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Millet: An Overview on Functional and Agronomic Attributes

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Abstract
Millet is the name of the traditional cereal grains. Globally, cereal grain production has surged to unprecedented heights. These grains are a vital component of human diets and the main source of energy for people. Foxtail millet, proso millet, pearl millet, finger millet, and sorghum. They have long been a staple meal for millions of people in semi-arid parts of Africa and Asia. Millets are a good source of protein, fiber, vitamins, and minerals. Among the numerous health benefits they offer are improved digestion, decreased risk of chronic diseases, and increased immunity. In addition to their nutritional importance, millets exhibit remarkable resilience to harsh environmental conditions like heat, drought, and low soil fertility. They are an essential crop for smallholder farmers, especially in climate change-vulnerable areas, due to their capacity to flourish in such challenging circumstances. The production of millet can increase the resilience of agricultural systems to climate change while also ensuring food security for marginalized populations. Millets also promote agro-biodiversity and the sustainability of ecosystems. They require fewer inputs for production, such as fertilizer, herbicides, and water, than major cereal crops like wheat and rice. This maintains soil health and biodiversity while reducing the environmental effect of agriculture.

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INTRODUCTION

Global production of cereal grains has increased to previously unheard-of levels. Since they supply most of our energy, these grains play an important role in the human diet. A record 2715 million metric tons of cereal were produced in 2019 (FAO, 2021). Population growth, climate change, rising food prices, water scarcity, environmental damage, and other socioeconomic repercussions are some of the global concerns that the globe is now dealing with. These unfavourable factors could affect grain productivity and regional agricultural development, raising food costs and raising serious issues with global food security. Khanal and Mishra (2017); Al-Amin and Ahmed (2016). Furthermore, a lack of resources makes it difficult for local farmers to manage these vulnerable conditions.

Therefore, in order to locate a suitable cereal crop that might be used as a food source, nutrition and technology specialists need to rethink on-field limited production issues (Adekunle et al., 2018). Given this, millet might be a wholesome substitute to satisfy the dietary needs of an expanding populace (Kumar et al. 2018).

Around the world, millets are a common cereal grain, especially in arid and semi-arid regions of Asia (China and India) and Africa. Their agro-industrial significance and excellent nutritional value make them especially intriguing (Saleh et al., 2013; Zhu et al., 2018). There are seven varieties of millets, each with its own development zones, colors, and shapes. The earliest and maybe the first cereal grains that people have utilized for domestic purposes are these round, small-seeded cereals, which are members of the Poaceae family (FAO, 2020). Millet is the sixth-highest-yielding grain in the world. Major and minor millets are the two varieties. Proso (*Panicum miliaceum*), finger (*Eleusine coracan*), foxtail (*Seratia italica*), and pearl (*Pennisetum glaucum*) are important millets. Black fonio (*Digitaria iburua*), white fonio (*Digitaria exilis*), Kodo (*Paspalum scrobiculatum*), barnyard (*Echinochloa colane*), small (*Panicum miliare*), and teff (*Eragrostis teff*) are examples of minor millets (Mahajan et al., 2021).

Although 31,019,370 metric tons of millet were predicted to be produced worldwide in 2018, India remained the top producer, followed by Niger, Sudan, and a number of other nations. Because of the favorable agroclimatic conditions that encourage millet development compared to other grains, it is estimated that over 96% of millet crops are farmed in Africa and Asia. To fulfill the nutritional needs of the world's expanding population, millet output has been continuously rising in recent decades. Millets are an important source of food for humans. All of the important nutrients—protein, carbs, fat, minerals, vitamins, and bioactive compounds—are abundant in millets.

The nutrition, bioactive compounds, and functionality of cereal grains can be affected by food preparation procedures such as dehulling, soaking, malting, milling, and fermentation. Beer, porridge, fermented and unfermented flat breads, and non-alcoholic drinks are only a few of the many food and drink items made from millets. The production and quality of such products are greatly influenced by the properties, interactions, structures, and content of the main ingredient, starch. To ascertain the nutritional value and health benefits of millets, Saleh et al. (2013) conducted a comprehensive analysis. Millets include 1.5–5% fat, 6–19% protein, 12–20% fibre, 60–70% carbs, and 2-4% minerals. The many traits and functional qualities of millets are displayed in Tables 1 and 2. Eleven millets have morphological traits, as seen in Fig. 1.

Table 1: Different characteristic of millets

Millets	Scientific Name	Colour	Shape	Size	Origin	Pictures	References
Little	*Panicium sumatrense*	Grey to straw white	Elliptical to white	1.8-1.9 mm	Southern Asia		Yousaf *et al.*, 2021
Pearl	*Pennisetum glaucum*	White, Yellow and Purple	Ovoid	3-4 mm	Tropical west Asia		Rai *et al.*, 2008

Finger	*Eleusin coracana*	Light brown to dark brown	Spherical	1-2 mm	East Central Africa		Kumar *et al.*, 2016
Proso	*Panicum milliaceum*	White cream, Yellow and Orange	Spherical to oval	3 mm	Central and East Asia		Mahajan *et al.*, 2021
Foxtail	*Setaria italica*	Pale yellow to orange	Ovoid	2 mm	China		Sharma *et al.*, 2018
Kodo	*Paspalum scrobiculatum*	Blackish brown	Elliptical to oval	1.2-9.5 µm	India and Africa		Yousaf *et al.*, 2021
Barnyard	*Echinochloa crusgalli*	White	Tiny round	2-3 mm	Japan and India		Mahajan *et al.*, 2021

Table 2: Functional properties of different millets

Sr. No.	Millets Name	Functional Properties	References
1.	*Sorghum bicolour*	Microbiological, Antioxidant, Oil absorption capacity, Water absorption capacity and anti-diabetes	Mashau et al., 2024 Mashau et al., 2024 Khoddami *et al.*, 2023 Thilagavathi *et al.* 2015 Pontieri *et al.* 2013
2.	*Panicum miliaceum*	Water and oil absorbing capacity, bulk density, forming and emulsifying , Antioxidant properties, Dietary Fiber	Jenipher *et al.*, 2024 Mathanghi *et al.*, 2021 Pilat et al., 2016
3.	*Panicum sumatrense*	Weight loss, Boost immunity, Water and oil absorbing capacity, bulk density,	Ambati *et al.*, 2019 Jenipher *et al.*, 2024
4.	*Pennisetum glaucum*	Antioxident, Anti-diabetic, Water and oil absorbing capacity, bulk density	El Kourchi *et al.*, 2024
5.	*Setaria italica*	Antioxidant, Anti-cancerous	Kaur *et al.*, 2024 Karpagapandi *et al.*, 2023
6.	*Eleusine coracana*	Antimicrobial, antioxidant, anti-diabetic and antifungal	Patil *et al.*, 2023
7.	*Echinochloa frumentacea*	Anti-cancerous, Cardiovascular and anti-diabetic	Duttta *et al.*, 2023

8.	*Paspalum scrobiculatum*	Antioxident , antifiber	Shikha *et al.*, 2024, Mishra *et al.*, 2023
9.	*Fagopyrum esculentum*	Antioxident, anticancer, anti-inflammatory, and antidiabetic	Phull *et al.*, 2023
10.	*Urochloa ramose*	Anti-nutrients, Antioxidant	Sunagar *et al.*, 2024 Kaushik *et al.*, 2024
11.	*Amaranthus caudatus*	Antioxidant, anti-inflammatory, and antibacterial	Sattar et al., 2024: Malik *et al.*, 2023

Figure 1: 11 millets morphology characteristic*:* *Sorghum bicolour* (A), *Panicum miliaceum* (B), *Panicum sumatrense* (C), *Pennisetum glaucum* (D), *Setaria italica* (E), *Eleusine coracana* (F), *Echinochloa frumentacea* (G), *Paspalum scrobiculatum* (H), *Fagopyrum esculentum* (I), *Urochloa ramose* (J) and *Amaranthus caudatus* (K)

While preserving nutritional value, crop diversity by using more coarse grains, such millets, can increase food production, lower greenhouse gas (GHG) emissions, and foster climate resilience. In 2020, Banerjee et al. More than 55% of the world's millets are currently grown in arid regions of Africa, with Asia coming in second at 40% and Europe at 3% (Fig. 2). Little millet, barnyard millet, proso millet, Kodo, finger millet, and foxtail millet. Finger millet (Ragi), sorghum (Jowar), and pearl millet (Bajra) comprise the majority of India's millets (Fig. 3) (APEDA 2022).the majority of India's millets (Fig. 3) (APEDA 2022).

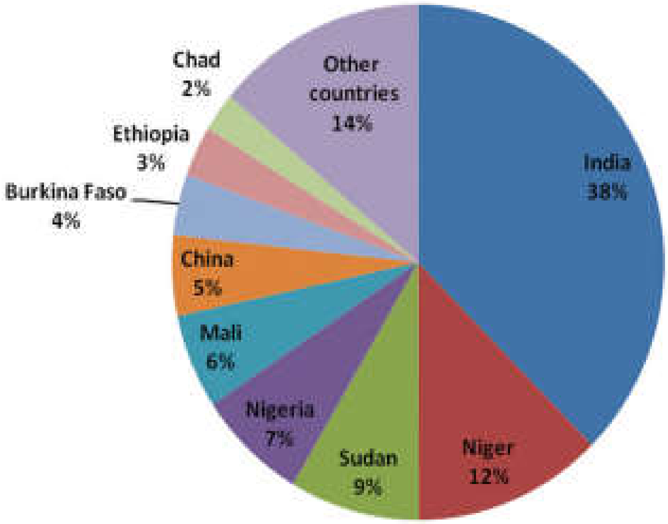

Figure 2: Millets production (%) in different countries of the world (FAQ 2018)

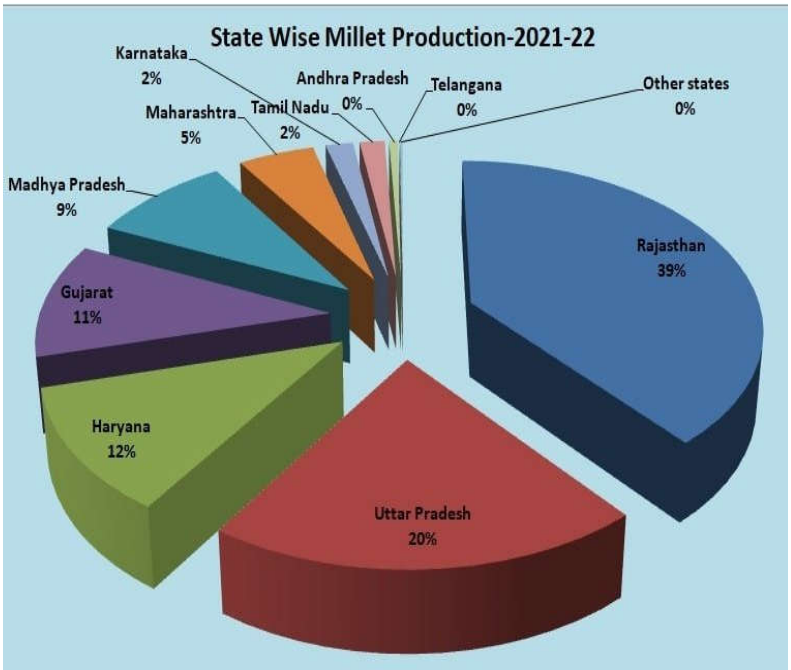

Figure 3: Millets production (%) in different states of India during 2021-22

The CAGR for the entire area is -3.00%, production is -0.94%, and yield is 2.12% (NITI, 2022). The table 3 represent the production of millet worldwide, 1961–2021. By 2023-24, six states—Rajasthan, Uttar Pradesh, Maharashtra, Karnataka, M P, and Haryana—will produce more than 79% of India's millet, according to the pie figure. Maharashtra accounts for 11%, Karnataka for 11%, Rajasthan for 32%, Uttar Pradesh for 18%, Madhya Pradesh for 7%, Haryana for 8%, Tamil Nadu for 4%, Andhra Pradesh for 3%, Gujarat for 3%, Uttarakhand for 1%, and others for 2% (APEDA 2024). Millet output (%) in various Indian states is displayed in Figure 4.

Table 3: Global millets production

Year	Harvested Area(ha)	Production
1961	43401259	25716840
1971	43520988	29747215
1981	37380058	26956983
1991	36892998	25040629.3
2001	35006858	28904169.6
2011	33968686	27049333.85
2021	30934728	30089625.23

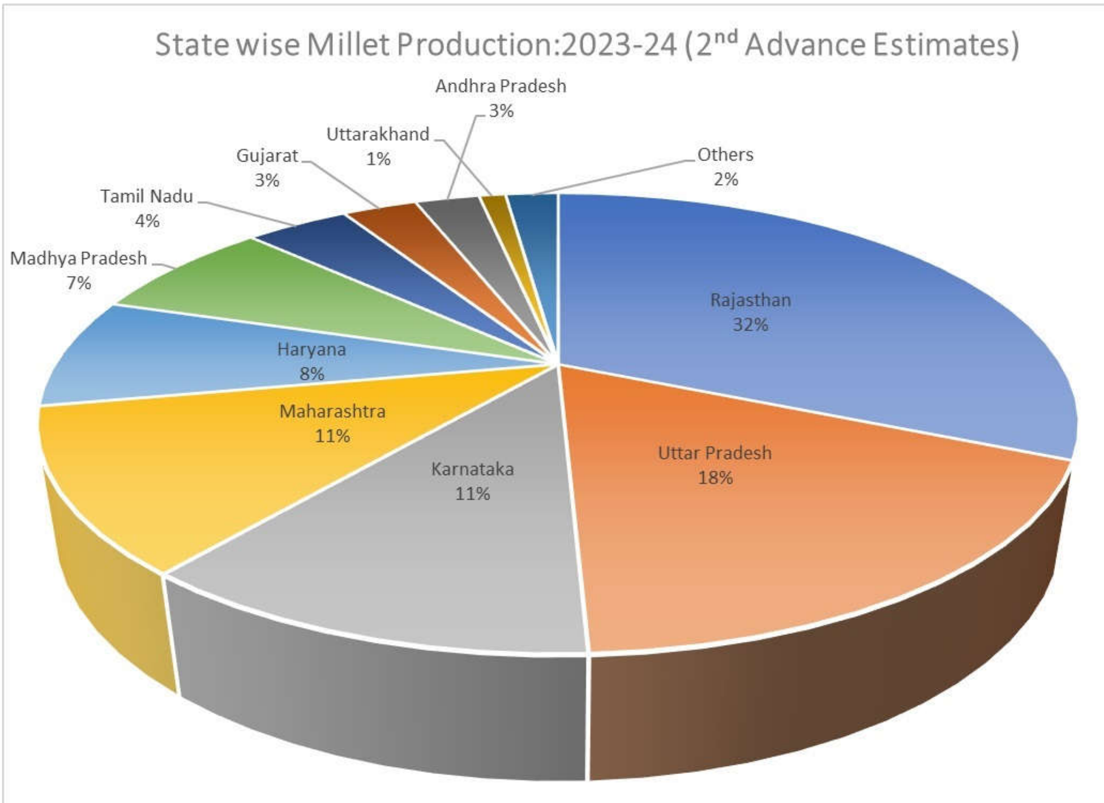

Figure 4: Millets production (%) in different states of India (APEDA 2024).

CONCLUSION

Strong, traditional cereal grains, millets are vital to sustainable agriculture and food security, especially in drought-prone areas. These varieties, which include finger, pearl, sorghum, and foxtail millet, all offer vital nutritional advantages. Because millets are rich in fibre, minerals, and essential nutrients, they can promote health and prevent lifestyle-related diseases like diabetes and obesity. Additionally, because millets are highly adaptive and use less water and inputs than other cereals, they promote biodiversity in agricultural systems and are more resilient to climate change. Their production and consumption present a practical means of improving environmental sustainability and human health.

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