in India and parts of Africa. Other essential crop species include Proso millet, Finger millet, and Foxtail millet. Millets were discovered to be less significant in the developing world. [79] Millets are a crop that can thrive in areas with low soil fertility and moisture, such as rain-fed or dry zones. Millets can grow in a variety of climatic and soil conditions and provide nutritious grain and fodder, but due to their short growing season, they can also fit into multiple cropping systems under irrigation as well as dry land farming[80,81]

V. NUTRITIONAL VALUES:

Table 2: Scientific nameof Miets and their Nutritional Profile

Name of the Millets	Scientific Name	Nutritional Profile							
		Carbohydrate (g)	Protein (g)	Fats (g)	Fiber (g)	Energy (KJ)	Calcium (mg)	Iron (mg)	Minerals (g)
Sorghum	Sorghum bicolor	67.68 ± 1.03	9.9-12	1.73±0.31	1.73 ± 0.40	398 ± 13	7.60 ± 3.71	3.95± 0.94	-
Pearl millet	Pennisetum glaucum	61.78 ± 0.85	10.6-14	5.43 ± 0.64	1.3-2.5	1456 ± 18	10-38	7.5-16.9	2-2.3
Finger millet	Eleusine coracana	66.82 ± 0.73	7.3-10	1.92 ± 0.14	3.6-4.2	342 ± 10	240-410	3.9-7.5	2.7-3
Foxtail millet	Setaria italica	60.09	12.3-15	4.30	4.5-8.0	331	10-31	2.8-19	2-3.3
Proso millet	Panicum milliaceum	70.04	10-13	1.10	2.2-9	341	14-23	0.8-5.2	1.9-4
Kodo millet	Paspalum scrobiculatum	66.19 ± 1.19	8.3-10	2.55 ± 0.13	5-9	1388 ± 10	10-31	0.5-3.6	2.6-5
Little millet	Panicum	65.55 ± 1.29	7.7-15	2.55± 0.13	4-7.6	1449 ± 19	17-30	9.3-20	1.5-5

	sumatrense								
Barnyard Millet	Echinochola crus-galli	65.55	6-13	2.20	10.1-14	307	11	15.2	4-4.4
Sorghum	Sorghum bicolor	67.68 ± 1.03	9.9-12	1.73±0.31	1.73 ± 0.40	398 ± 13	7.60 ± 3.71	3.95± 0.94	-

Millet is one of those crops that has long been regarded as a healthy addition to one's diet. Table 2 shows that millet diets are high in phytoconstituents, minerals, vitamins, and fibrous materials (non starch polysaccharides), all of which are essential for normal development, type 2 diabetes control, and overall nutritional well-being [682,83,84,85]. The bioactive phytochemicals present in millets, such as phenolics, betaglucan, sterols, inulin, lignans, flavonoids, pigments, dietary fibre, and phytate have been linked to a variety of significant health benefits [85,86,87]. Millets are classified into two botanical families and tribes: the Choridoideae subfamily and Eragrostideae tribe (finger millet and teff) and the Panicoideae subfamily and Paniceae tribe (all other millets) (table no 2)(8). Millets are classified as major and minor millets in the Poaceae (true grass) family and are found in India, China, Malaysia, Sri Lanka, and Australia. The Poaceae family is important for both farming and environme ntal nutrition (16). Pearl millet (Pennisetum glaucum, with synonyms P. americanum, P. typhoides, and P. typhoideum), Foxtail millet (Setaria italica), Proso millet (Panicum miliaceum), and Finger millet (Panicum miliaceum) are the most common forms (Eleusine coracana). Barnyard millet (Echinochloa spp.), Kodo millet (Paspalum scrobiculatum), Little millet (Panicum sumatrense), Guinea millet (Brachiaria deflexa/Urochloa deflexa), and Browntop millet (Urochloa ramose/Brachiaria ramose/Panicum ramosum) are several examples of minor millets [37,39,40,41]

VI. MAJOR HEALTH

Table 3: Major Health Benefit

Name of the millets	Major health benefits	References
Pearl millet	Prevent heart related disease, lower the level of triglycerides, natural antioxidants, and reduce the incidences of inflammatory bowel diseases.	Chandrasekara and Shahidi (2011), Islam, Manna, and Reddy (2015), Kim and Je, (2016), Liu, Wu, Li, and Zhng (2015
Finger millet	Reducing the risks of diabetes mellitus and gastro- intestinal tract disorders, ability to scavenge the free radicals	Muthamilarasan, Dhaka, Yadav, and Prasad (2016)
Foxtail millet	Anti- hyperglycemic Anti- lipidemic agents in diabetic conditions, inhibits pro- inflammatory and hypertrophic response	Sireech et al. (2011), Choi et al. (2008)
Little millet	Reduce cholesterol level in the case of cardiovascular disorder, reduce fasting blood glucose, and lipid parameters in diabetic subjects	Surekha (2004)
Barnyard millet	Act as inhibitor of the cancer developing cells, reducing blood glucose, and lipid levels	Sharma, Saxena, and Riar (2016), Ugare, Chimmad, Naik, Bharati, and Itagi (2011)
Proso millet	It improve the glycemic responses and plasma level, protect against D- galactosamine- induced liver injury	Park et al. (2008), Ito et al. (2008)

Table 3: shows the major health benefits of certain millet varieties. Those nutraceuticals are said to be beneficial for diabetes, cardiovascular disease, asthma, migraine, blood pressure, and the immune system [100,101,102,103]. Millets with a high fibre content are essential for preventing gallstone formation.

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