Current Status and Promotional Strategies of Millets: A Review

Abstract

Millets or nutri-cereals are high-energy foods, its domestication and cultivation date back at least 10,000 years. Millets are typically grown on degraded, marginal terrain that receives little rainfall and has low soil nitrogen concentration. Finger millet, Pearl millet, Foxtail millet, Barnyard millet, Proso millet, Kodo millet, and Tiny millet are the seven major millets grown around the world. In the case of India, millet output peaked in the 1980s and then steadily fell as a result of a substantial fall in the area that was being grown. The abundance of dietary fibres, antioxidants, minerals, phytochemicals, polyphenols, and proteins in millets makes them special in the fight against diseases. Millet is currently addressing an essential field of research for food scientists because to their considerable engagement in nutritional security and potential growing health consequences. Millets' nutritional value can be further enhanced by using appropriate and efficient processing techniques. Given the numerous health advantages and environmental benefits of millets, it is urgently necessary to create millet-based government policies that acknowledge their contributions to achieving nutritional security and bring them back into agricultural production in order to create cropping systems that are climate resilient.

Keywords: Millets, Nutri-cereals, Nutritional Security, Climate Resilient.

Introduction

“Millets are one of the world's oldest domesticated and farmed crops, having been grown for food and animal fodder for between 8,700 and 3,300 years” (Lu *et al*., 2009). The word "millet" comes from the French word "Mile," which means "thousand," suggesting that a small amount of millets contains many thousands of grains. “Millets are frequently produced in marginal or degraded areas with very low nutrient levels and semi-arid conditions with very little rainfall.The crops provide food for people in areas where hunger is a common occurrence, and millets provide a more consistent harvest than other crops in low rainfall areas” (Tadele 2016). Millets are C4 plants that have very high levels of photosynthetic efficiency, a short lifespan, a higher capacity to produce dry matter, and a high level of heat and drought tolerance. They may also rapidly adapt to damaged soils that are acidic, salty, and contain harmful aluminium (Yadav and Rai 2013). Millets have unique qualities that make them appropriate crops for overcoming climate change obstacles and developing millet-based climate resilient technology.

Millets are distinctive agricultural goods from India that are in high demand on the international market. By 2025, it is predicted that millets will be in high demand worldwide, reaching $12 billion as people turn to healthier grains. With an annual output of roughly 12 million tonnes, India is one of the major millets growers and might profit from this development.With the challenges of drought and its detrimental effects on agricultural crop production, millets are suited for "climate wise agriculture" because they require less water or other inputs. In addition to absorbing the most carbon dioxide possible from the air, they also emit oxygen, which helps to reduce climate change (Kumari *et. al*., 2023).

“Micronutrient deficiency, often known as hidden hunger, is a major issue in our nation, particularly in areas like Bihar and Orrisa. Small-seeded millets are robust grasses that do well as rain-fed crops in dry climates. Even in poor soil and under changing climatic circumstances, little millets can be grown. One of the first food grains that have been domesticated by humans, millets have been a staple in Northern Africa for thousands of years. They were also a staple in China and India before other cereals like rice and wheat gained prominence. Millets are a small member of the small seeded grass family, spherical in shape, and minor cereals (Poaceae).It is distinguished by their extraordinary capacity to thrive in less fertile soil, tolerance to drought, immunity against pests and diseases, and a brief growing season” (Devi *et al*., 2004).

“Millets are referred to as nutri-cereals and were staples that provided millions of people with food security up until the Green Revolution. Millets declined as a result of the negative consequences of the green revolution since the policies were pro-wheat and rice at a time when food security was the key concern. We see increased stress-related illnesses and lifestyle ailments in contemporary India. Millets' resurgence has therefore gained attention. This revival was started by ICAR-IIMR led consortium efforts to establish a value chain on millets in order to stimulate demand for nearly ten years, by developing value added technologies and turning them into commercial products” (Dayakar Rao *et al*., 2011).Technology licencing for startups has developed into an ecosystem with a startup pipeline. These startups required support systems to help them progress. As a result, IIMR began experimenting with incubation, first with the ICAR-funded Agri-Business Incubation (ABI) and then with the Department of Science and Technology (DST) of the Government of India.

There are various ways to enhance nutritional value of millets. Sprouting: Millets' nutrient content, including that of vitamins, minerals, and antioxidants, can be increased by sprouting them. Sprouting reduces anti-nutrients and increases the bioavailability of the nutrients (Gupta, Gangoliya, & Singh, 2015). Fermentation: Millets can be fermented to increase their availability of some nutrients and improve their digestion. Additionally, it creates healthy substances like probiotics and bioactive peptides. Fortification: Adding vital vitamins and minerals to millet-based goods can aid in addressing micronutrient deficits. Fortified millet products frequently contain iron, zinc, and vitamin B complex (Hotz, C., & Gibson, R.S., 2007). Complementary protein sources: A comprehensive protein profile can be created by combining millets with other protein-rich foods like legumes, nuts, or seeds, which will improve the amino acid composition overall. Cooking and soaking: Cooking millets increases the bioavailability of nutrients like proteins and minerals while soaking millets can lower anti-nutrients.

Biofortification: Millet's nutritional value can be increased by choosing cultivars with naturally greater nutrient contents through breeding methods. For instance, biofortification has been used to create millet cultivars with high iron and zinc content.

Production of Millets in World

"The FAO estimates that 89.17 million metric tonnes of millets were produced globally from an area of 74.00 million hectares in 2020. Almost 90% of the world's millets are produced from sorghum and pearl millet, which are followed by finger millet, foxtail millet, proso millet, barnyard millet, little millet, and kodo millet. Millets (pearl millet and lesser millets) are grown in more than 93 nations worldwide. Sorghum, which is one of the millets, is grown on 42.1 million ha of land in 105 nations, while production data for pearl millet and other minor millets are available from 93 countries" (Obilana 2003). "Millets are produced and consumed in developing nations, primarily in Africa and Asia, at a rate of about 97%. With 26.6% of the world's millet farming area and 83% of Asia's, India is the greatest millet producer in the world. In the Indian states of Odisha, Madhya Pradesh, Jharkhand, Rajasthan, Karnataka, and Uttarakhand, millets have long been a staple of tribal cuisine" (Sood *et al.,* 2019).

The average harvested area of millet from the various continents, using the year 1961 as a baseline, showed that Asia was the top producer of millet (27.1 M ha), followed by Africa (11.8 M ha), Europe (4 M ha), America (2.6 M ha), and Oceania (0.02 M ha). Nevertheless, according to data from 2021, Africa had the largest area (18.6 million hectares), followed by Asia (11.66 million hectares), Europe (0.37 million hectares), America (0.27 million hectares), and Oceania (0.27 million hectares) (0.04 M ha). The largest millet farming area on the African continent was found in West Africa (12.7 M ha), followed by North Africa (2.81 M ha) (FAOSTAT 2021)

Table 1 :Production of Millets in World.

Region	Area (ha)	Yield (kg/ha)	Production (tonnes)
Africa	18595786.00	651.00	12105491.58
Asia	11660767.00	1456.70	16997317.16
Europe	368145.00	1607.20	591691.55
Americas	274159.00	1307.70	358503.81
Oceania	35870.00	1020.90	36621.13

Source: FAOSTAT 2021

Production of Millets in India

The world's largest producer of millets is India. Over 21 States in India grow millets. Rajasthan, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala, Telangana, Uttarakhand, Jharkhand, Madhya Pradesh, Haryana, and Gujarat are all seeing significant momentum. The fact that India produces the highest amounts of Barnyard (99.9%), Finger (53.3%), Kodo (100%), Small millet (100%) and Pearl millet (44.5%) from an area of 8.87 million hectares is noteworthy.

Millets are grown in India on an area of 13.63 million hectares, yielding 18.02 million tonnes at 1256 kg/ha (Directorate of Economics and Statistics, 2021). The top three states in India for millets cultivation are Maharashtra, Karnataka, and Rajasthan. With regard to tiny millets, Madhya Pradesh leads the way with 32.4% of the total area, followed by Chhattisgarh (19.5%), Uttarakhand (8%), Maharashtra (7.8%), Gujarat (5.3%), and Tamil Nadu (3.9%). With a production of 1174 kg per hectare, Uttrakhand leads Gujarat (1056 kg per hectare), Tamil Nadu (1067 kg per hectare) by (Anbukkani *et al*., 2017).

Between 1955-1956to2013-2014, the area planted with minor and finger millet substantially reduced. Little millet saw an almost eight-fold fall in area from 53.35 lakh ha in 1955–1956 to 6.82 lakh ha in 2013–2014. Moreover, throughout these times, minor millet production saw a fourfold decline. Even so, there was only a very slight increase in the production of minor millets compared to other crops.

Table 2 :Millets production in India

Crop	Area ('000 ha)	Production ('000 tonnes)	Yield (Kg/ha)
Sorghum	4377.87	4812.07	1099
Pearl Millet	7652.10	10863.17	1420
Finger millet	1159.40	1998.36	1724
Minor Millets	444.05	346.95	781

Source: Directorate of Economics and Statistics, 2020-21

Nutritional Status of Millet

Food and nutrition security exists when all people at all times have physical, social, and economic access to food, which is consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services, and care, allowing healthy and active life," according to the World Health Organization (UNSCN 2013). "Food security must include nutrition security since good nutrition necessitates more than just providing enough calories for every man, woman, and child" (Hwalla *et al*., 2016). In order to provide nutrition security, "food," "health," and "care" are all necessary. Hence, without household food security, it is impossible to attain nutrition security (FAO 2009).

Millets have been grown and used for a very long time. Millets were a staple in the ancient people's diets, ensuring their sustenance. Millets are an African native that were later spread to other regions of the world (Bhat *et al*., 2018). Major millets, which include sorghum and pearl millet, and minor millets, which include finger millet, kodo millet, barnyard millet, proso millet, small millet, and foxtail millet, are how they are separated (Behera 2017).They are commonly used as fuel, food, feed, and fodder. In various regions of India only five to six decades ago, different kinds of millets were being grown and formed a significant portion of the diet. They were utilised in a variety of regional dishes as whole grains, flour, or partially broken grains.

Millets are a great source of fibre and slow-digesting starch, both of which are beneficial for the gut where billions of bacteria live, including Lactobacillus acidophilus, rhamnosus GG, Actinobacteria, and Bifido species. Millets include non-starch polysaccharides, which make up a significant portion of dietary fibre and function admirably as prebiotics by fermenting resistant starch to produce short-chain fatty acids.

People are being pushed to seek out healthy and nourishing diets due to the current sedentary lifestyle's association with a number of health conditions. Tiny millets satisfy these needs of contemporary civilization because they are a nutritious dietary option and a repository of nutrients. “When it comes to nutrition, millets are most well-known for being an excellent provider of the minerals phosphorus, magnesium, and manganese. The growth of bodily tissue and the metabolism of energy depend on phosphorus, which has been linked in research to a lower risk of heart attack. Comparing little millets to fine cereals, they are more nutrient-dense. The best provider of calcium (300–350 mg/100 g) is finger millet, while other small millets are also strong sources of phosphorus and iron.Protein composition varies between 7 and 12%, whereas fat content varies between 1 to 5.0%. A huge portion of the population living in millet-growing areas, which are thought to be the most disadvantaged people, benefits greatly from the millets' increased fibre content, protein quality, and mineral composition” (Singh *et al*., 2019).

Table 3 :Nutritional Benefits of Millets (for 100g of each millet)

Crops	**Protein (g)**	**Fiber (g)**	**Minerals (g)**	**Iron (mg)**	**Calcium (mg)**
Sorghum	10	4	1.6	2.6	54
Pearl millet	10.6	1.3	2.3	16.9	38
Finger millet	7.3	3.6	2.7	3.9	344
Foxtail millet	12.3	8	3.3	2.8	31
Proso millet	12.5	2.2	1.9	0.8	14
Kodo millet	8.3	9	2.6	0.5	27
Little millet	7.7	7.6	1.5	9.3	17
Barnyard millet	11.2	10.1	4.4	15.2	11
Teff	13	8	0.85	7.6	180
Fonio	11	11.3	5.31	84.8	18
Brown top millet	11.5	12.5	4.2	0.65	0.01

Source: Indian Institute of millets Research

Promotional Strategies for Millets

The government's food policy greatly favoured wheat, rice, and maize while ignoring other small grains with deep cultural roots in an effort to boost food grain output. While the output of other small crops and millets decreased, the green revolution benefited the development of big grains (Nelson *et al*., 2019).

It is undeniable that climate change is occurring today, and its effects are being felt all across the world through changes in precipitation patterns, more rapid glacier melting, and rising air temperatures (Knappenberger *et al*., 2001; IPCC 2007). According to current projections, global mean annual temperatures will rise by 1°C by 2025 and 3°C by the end of the twenty-first century, rainfall frequency and volume would decline by more than 30%, and atmospheric CO2 levels will double between 2025 to 2070. The recent global phenomenon of climate change has resulted in a decrease in the yield of major staple cereals. Bearing in mind the aforementioned millets benefits, efforts have accelerated to use millets as a crop that is climate resilient. Recently, a number of private and public organizations have double with millets' value addition to produce food and non-food goods. Nonetheless, governments play a significant role in developing strategies to encourage the production and consumption of millets. Before recommending a climate smart cropping system, it is important to concentrate on the socioeconomic status, resource availability, average output of the focal crop, and current risk management strategies of a given locality.

In order to analyze the crop state in the field, farmers might be encouraged by the availability of high-yielding cultivars, a variety of equipment including handheld crop sensors, rain gauges, decision support tools, leaf colour charts, zero-till gear, and enhanced production possibilities. To guarantee millet growers' returns, the government must set a minimum support price for the grain.

Under the scenarios of a changing climate, the employment of high-efficiency water management techniques, such as rainwater harvesting and water conservation through drip irrigation, is crucial in dry and semi-arid regions that receive less rainfall. Participatory variety selections are used to determine and choose climate-resistant millet varieties while taking into account gastronomic merits, regional preferences, agronomic qualities, and scientific findings. Via newspapers, radio interviews, television programmes, and text messaging, the farming community must be connected to crop and weather information as well as agro-advisory.

With print and electronic media, customers can be effectively informed about the nutritional and health benefits, which will boost demand for millets and the value-added products made from them.

The main drivers behind the development of the nutraceutical market, which is anticipated to grow significantly in the years to come, are the rising demand for nutrient-dense foods, the effectiveness and efficiency of the consumed product, and the increased consumer and healthcare industry knowledge. In order to encourage scientific study, the Food and Drug Administration has also released legislation promoting this new industry. Hence, to have a significant impact on human nutrition globally, it is vital to identify elements that are beneficial to health and raise the levels of essential nutrients in staple crops. The development of "smart" biofortified crops will be facilitated by the targeting of nutritionally important genes and proteins using cutting-edge biotechnology tools and procedures. Items from these crops with additional value can help with a variety of problems, including lowering protein-energy deficiency. The impact of these goods on the body's uptake, defence, homeostasis, and nervous system control can be studied before exploring hypoallergenic foods and contemporary methods for developing nutraceuticals. According to preliminary study, finger millet has a bright future in the nutraceutical sector and offers a theoretical basis for its use as an economically viable store of nutrients for the decline of chronic diseases. Yet, little research has been done on the characteristics of millets or their potential for use in agriculture or nutrition.

Constraints

For the millet production system to operate better, climatic parameters like rainfall pattern and distribution, edaphic factors like soil type, soil fertility, and agronomic management, as well as the socioeconomic status of agricultural communities, are all crucial (Sood *et al*., 2019). The main environmental and soil conditions that limit the growth of millet include moisture stress, nutritional stress, salinity, alkalinity, acidity, and heat stress. Because that millet is typically farmed by resource-constrained farmers in drylands, moisture stress is thought to be the main barrier to millet production.Any physiological stage of millets' growth is susceptible to drought. Millets have a low productivity because they are produced on marginal terrain, which has poor soil fertility, little organic matter, salinity, and alkalinity. At the seedling emergence stage, the crop is adversely impacted by the soil's salinity and poor drainage (Macharia *et al.*, 1994).

The most significant biotic restrictions related to millets include the prevalence of illnesses, insect-pests, parasitic nematodes, birds, parasitic plants, and weeds. Downy mildew (sorghum and pearl millet), blast (finger millet), grain mould (sorghum), smut (foxtail millet, barnyard millet, teff, and sorghum), rust (sorghum, teff, and foxtail millet), ergot (pearl millet and sorghum), and charcoal rot (sorghum) are the major diseases of millets (Strange and Scott 2005; Das 2013). Since weed infestation alone is responsible for a 29% output reduction in millet, weed infestation is also seen as a significant barrier to the production of millet globally (Burkill 1985). The manual weed control combined with hand bird scaring in the absence of a strong preemergence weedicide raises the expense of producing high-quality seed in minor millets. For millet growers, bird damage is likewise regarded as a significant biotic hazard; in isolated crop fields, yield reduction might exceed 100%. (Sood *et al*., 2015).

Conclusion

We are aware of the advantages that key millets have over main staple grains in terms of their nutritional content, climatically adaptable characteristics, and health-promoting qualities. To depict millets as the future's golden crops, the public sector needs to make well-thought-out, long-term investments in multidisciplinary research projects. An Initiative for Nutritional Security through Intensive Millet Promotion, for instance, is being implemented by the government of India (INSIMP). The Indian government has started a national nutraceutical mission after realizing their enormous potential as nutraceuticals and their resilience to climate change. Because of the changing climatic conditions, the lack of improved high-yielding varieties and hybrids that are suitable for mechanized farming, the absence of favourable government policies to support millet cultivation and marketing, the exclusion of millet from the public distribution system, and the failure to set minimum support levels, the area under cultivation is not increasing. Integration between academics, farmers, policymakers, and rural agro-service providers is urgently required in order to develop climate resilient cropping systems and improve global resources and conditions that support millets' cultivation and consumption.

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