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Millet: An Overview on Functional and Agronomic Attributes

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ABSTRACT
The traditional cereal grains known as millets. Production of cereal grains has increased to previously unheard-of levels worldwide. Since they are the main source of energy for humans, these grains are an essential part of their diet. Foxtail millet, Proso millet, Finger millet, Pearl millet, Barnyard millet, and Sorghum. For millions of people in semi-arid parts of Asia and Africa, they have long been a staple diet. Foods high in protein, dietary fiber, vitamins, and minerals are found in millets. Enhanced immunity, decreased risk of chronic diseases, and better digestion are just a few of the many health advantages they provide. In addition to their nutritional worth, millets are remarkably resistant to extreme weather, such as heat, drought, and low soil fertility. Because of their capacity to flourish in such harsh conditions, they are an essential crop for smallholder farmers, especially in areas that are susceptible to climate change. In addition to providing food security for disadvantaged groups, millet production can strengthen agricultural systems' resistance to climate change. Additionally, millets support ecosystem sustainability and agro-biodiversity. Compared to main cereal crops like wheat and rice, they require fewer inputs for cultivation, including fertilizer, herbicides, and water. This lessens agriculture's environmental impact while preserving biodiversity and soil health. Cropping systems that incorporate millets.

KEYWORDS: *Traditional Cereal, Millets, Dietary Fiber, Protein, Agro-Biodiversity.*

INTRODUCTION

Cereal grain production has reached unprecedented levels around the world. These grains play an important part in the human diet as their primary source of energy. Overall, cereal production in 2019 was a record 2715 million metric tons (FAO, 2021). However, the globe is currently dealing with a number of global concerns, including population growth, climatic changes, rising food prices, water scarcity, environmental damage, and other socioeconomic consequences. These negative aspects could have an impact on regional agricultural development and cereal output, resulting in high food prices and serious food security concerns around the world (Al-Amin & Ahmed, 2016; Khanal & Mishra, 2017). Furthermore,

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local farmers face difficulties in dealing with these susceptible conditions due to inadequate resources. As a result, nutrition and technology specialists must redesign on-field limited production challenges in order to find a suitable cereal crop that may be considered a potential food source (Adekunle *et al.,* 2018). In this regard, millet may be a nutritious alternative to suit the nutritional needs of a growing population (Kumar *et al*. 2018).

Millets are an important cereal grain consumed worldwide, particularly in arid and semi-arid regions of Africa and Asia (India and China). They are of particular interest due to their high nutritional value and agro-industrial significance (Saleh *et al.,* 2013; Zhu *et al.,* 2018). Millets are classified into seven varieties with varying colors, forms, sizes, and cultivation zones. These grains are the oldest and most likely the first cereal grains known to humans for domestic use; they are small-seeded, round cereals from the Poaceae family (FAO, 2020). Millet is the world's sixth-highest-yielding grain. Millets are divided into two categories: major and minor. Major millets include pearl (*Pennisetum glaucum*), proso *(Panicum miliaceum*), finger *(Eleusine coracan*), and foxtail (*Seratiaitalica)*. Minor millets include barnyard (*Echinochloa colane*), small (*Panicum miliare*), Kodo (*Paspalum scrobiculatum*), black fonio (*Digitariaiburua*), white fonio (*Digitariaexilis*), and teff (*Eragrostis teff*) (Mahajan *et al.,* 2021). The global millet production in 2018 was expected to be 31,019,370 metric tons; nonetheless, India was the greatest producer, followed by Niger, Sudan, and other countries. It has been estimated that more than 96% of millet crops are grown in Africa and Asia due to the favorable agro-climatic conditions that promote millet growth, unlike other cereals. Millets are a significant source of human food, and production has been continuously expanding in recent decades to fulfil the dietary needs of the growing global population. Millets are high in all important elements, including protein, carbs, fat, minerals, vitamins, and bioactive substances. Food preparation processes, including dehulling, soaking, malting, milling, and fermentation, can impact the nutrition, bioactive chemicals, and function of cereal grains. Millets are used to make a variety of culinary and beverage products, including fermented and unfermented flatbreads, beer, porridge, and non-alcoholic drinks. Such goods' production and quality are heavily influenced by the composition, structures, qualities, and interactions of their main component, starch. Saleh *et al.,* (2013) conducted a comprehensive analysis of millets to assess their nutritional value and health benefits. Millets provide 60–70% carbs, 1.5–5% fat, 6–19% protein, 12–20% dietary fiber, and 2–4% minerals. Table 1 and 2 showed the different characteristics of millets and functional properties. Fig. 1 shows that 11 millets have morphological characteristics.

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*	Antioxidant , 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)

Crop diversification by the use of more coarse cereals, such as millets, can boost food production, reduce greenhouse gas (GHG) emissions, and enhance climate resilience without sacrificing nutritional value (Banerjee, et al., 2020). Nowadays, dry regions of Africa cultivate about 55% of the world's millets, followed by Asia at 40% and Europe at 3% (Fig. 2). Finger Millet, Foxtail, Kodo, Barnyard, Proso, and Little Millet. The majority of India's millets are produced as finger millet (Ragi), sorghum (Jowar), and pearl millet (Bajra) (Fig. 3) (APEDA 2022).

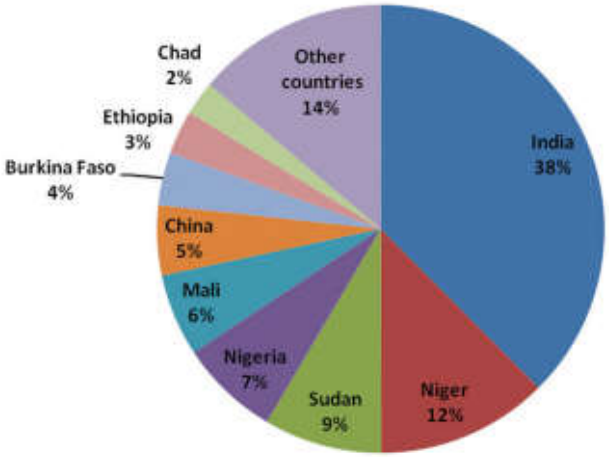

Figure 2: Millets production (%) in different countries of the world (FAQ 2018)

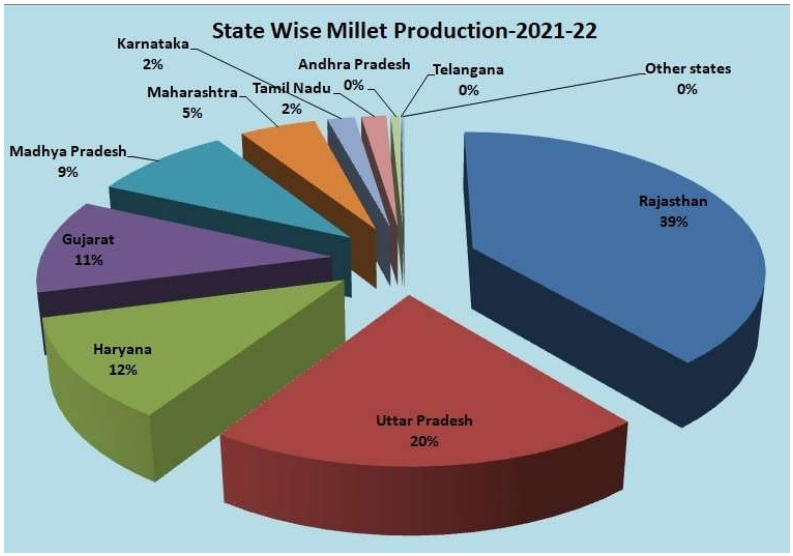

Figure 3: Millets production (%) in different states of India during 2021-22

The CAGR for the total area is -3.00%, production is -0.94%, and yield is 2.12% (NITI, 2022). Table 3: Global millets production 1961-2021. Six states, Rajasthan, Uttar Pradesh, Maharashtra, Karnataka, Madhya Pradesh, and Haryana, account for more than 79% of millet production in India according to the pie chart in 2023-24. Madhya Pradesh - 7%, Haryana - 8%, Tamil Nadu - 4%, Andhra Pradesh - 3%, Maharashtra - 11%, Karnataka - 11%, Rajasthan - 32%, Uttar Pradesh - 18%, 3% go to Gujarat, 1% to Uttarakhand, and 2% others (APEDA 2024**).** Figure 4 showed millets production (%) in different states of India.

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

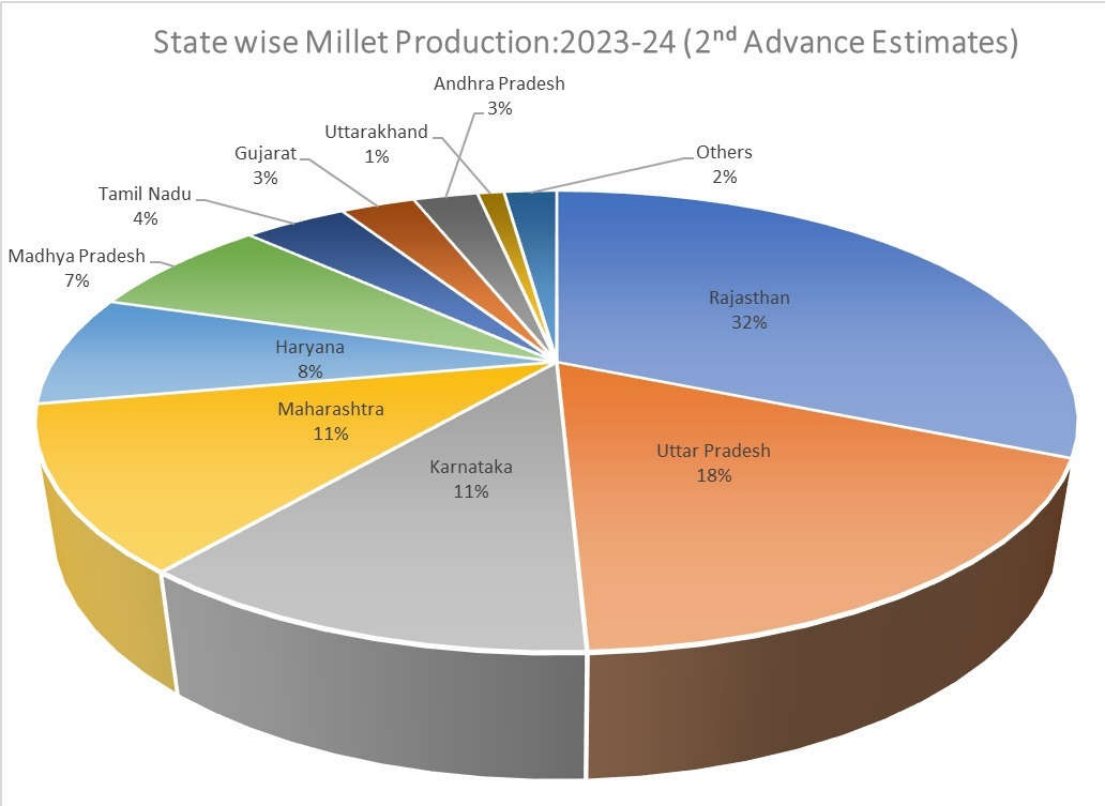

Figure 4: Millets production (%) in different states of India (APEDA 2024).

CONCLUSION

Millets are robust, traditional cereal grains that are essential to food security and sustainable agriculture, particularly in areas with poor soil and drought conditions. Each of these types, which include foxtail millet, sorghum, finger millet, and pearl millet, has special nutritional advantages. Millets are beneficial for fostering health and averting lifestyle-related illnesses like diabetes and obesity since they are high in fiber, minerals, and vital nutrients. Additionally, millets are more resilient to climate change and encourage biodiversity in agricultural systems since they are extremely adaptive and need less water and inputs than other cereals. Their production and consumption offer a viable way to enhance human health and environmental sustainability.

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