

Review

# Pearl millet (*Pennisetum glaucum* (L.) R. Br.) Production constraints, Nutritional value and health benefits

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Pearl millet is a group of grains that are well-known for their culinary applications as well as their health-promoting properties. It is one of human's oldest foods, and is possibly the first cereal grain used for domestic uses. In the world's poorest countries and among the poorest people, millet grain is the most fundamental food source. So, the objective of this article is to revise the production constraints and health benefits of pearl millet. Millets are less expensive than other grains and are a mainstay for the lower sections of society. Fortification of millets is a cost-effective way to address a deficiency and a viable technique for increasing the consumption of fortified millet products. Although millets are important and high in micronutrients, there are several factors affecting pearl millet production; drought stress and low soil fertility, disease and insect pests and parasitic weeds striga are among the issues. The majority of nutrients are unavailable due to the presence of anti-nutrients, which restrict the nutritional value of millets, resulting in a deficiency in the diet of the majority of Indians. As a result, nutritional availability and product development can be improved by fortifying millets. There is a need to diversify the usage of these millets in the current era of food scarcity by producing various millet recipes. Millet is a tasty cooked cereal that may be served as a side dish or popped like corn as a snack or morning cereal. The whole millet can be stored safely for up to two years if properly stored. Millet is a nutrient-dense, healthful, and versatile grain that should be included in everyone's diet.

**Keywords:** Pearl millet, Nutrition, Constraints, Production, Health benefit

## INTRODUCTION

After rice, wheat, maize, barley, and sorghum, pearl millet *Pennisetum glaucum* (L.) R. Br. is the world's sixth most important crop (Burton, 1983, Prem 2012, Venkata *et al.*, 2018). It is a widely produced rain-fed cereal crop in arid and semi-arid parts of Africa and Southern Asia, and it may be grown in places with low rainfall (200 to 600 mm/year) which is difficult for maize and sorghum husbandry (Ismail *et al.*, 2012). Pearl millet is an orphan crop of the grass family Poaceae that is also thought to be one of the lost crops. Among the major cereal crops, it can produce a reliable yield in areas excessively arid and hot constantly. It is the second most stable diet in East and Central Africa (Lagat *et al.*, 2018).

It has a high photosynthetic efficiency C4 and a high biomass production potential (Faridullah *et al.*, 2010). In many parts of the world, pearl millet is generally recognized as a versatile crop (IFAD, 1999). It is an annual grass with a height range of 30 cm to more than 4 m and is highly cross-pollinated with diploid ( $2n = 2x = 14$ ). (Abalo, 1989).

The pearl millet was domesticated from a wild grass on the southern edge of the Sahara's central highlands around 4000-5000 years ago B.C. It was eventually rapidly diffused over Africa and Asia's semiarid tropics (Lubadde *et al.*, 2017). Approximately one-third of the world's millet is grown in Africa, with West Africa

accounting for 70%. Nigeria, Niger, Burkina Faso, Chad, Mali, Mauritania, and Senegal are among Africa's largest pearl-millet producers in the west, while Sudan and Uganda are in the east. In southern Africa, the agricultural market has resulted in maize partially or completely replacing this traditional nutritious crop. It's also a hot-and-dry-climate crop that can be produced in Ethiopian areas with insufficient rainfall. Pearl millet can usually generate a crop even when there isn't much rain (NRC, 1996).

Beyond pasturing and open grazing alone, pearl millet is the last alternative cereal crop for cultivation on the outskirts of the desert (Bashir *et al.*, 2014). There is no more drought-tolerant cereal crop to alleviate the threat of starvation, and nothing can be replaced if it fails (NRC, 1996). As a result, millions of people are forced to entrust their life to this crop plant. More pearl millet is grown in Africa, where the fear of drought is always there, and the terrain quickly fluctuates between wet and dry seasons, with rains sometimes restricted to only a few months and full drought prevailing for the remainder of the year (NRC, 1996).

For the past half-century, the role of pearl millet has been of virtually incalculable significance to millions of rural people in Eastern and Southern Africa. In arid and semi-arid regions of the world, it is a staple diet for the majority of poor farmers, as well as a crucial feed crop for animals. Its grain is also an excellent source of animal feed, equivalent to maize for poultry (Harold 2015). It also provides food for humans, and the stems are used to construct hut walls, fences, and roofs, as well as to make sunshades, brooms, baskets, and mats (IFAD, 1999). The crop is also a valuable diet since it lacks the tannins and other chemicals found in sorghum that impair digestion (NRC, 1996).

Furthermore, of the grains maize, sorghum, and finger millet, pearl millet is the most nutritious, having high protein and energy levels. It has a lot of grain iron and zinc (Jukanti *et al.*, 2016, Lagat *et al.*, 2018, Govindaraj *et al.*, 2019). Certain cultivars of grain are roasted whole and eaten right away. Millet flour mixed with dried dates and dried goat cheese is a staple dish in Niger's mountainous regions. It's fermented, like maize or sorghum, to make a traditional Nigerian weaning food that's still eaten today (NRC, 1996).

Despite its importance, pearl millet is regarded as a lost crop, and it is today an orphan among the key grains due to its lack of scientific and political backing. Outside of India and portions of Africa, few people have ever heard of it. As a result, in terms of genetic improvement, it trails behind sorghum and considerably behind the other major crops. Its average production per hectare, for example, is extremely poor, and it is virtually completely a subsistence crop. It is critical to evaluate the crop's key production constraints, nutritional value, and health benefits. Previous reviews and studies concentrated on Proso millet (Jukanti *et*

*al.*, 2016); (Lubadde *et al.*, 2017); and pearl millet (Awadallah *et al.*, 2017, D. Patni and M. Agrawal, 2017), which is insufficient information to grasp and thoroughly know the pearl millet. As a result, the purpose of this review paper is to evaluate and discuss the production constraints, nutritional composition, and health benefits of pearl millet.

### **Pearl millet Taxonomy, Origin and distribution**

The allogamous and diploid pearl millet *Pennisetum glaucum* (L.) R. Br. belongs to the family Poaceae, subfamily Panicoideae, tribe Paniceae, subtribe Panicinae, section Pennicillaria, and genus *Pennisetum* (Rai *et al.*, 1997). With 75–80 percent out-crossing, pearl millet is primarily a cross-pollinated crop (Rai *et al.*, 1999). It's a tropical C4 cereal crop with a strong tillering rate. On the surface of the erect candle-shaped terminal spikes, it has granules. Grain size ranges from 0.5 to 2.0g/100, and grain number per spike varies from 500 to 3,000, depending on the size of the spike (Andrews, 1990). Typhoides (found primarily in India and Africa), nigritarum (dominant in the eastern Sahel), globosum (dominant in the western Sahel), and leonis (dominant on the West African coast) are the four cultivated varieties of pearl millet (Brunken *et al.*, 1977; Rai *et al.*, 1997; The Syngenta Foundation for Sustainable Agriculture, 2006).

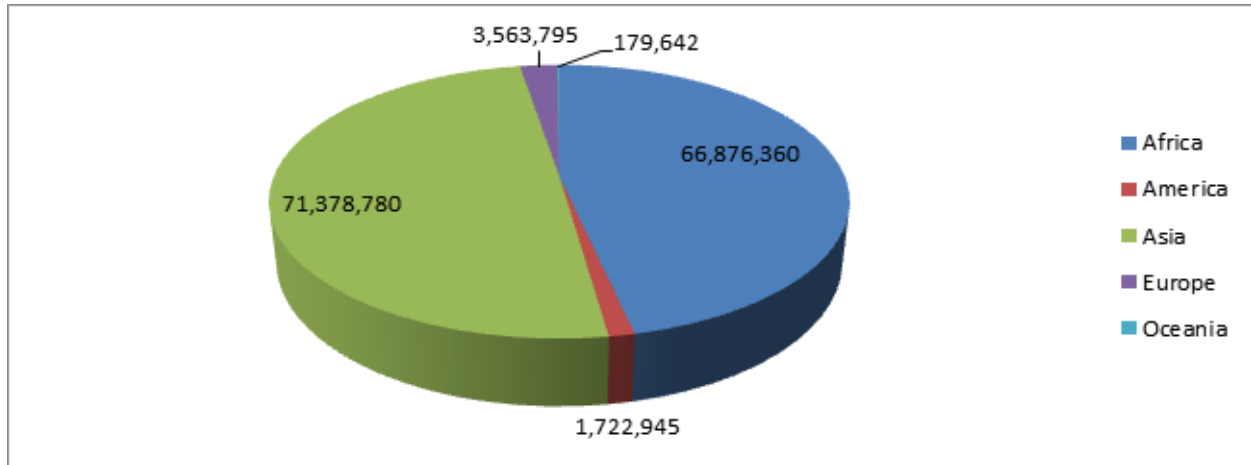
Pearl millet's geographical origin and domestication center are both in Western Africa (Brunken *et al.*, 1977; Rai *et al.*, 1997; Syngenta, 2006). Following then, the crop was brought to India, where the first archeological documents date back to 2000 B. C. (Oumar *et al.*, 2008).

Pearl millet is a tropical grain that originated in central Africa and is now widely distributed throughout the tropics and India. It was first introduced to the west in the 1850s, and it quickly established itself as minor forage in the Southeast and Gulf Coast states. Between 4000 and 5000 years ago, the plant was probably domesticated as a food crop at the southern edges of the Sahara's central highlands. Since then, it has spread rapidly across Africa and Asia's semiarid tropics.

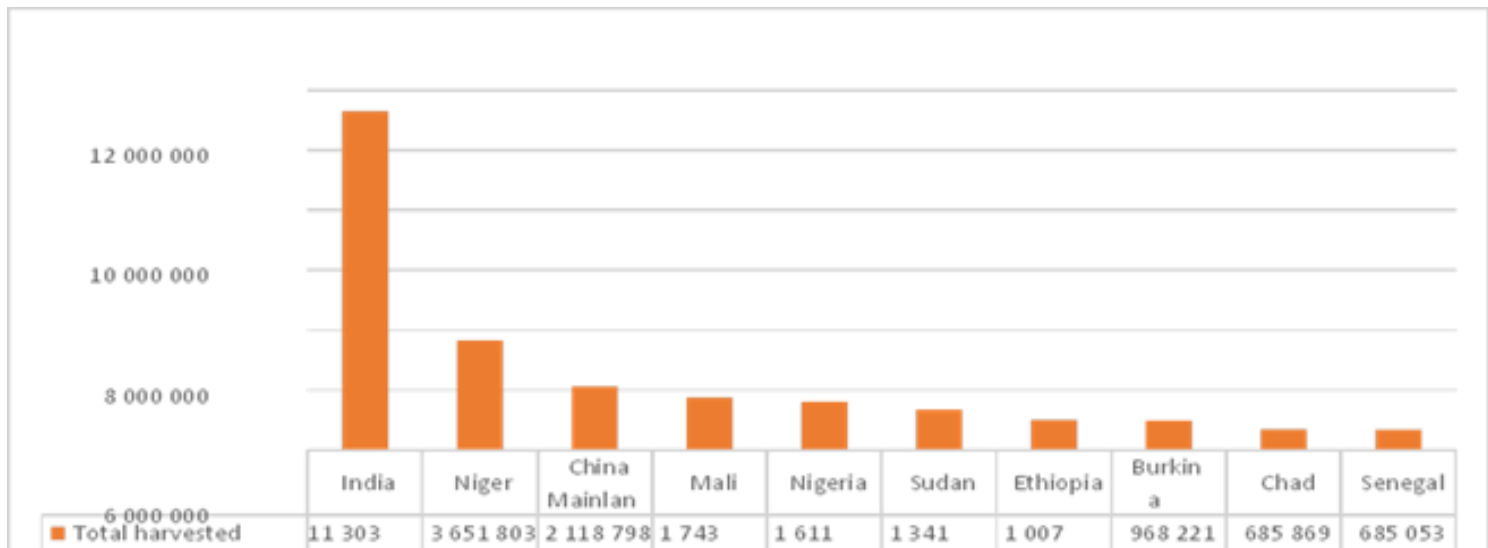
### **Pearl Millet production**

The FAO estimates that Asia produces 49.66 percent of the world's millet, while Africa produces 46.53 percent. Europe, America, and Oceania (Australia, New Zealand, and others) produce 2.48 percent, 1.20 percent, and 0.12 percent of global millet production, respectively (Figure 1).

India, Niger, and China are the world's top millet producers, accounting for more than 55 percent of global output. For many years, India was the world's leading millet producer; but, in recent years, millet output in Africa has increased (MGG 2019). According to FAO (2020), India produced over 11 million tons of pearl millet on average in each of the previous five years, followed by



**Figure 1.** World Millet Production Share by Region  
**Source:** FAOSTAT (2020)



**Figure 2.** Top 10 World Millet Producers (Average: 2014-2018 in tons)  
**Source:** FAOSTAT (2021)

Niger and China, which produced over 3 million tons and over 2 million tons, respectively (Figure 2).

According to Orr, Mwema, Gierend, and Nedumaran (2016), millet was planted on 33 million hectares worldwide between 2010 and 2012, with 60% (19 million hectares) in Africa and 38% (14 million hectares) in Asia. Although India is the world's top millet producer, Niger, an African country, came in second with 18,259,016 tons produced between 2014 and 2018. Other African countries, such as Mali, Nigeria, Sudan, and Ethiopia, are also among the top ten millet producers in the world, in that order.

Millet production is increasingly concentrated in Africa, with the continent accounting for 45 percent of global production in 2010-12, up from 28 percent in 1981-83. The majority of millet is grown in Western Africa, in

countries like Niger and Mali, which are among Africa's top millet producers (Orr *et al.*, 2016) Figure 3.

Niger produced 39 % (3,651,803 tons) of Africa's millet every year on average from 2014 to 2018, followed by Mali (19 % (1,743,775 tons), Nigeria (17 % (1,611,726 tons), Sudan and Ethiopia (14 % (1,341,000 tons) and percent (1,007,054 tons) throughout the same period (Figure 4).

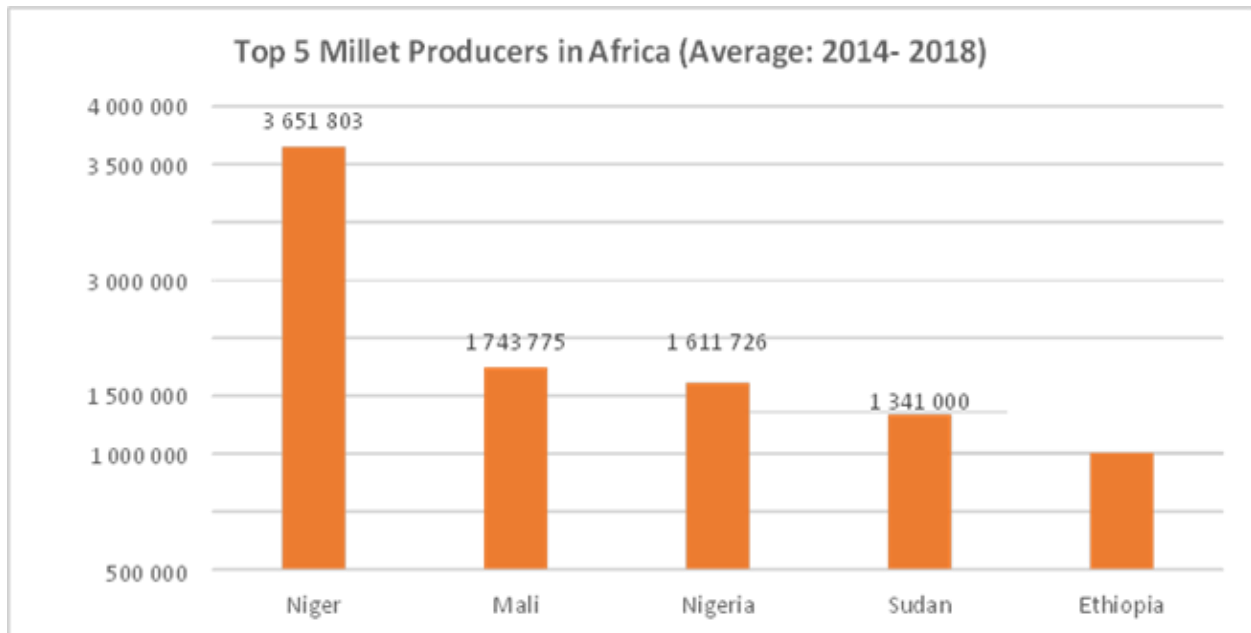
**Pearl millet production constraints**

**Drought stress and low soil fertility**

Abiotic restrictions impacting pearl millet productivity include drought stress and inadequate soil fertility (Drabo *et al.*, 2019). For instance earl millet is mostly grown in



**Figure 3.** Hybrid pearl millet production in Namibia  
**Source:** Market intelligence report on pearl millet grain, Namibia, 2021



**Figure 4.** Top 5 Millet Producers countries in Africa (Average: 2014- 2018 in tons)  
**Source:** FAOSTAT (2021)

Burkina Faso's semiarid Sahelian and Sudano-Sahelian zones, which have poor soils, intermittent rainfall, and high temperatures. Climate change has increased the intensity and frequency of biotic and abiotic pressures in Sub-Saharan Africa (SSA), especially Burkina Faso, necessitating the development of more tolerant agricultural cultivars (Bationo and Ntare 2000).

Drought can strike at any stage of growth, but terminal (or end-of-season) drought is more common and better known than pre-flowering stress (Rai *et al.*, 1999). Post blooming crop growth is especially vulnerable to moisture

shortages, according to Mahalakshmi and Bidinger (1985), and grain yield was lowered by 40–49 percent under terminal drought circumstances, according to Fussell *et al.*, (1991). Another key productivity limitation in pearl millet is high-temperature stress. Because of a variety of factors, increased air and soil temperatures result in lower yields. Even though pearl millet has a higher thermo-tolerance than other cultivated cereals, crop stand failure due to heat stress is common in arid areas (de Wet *et al.*, 1992). The majority of pearl millet is grown on marginal soils with low intrinsic fertility.

Because the majority of pearl millet growers are smallholder or marginal farmers, fertilizer and other agricultural inputs are rarely used, results in low yields.

### Disease and Insect pests

*Sclerospora graminicola* (Sacc.) Schroet, which causes downy mildew (DM), is a serious biotic limitation in pearl millet production, producing a severe crop and economic losses. In India and Africa, DM damage of pandemic proportions has been observed in high-yielding single-cross hybrids (Murthy *et al.*, 2007). Leaf blast or leaf spot, caused by *Pyricularia grisea* (Cooke) Sacc.; (teleomorph; *Magnaporthe grisea* (Herbert) Barr; Sharma *et al.*, 2013), is another developing disease that causes large yield grain and forage losses in pearl millet. Smut (*Tolyposporium penicillariae* Bref.), ergot (*Claviceps fusiformis*, Loveless), and rust are other diseases that harm pearl millet production.

Insects aren't a major problem for pearl millet production in India, but they are in Sub-Saharan Africa. Despite the fact that there are more than 100 pests recorded in pearl millet, only a few of them generate major economic losses. Shoot fly (*Atherigona approximata* Malloch), stem borer (*Chilo partellus* Swinhoe), ear head caterpillars (*Helicoverpa armigera* Hubner), white grub (*Holotrichia longipennis*), and grey weevil are the most common pests of pearl millet (*Mylocerus maculosus* Desb.; Yadav *et al.*, 2012). Pest problems have increased over the world as a result of the introduction of uniform and high-yielding cultivars. Insect pest losses and distribution differ from one region to the next. For the control of important pests, agronomic, chemical and biological control strategies have been advocated as part of integrated pest management.

### Parasitic weeds striga species

*Striga* species are notorious parasitic weeds affecting pearl millet production in the Sahel and Sudano-Sahel regions (Emechebe *et al.*, 2004). There are 13 *Striga* species reported in Burkina weeds of cereal and legume crops, respectively (Boussim *et al.*, 2011). Yield losses due to *S. hermonthica* vary between 7 and 41% in the central zones, while up to 55% losses

have been reported in the eastern zones of Burkina Faso (Zombré *et al.*, 1992, Traoré *et al.*, 2001). The parasitic weed has a wide range of hosts, including rice (*Oryza glaberrima* Steudel and *O. Sativa* L.), maize (*Zea mays* L.), Sorghum (*Sorghum bicolor* [L.] Moench), pearl millet, and fonio (*Digitaria exilis* (Kippist) Stapf) (Boussim *et al.*, 2011), Mrema *et al.*, 2017). The wide host range, the easy dispersal of *S. hermonthica* seeds by animals and wind, and the seeds' ability to stay viable in the soil for about 14 years make it difficult to control the weed (Emechebe *et al.*, 2004). In sub-Saharan, witch weed (*Striga hermonthica*), a destructive parasitic weed, is a

serious threat to pearl millet production (Wilson *et al.*, 2004). Under drought conditions, *Striga* infestation can cause up to 100 % grain yield losses (Kountche *et al.*, 2013).

### Insufficient agricultural inputs

Smallholder farmers with little resources are the principal producers of pearl millet (FAO, 2008; Erbaugh *et al.*, 2010). As a result, there are various inefficiencies in the production, supply, marketing, and utilization of machinery and equipment. These inefficiencies distort the production process and limit their ability to maximize value addition along the chain (Oni, 2011). The size of the cultivated area is governed by the type of cultivation equipment utilized (Acquah, 1997; Kumar *et al.*, 2010). Consequently, farm operations such as land clearing, crop harvesting, and processing are carried out with simple hand tools such as a hoe, cutlass, axe, sickle, and other local farm implements, which are inefficient in terms of adding value to the chain (Ismaila *et al.*, 2010; Oni, 2011). Farmers in the value chain have a low need for pearl millet inputs since they have no culture of buying inputs for these crops. Most farmers cannot afford to buy inputs, so they rely on indigenous technology and seed recycling instead (Mwanga, 2002). Since then, the traditional implements and instruments employed in the pearl millet production process add less value to the chain (Kumar *et al.*, 2010).

### Inadequate production knowledge and skills

Small-scale pearl millet growers lack the necessary production skills and expertise to contribute value to the pearl millet value chain. Due to a lack of knowledge and experience, pearl millet farmers, for example, do not sow at the optimal time. This behavior has a detrimental impact on pearl millet value addition and selling (Kumar *et al.*, 2010). Farmers also choose pearl millet panicles after harvest to use as seeds the following season, resulting in minimal value addition in the chain (Roden *et al.*, 2007). Furthermore, *gesnerioides* (Willd) Vatke being the Faso, with *Striga hermonthica* (Del.) Bentham and *S.* most devastating traditional production implements and techniques add less value to the pearl millet chain (Kumar *et al.*, 2010).

### Pearl millet has a low demand

In Africa's low-income, low-growth, agriculture-dependent countries, urban food demand is characterized by limited purchasing power and a strong bond between consumers and their traditional meals, as a result of their different social and cultural backgrounds. Poor prices and insufficient market demand for processed products, among other issues, force small-scale agriculture businesses to sell on credit, a debt that later turns out to be bad debt (Ja'afar-furo *et al.*, 2011). Tanzania's food

and feed sectors for instance are now using small quantities of pearl millet due to a lack of expertise with these crops as well as uncertainties regarding customer demand (Rohrbach and Kiriwaggulu, 2007).

### **Inaccessibility of hybrid varieties**

Variety development, inspection and certification, seed production, processing, marketing, and provision of services are all responsibilities that most seed value chain actors perform at the end of the chain (Erbaugh, 2010). However, the number of new kinds available is limited. The amount of money distributed remains minimal in comparison to farmer needs, and only a few farmers have access to it. Varieties, as well as the distribution networks needed to get this better seed into the hands of people who need it, Rohrbach and Kiriwaggulu (2007). However, there is no commercial seed market in the majority of African countries. Agricultural research on products, however, is rare (Mwanga, 2002; Kremer and Zwane, 2003). As a result, it appears that the usage of certified modified seeds for this crop is low, resulting in low-value addition and marketing of pearl millet in the chain (Muliokela, 2005 and Larson *et al.*, 2006, quoted by Erbaugh *et al.*, 2010).

### **Nutritional importance of Pearl millet**

Likewise, of the grains maize, sorghum, and finger millet, pearl millet is the most nutritious, having high protein and energy levels. It has a lot of grain iron and zinc (Jukanti *et al.*, 2016, Lagat *et al.*, 2018, Govindaraj *et al.*, 2019). Certain cultivars of grain are roasted whole and eaten right away. Millet flour mixed with dried dates fruit and dried goat cheese is a staple dish in Niger's mountainous regions. This nutrient-dense concoction is transported on lengthy travels through the Sahara and consumed raw, without the need for preparation. It's fermented, like maize or sorghum, to make a traditional Nigerian weaning food that's still eaten today (NRC, 1996).

The world is in the throes of a slew of health problems and chronic diseases. According to the 2016 Global Nutrition Report, 44 percent of the population in 129 nations (countries with data) suffers from severe undernutrition, adult overweight, and obesity (IFPR, 2016). The majority of these disorders are caused by a nutrient-deficient diet. According to UN Food and Agriculture Organization estimates, around 795 million people (10.9 percent of the world's population in 2015) were undernourished. On the other hand, more than 1.9 billion adults under the age of 18 (39 percent of the world's population) were overweight, with another 13% being obese (FAO, 2015, WHO, 2015).

In 2014, the global population's average body mass index (BMI) was reported to be 24 kg/m<sup>2</sup>, which is higher than the WHO's recommended range of 21 to 23 kg/m<sup>2</sup>(WHO, 2016). The World Health Organization has

already designated obesity-related comorbidities such as cardiovascular disease and diabetes to be epidemics. India has the world's highest population of undernourished people. Around 194.6 million individuals, or 15.2 percent of India's entire population, are malnourished. India was placed 100th out of 119 countries in the 2017 Global Hunger Index. India has a worse score than Nepal, Sri Lanka, and Bangladesh (Von Grebmer *et al.*, 2017).

Protein energy malnutrition (PEM) caused 4,69,000 deaths, with 84,000 deaths due to a lack of other essential nutrients such as iron, iodine, and vitamin A. (Lozano *et al.*, 2010). Obesity is also a major public health concern in India, with an obesity prevalence incidence of 11% in men and 15% in women (Kumer *et al.*, 2018). Millets are the sixth most widely grown cereal grain in the world, and they are still a staple diet in many parts of the globe. These are a rich source of several essential nutrients, and hence offer a distinct advantage in the fight against nutrient deficiency in third-world nations.

### **Energy**

According to the Nutritive Value of Indian Foods, pearl millet has a high energy content (361 Kcal/100g), which is equivalent to regularly consumed cereals such as wheat (346 Kcal/100g), rice (345 Kcal/100g), maize (125 Kcal/100g), and sorghum (349 Kcal/100g) (NIN, 2003).

### **Carbohydrate**

Starch, dietary fiber, and soluble sugars are the carbohydrate components of pearl millet grains. The amylose content of pearl millet starches ranges from 20 to 21.5 percent, and they have a higher swelling power and solubility than other starches (Lestienne *et al.*, 2007). The starch composition of different pearl millet varieties ranges from 62.8 to 70.5 percent, with soluble sugar ranging from 1.2 to 2.6 percent. In a range of 1.2 to 2.5 percent, free sugars such as glucose, fructose, sucrose, and raffinose are present (Jambunathan and Subramanian, 1987; Gupta and Nagar, 2010).

### **Proteins**

Gluten-free pearl millet grain Protein content ranges from 9 to 13 percent. The essential amino acid profile of pearl millet protein demonstrates that it contains more lysine, threonine, methionine, and cystine than sorghum and maize proteins (Adeola *et al.*, 2005). It also has a greater tryptophan concentration (Ejeta *et al.*, 1987; Hosoney *et al.*, 1994; Rooney and McDonough 1987). The lysine level of protein in pearl millet grain has been observed to range from 1.9 to 3.9g per 100g of protein (Serna-Saldivar *et al.*, 1994). This favorable amino acid balance, combined with a high quantity of essential amino acids

and outstanding *in vitro* pepsin digestibility scores, suggests that pearl millet is a nutrient-dense and easily digestible source of caloric and protein for humans (Ejeta *et al.*, 1987). Arginine, threonine, valine, isoleucine, and lysine were the essential amino acids with the highest digestion in pearl millet. Other grains have a lower apparent small intestine digestibility of critical amino acids than pearl millet (Adeola *et al.*, 2005; Kalinova and Moudry, 2006).

### Lipids

Pearl millet grain has greater total lipid content than any other millet, ranging from 1.5 to 6.8%. (Taylor, 2004). The fatty acids palmitic, stearic, and linolenic acids are higher in pearl millet, while oleic and linoleic acids are lower (Adeola *et al.*, 2005). Pearl millet grain has a comparatively high energy density due to its increased oil content (Hanna *et al.*, 1990). Unsaturated fatty acids account for around 75% of the fatty acids in pearl millet, with linoleic acid being particularly abundant (46.3%).

### Minerals

The mineral content of grain can be determined by environmental factors such as soil composition and nature. Minerals abound in pearl millet, which contains significant amounts of calcium, phosphorus, magnesium, and iron (Burton *et al.*, 1992). Pearl millet had an ash level ranging from 1.6 to 3.6 percent (Serna-Saldivar *et al.*, 1994). Minerals can be found in the pericarp, aleurone layer, and germ of pearl millet, making it a valuable source of nutrients. The removal of certain sections of the millet during refining, results in the loss of some of these vital nutrients (Serna-Saldivar *et al.*, 1994; Shahidi and Naczki, 2003).

### Health benefits of pearl millet

When it comes to mineral concentration, millets are far ahead of rice and wheat. Each millet contains more fiber than rice or wheat. When compared to rice, finger millet has thirty times the amount of calcium, while every other millet has at least double the quantity of calcium. Millet is far superior to rice and wheat in every way and is thus the answer to the malnutrition that afflicts the vast majority of India's population. Pearl millet is high in B-complex vitamins and contains more than most grains. Protein, minerals, and lecithin are all abundant. Millet is also the least irritating of all grains for allergy sufferers.

A study was conducted, and it was discovered that millet is the only grain capable of providing all of the needed amino acids and vitamins to experimental animals when fed as the sole source of nutrition. When millet is cooked, a mucilaginous substance comes to the surface.

This chemical appears to have some therapeutic properties in situations of gastrointestinal inflammation

and ulceration. Millet is one of the easiest cereals to digest and work with. Millet is a highly nutritious grain that is non-glutinous (unlike buckwheat and quinoa) and does not produce acid, making it calming and simple to digest. It is one of the least allergic and digestible grains available, and because it is a warming grain, it will aid to warm the body during cold or wet seasons and regions.

Millet is a pleasant grain that has a somewhat sweet, nut-like flavor and is high in nutrients. It has about 15% protein, a high fiber content, B-complex vitamins like niacin, thiamin, and riboflavin, the essential amino acid methionine, lecithin, and a little quantity of vitamin E. Iron, magnesium, phosphorus, and potassium are all abundant in this mineral. The seeds are also high in phytochemicals such as Pythic acid, which is thought to lower cholesterol, and Phytate, which has been linked to a lower risk of cancer. Millet is more than just a unique alternative to more often consumed grains. It was rated as a good source of several key nutrients, including manganese, phosphorus, and magnesium, by our food ranking system.

Plant-based diets have been proven to protect against a variety of degenerative diseases, including cancer, cardiovascular disease, diabetes, metabolic syndrome, and Parkinson's disease, according to epidemiological evidence from research studies (Manach *et al.*, 2005; Scalbert *et al.*, 2005; Chandrasekara and Shahidi, 2012). Millets must also be recognized as functional foods and nutraceuticals since they supply essential nutrients such as dietary fibers, proteins, energy, minerals, vitamins, and antioxidants. Millets have been linked to several health benefits, including the prevention of cancer and cardiovascular disease, the reduction of tumor incidence, the reduction of blood pressure, the risk of heart disease, cholesterol, and fat absorption rate, the delay of gastric emptying, and the provision of gastrointestinal bulk (Truswell, 2002; Gupta *et al.*, 2012).

Millet's lignin and phytonutrients work as powerful antioxidants, reducing the risk of heart disease. As a result, pearl millet is thought to be beneficial to heart health (Ahmed *et al.*, 2009). Pearl millet has high quantities of magnesium, which has been demonstrated to help manage blood pressure and decrease cardiac stress. Pearl millet has a high magnesium content, which helps asthma patients lower the severity of their symptoms and is also useful in minimizing migraine attacks. Because of its high fiber content, pearl millet can help in weight loss (Scalbert *et al.*, 2005). Pearl millet's high fiber content has also been linked to a lower risk of gall stones.

Pearl millet's insoluble fiber content decreases the generation of excess bile in our system (Liu, 2007). Because of the fiber content, the grain takes longer to pass through the stomach and into the intestines (Miller, 2001). In this way, pearl millet satisfies hunger for a long time and thus helps to reduce overall food consumption. Compared to other cereals, pearl millet has a better

apparent small intestine digestibility of essential amino acids. Pearl millet is a nutritious and well-digested source of calories and protein for humans, with a high quantity of essential amino acids and outstanding *in vitro* pepsin digestibility ratings.

Pearl millet has a plethora of health-promoting characteristics. As a result, the grain is easily digestible and has a low risk of triggering allergic reactions. It can be safely included in the meals of infants, breastfeeding mothers, the elderly, and convalescents due to its hypoallergenic properties. Non-enzymatic glycosylation, the chemical interaction between the aldehyde group of reducing sugars and the amino group of proteins, is a crucial contributor to diabetes and aging issues (Monnier, 1990). Millet grains are high in antioxidants and phenolic compounds; nevertheless, phytates, phenols, and tannins have been shown to contribute to antioxidant activity in health, aging, and metabolic syndrome (Bravo, 1998).

### Products of pearl millet

Pearl millet grains are used to make porridges, flatbreads, couscous, desserts, alcoholic beverages (opaque beer or Dogon millet beer, chibuku shake, mbeg, merissa), and non-alcoholic beverages (pombe, pito, boza, kunun Zaki, bushera, mahewu, oskikundu, marewa) in Africa and India (Adebiyi et al., 2018). The majority of these goods are made in households or small production units and are consumed during meals. However, few studies on the nutritional and sensory aspects of these products have been published. Furthermore, due to a large number of diverse local variations, this study will be limited to discussing a few examples of pearl millet culinary preparations found in worldwide literature. It is eaten with yoghurt or mashed in water before being eaten as porridge, depending on the location (Filli, et al., 2013).

Porridges, the most often consumed pearl millet food product, can be made from fermented or unfermented pearl millet flour (Adebiyi et al., 2018). Depending on the amount of flour used, their consistency can range from thick to thin (30 percent down to 10 percent). Cooking flour in boiling water with vigorous stirring can be used to make a variety of porridges. Furthermore, depending on the added ingredient, the flavor and pH of these goods can vary significantly (Kajuna, 2001; Taylor, 2016).

In addition to salted products, pearl millet grains can be used to produce sweets. Ladoo and Dakuwa prepared small sweet balls from roasted pearl millet grain flours that are typically consumed in India and Nigeria, respectively. According to Singh and Sehgal (2008) and Nkama, Gbenyi, and Hamaker (2015), potential ingredients such as popped pearl millet grain and malted flour can be added to those sweets for nutritional improvements.

Further, pearl millet flour has a lot of potential for developing popular products in other parts of the world,

like ready-to-eat snacks (Balasubramanian et al., 2012), weaning products (Balasubramanian *et al.*, 2014), and non-dairy fermented beverages (Balasubramanian *et al.*, 2014), (Mridula *et al.*, 2015). Furthermore, it can be used as a wheat flour substitute in a variety of food dishes such as biscuits, pastas, whole grain breads, and kibbeh (Adebiyi et al., 2018; Awolu, 2017; Brasil et al., 2015; Jalgaonkar and Jha, 2016; Maktouf *et al.*, 2016).

### Drawback of pearl millet

All importance and benefit of pearl millet discussed earlier aren't to argue that pearl millet is without flaws. The crop does, have several serious difficulties. For one thing, processing the raw grain is laborious. Before grinding the grain into various particle sizes for usage in various goods, many consumers decorticate (dehull) it. Traditional hand pounding gives modest flour yields (about 75 percent) and the result has poor storage stability (NRC, 1996).

Millet includes anti-nutrient components such as polyphenols and tannin, phytic acid and phytate, goitrogens, and oxalic acid. The bran contains a lot of polyphenols and tannic compounds. *In vitro*, there is a strong connection between tannin levels and protein digestion. Decortication, reduces the number of tannins in the plant while enhancing protein digestibility. Millet changes color reversibly from grey to yellow-green at alkaline pH and somewhat reversibly from grey to creamy white at acidic pH due to the presence of phenolic compounds (glucosylvitexin, glucosylorientin, vitexin).

### CONCLUSIONS

Pearl millet is the sixth most important cereal crop after rice, wheat, maize, barley and sorghum. It is commonly farmed on 30 million hectares in Asia and Africa's arid and semi-arid tropical regions, contributing to about half of global millet production. It is an essential cereal crop as it is affluent in nutrition and climate hardy crop which is grown in harsh conditions, but as a subsistence crop; it is a staple food that supplies a major proportion of calories and protein to large segments of the population living in the semi-arid tropical regions of Africa and Asia. Pearl millet remains a staple diet in many parts of the world. These are high in various vital nutrients and hence provide a significant advantage in the fight against the nutrient shortages in developing countries. It's also a hot-and-dry-climate crop that can be grown in locations where rainfall is scarce. Even when there isn't much rain, pearl millet can usually produce a harvest.

The production of pearl millet is influenced by several factors. Drought stress and low soil fertility, disease and insect pests, parasitic *Striga* species, inaccessibility of hybrid varieties, lack of product knowledge and skills, insufficient agricultural input, and low demand for pearl millet are among the factors.



Pearl millet has a high energy level, according to the Nutritive Value of Indian Foods. The starch content of various pearl millet cultivars varies from 62.8 to 70.5 percent, with soluble sugar content varying from 1.2 to 2.6 percent. Pearl millet protein includes higher lysine, threonine, methionine, and cystine than sorghum and maize proteins, according to the essential amino acid profile. The total lipid content of pearl millet grain is higher than any other millet grain, ranging from 1.5 to 6.8%. Pearl millet has higher levels of palmitic, stearic, and linolenic acids, but lower levels of oleic and linoleic acids. Pearl millet is rich in minerals, including considerable quantities of calcium, phosphorus, magnesium, and iron. The ash content of pearl millet ranged from 1.6 to 3.6 percent.

B-complex vitamins are abundant in pearl millet, with more than most grains. Millets, which provide vital nutrients such as dietary fibers, proteins, energy, minerals, vitamins, and antioxidants, must also be acknowledged as functional foods and nutraceuticals. Millets have been related to a multitude of health advantages, including cancer and cardiovascular disease prevention, tumor reduction, blood pressure reduction, heart disease risk, cholesterol, and fat absorption rate, delayed stomach emptying, and the provision of gastrointestinal bulk and lecithin. For allergy patients, millet is the least irritating of all cereals. The high fiber content of pearl millet has also been related to a lower risk of gall stones.

As a result, in the current era of food scarcity, it is necessary to diversify the use of pearl millets by developing a variety of millet dishes. Millet is a delicious cooked cereal that may be served as a side dish or popped like corn for a snack or breakfast cereal. If properly stored, the whole millet can be kept for up to two years. Millet is a nutrient-dense, nutritious, and versatile grain that everyone should consume.

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