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Uncovering the Types: Health Benefits of Millets: A Review

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Abstract

Given the current conditions of shifting dietary preferences, population growth, and unchecked exploitation of natural resources, there are not enough resources to ensure that everyone has access to a healthy diet. Since natural plant resources are quickly running out, other options must be investigated. In addition to the basic crops, such as wheat and rice, many other underutilised crops are also consumed, many of which have the potential to replace the staples. One of the main underutilised crops with the potential to be a nutritional cereal is millets. Millets are small grain crops that are members of the Poceaea family. They can withstand a variety of weather conditions, including drought. They are gluten-free and, most importantly, high in protein. They are an abundant supply of phytochemicals with therapeutic qualities, such as antioxidant activities, which help prevent a wide range of illnesses. The various types of millets, their production in India, their nutritional makeup, and their importance are the main topics of this review. The article highlights the need for more study on the nutritional attributes and practical applications of different millet types while describing the nutritional worth and health advantages of millets.

Keywords: Pearl millet, finger, sorghum, proso, foxtail, little, kodo, barnyard

INTRODUCTION

Recent years have seen a rise in the popularity of millets because of their remarkable nutritional profile and several health advantages. Filled with vital elements including fibre, vitamins, and minerals, millets provide a gluten-free, sustainable substitute for conventional grains. Consuming them has been associated with a host of health benefits, such as improved digestion, better control over weight, and a lower chance of developing chronic illnesses. Millets were first brought home 10,000 years ago, which is when they were first cultivated and farmed. The little kernels that are produced by tiny grassy plants in the Poaceae family are the reason millets are grown. Although they go by a different name, they are noteworthy crops because of their nutritional worth, therapeutic uses, ability to feed animals, and ability to survive times of food scarcity (Kumar et al., 2021). The French word "mile," which means "thousand," is where the name "millet" comes from, this implies that a tiny amount of millets contains thousands of grains. A large area of poor or abandoned land with minimal nutrient content and semi-arid climates with very little rainfall are ideal places to produce millets. The crops help individuals in locations where hunger is a common occurrence to feed themselves, while comparing millet crop yields to those of other agricultural products, they are often more constant and predictable in regions with little rainfall (Tadele, 2016). C4 plants like millets have remarkably high photosynthetic efficiency, a short growing season, a greater capacity to produce dry matter, and a high level of drought and heat tolerance. Additionally,

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they can readily adjust to deteriorated acidic, saline, and aluminium-toxic soils. Due to these unique qualities, millet is a good crop for developing solutions based on climate resilience and overcoming the issues brought on by climate change (Yadav and Rai, 2013).

Sixth in importance among cereal grains worldwide, these small grains are an important source of nutrients and energy for lakhs of individuals in India, China and Africa, especially in arid & semi-arid regions (Das et al., 2019). Since of their higher nutritional value than conventionally made major cereals, they are often mentioned to as "Nutri-Cereals" as they contain more nutrients than other major grains (FAO, 2018). As per the Indian Council of Agricultural Research & the Indian Institute of Millets Research (ICAR-IIMR), Nutri-cereals are incredibly nutrient-dense grains that have the equivalent content of nutrients as commonly consumed cereal dishes (Saini et al., 2021). Millets are extremely nutrient-dense crops that are abundant in dietary fibre, vital fatty acids, protein and various minerals, like zinc, iron, calcium, magnesium, potassium, and vitamins, including the B-complex. Additionally, by regulating blood pressure and sugar levels, millets help cure and prevent a number of ailments, including celiac disease, heart disease, thyroid issues, blood pressure and diabetes (Ambati, 2019).

INDIA'S MILLETS PRODUCTION

It is India that is the world's biggest millet producer. By 2020, the combined yield of two major millets produced in India, Jowar (Sorghum) & Bajra (Pearl Millet), accounted for over 19% of the millet produced globally. In particular, India supplied 8.09% of the production of millet worldwide that year in the form of sorghum and 40.51% in the form of pearl millet. Rajasthan, Karnataka, Maharashtra, Haryana, Madhya Pradesh (MP), Uttar Pradesh (UP), Tamil Nadu, Andhra Pradesh, Gujarat & Uttarakhand are the major Indian millets' cultivating states. Between 2020 and 2021, the 10 states in question accounted for 98% of India's total millet output. Remarkably, eighty-three percent of the world's millet production takes place in states like Gujarat, UP, Maharashtra, Rajasthan, Karnataka & Haryana combined. Rajasthan became a major player, contributing 28 percent of India's millet production.

There are several varieties of millet native to India, including amaranths & buckwheat which are pseudo millets, as well as Kodo, Finger Millet, Jowar, Barnyard, Thinai Rice (Foxtail), Proso & Little Millet. In India, the 3 main types of millet that are grown including Bajra, Ragi & Jowar. **(APEDA, India)**

TYPES OF MILLETS

They fall into 2 general categories: major millets & little millets, based on their measurements. Jowar, ragi, and bajra are 3 major millets. Proso, foxtail, barnyard, little millet and kodo are examples of minor millets. Two such pseudo-millets that botanists have identified are amaranth and buckwheat **(FSSAI, 2020)**.

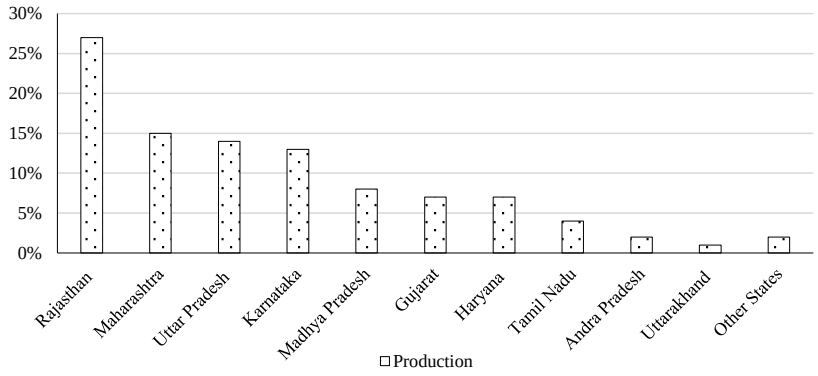

Figure 1. India's state-wise millet production (2021-22).

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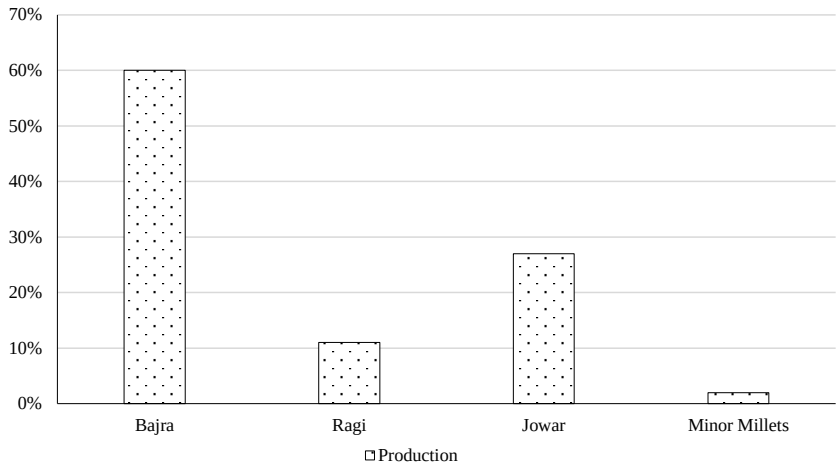

Figure 2. Production of millets in India (2021-22).

Major Millets

These are conventional, extensively grown grains that are produced in large numbers all throughout the world. They are staple foods in many parts of the world, contributing significantly to food security and frequently used as the main source of calories in diets.

Sorghum

African grain crop *Sorghum bicolor L.* was introduced around 3,000–5,000 years ago (de Morais Cardoso et al., 2017). Worldwide cereal crop ranked fifth in importance, sorghum is extensively farmed as a grain, sweet potato, fodder, low-lignin, and biomass crop. It may be grown in a variety of regions (Bhatt et al., 2022). The majority of sorghum types are heat- and drought-tolerant, which is important in dry regions (Ratnavathi and Komala, 2016). Numerous phytochemicals, like policosanols, phenolic acids, tannins, phytosterols, and anthocyanins, are rich in sorghum. These phytochemicals might have a big effect on people's health. Tannin-containing sorghums have been well documented to decrease calorie availability and hence cause weight gain in animals. This characteristic may be helpful in lowering human obesity. Moreover, sorghum phytochemicals support animal cardiovascular health (Awika and Rooney, 2004).

Finger Millet

Commonly known as ragi, is an allotetraploid crop that descended from *E. coracana subsp. Africana*. There are around 10 species in the genus Eleusine, including variations that are annuals and perennials (Vetriventhan et al., 2016). It has traditionally been an important element of staple foods, particularly in India and eastern and central Africa. It goes by a number of names in Africa, but in Sri Lanka, it is known as Koracan (Shobana et al., 2013). Finger millet was probably first farmed 5000 years ago in the Ethiopian highlands and Western Uganda, and by 3000 BC it had made its way to the Western Ghats of India (Vetriventhan et al., 2016). India is ranked sixth in the world for its output, after bajra, sorghum, wheat, and rice. It is a naked caryopsis with a seed coat colour of brick red. Usually, it is used as the entire meal to prepare traditional dishes like ambali (thin porridge), mudde (dumplings), and roti (unleavened breads or pancakes). Regular eating of whole grain cereals and their derivatives has been shown to reduce the incidence of gastrointestinal malignancies, CVDs, type II diabetes, and a host of other conditions (Devi et al., 2014).

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Table 1. Types of millets.

Category	English Name	Common Name	Scientific Name	Picture
Major Millets	Sorghum	Jowar	*Sorghum bicolor L.*	
	Finger Millet	Ragi	*Eleusine coracana L.*	
	Pearl Millet	Bajra	*Pennisetum glaucum*	
Minor Millets	Proso Millet	Chena	*Panicum miliaceum*	
	Foxtail Millet	Thinai Rice / Kangni	*Setaria ialica*	
	Barnyard Millet	Sanwa	*Echinochloa crusgalli*	
	Little Millet	Kutki	*Panicum sumatrense*	
	Kodo Millet	Kodon	*Paspalum scrobiculatum*	
Pseudo Millets	Amarantha	Rajgira	*Amaranthus caudatus L.*	
	Buckwheat	Kuttu	*Fagopyrum esculentum*	

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Pearl Millet

In semiarid parts of Asia and Africa, it is the 6th most significant grain in the world. Around 3000 years ago, pearl millet was first grown on the edge of the Sahara Desert as a result of the present drying epoch, which led to the replacement of Mediterranean grains with other species more adapted to changing weather patterns and increasing aridity (Bhatt et al., 2022). It is a robust cereal crop that is produced in regions with insufficient rainfall, unlike wheat and rice. Though it is only found in Africa and Asia, where it is the most widely distributed of all millet varieties, it is grown over twenty-nine million hectare of land (Rathore, 2016). Over 95% of pearl millets are cultivated in developing nations, India accounts for 9.8 million hectares of the global output. (Rani et al., 2018). Its phytochemical components support lipid profile maintenance and cholesterol reduction. It has significant amounts of unsaturated fatty acids, copper, zinc, folate, iron, calcium, and magnesium as well as vitamin B complex (Rao et al., 2018). It works as a bio-fortifier to fight the anaemic population because of its high folate content. The presence of magnesium has been shown to improve the management of migraines and ease asthmatic patients' breathing problems (Ambati, 2019). Along with being anti-fungal and anti-ulcerative, it also contains certain phytonutrients including flavonoids, apigenin, myricetin & lignin that aid in reducing CVDs and breast cancer (Thakur and Tiwari, 2019).

Minor Millets

These grains are farmed on a lower scale than major millets. They add variety to diets and are highly valued for their nutritional content. Furthermore, their resilience and viability in sustainable agriculture are being recognised more and more.

Proso Millet

An significant grain for human diets since ancient times, it is mostly grown in Europe, Asia, Australia & the United States (Čukelj Mustač et al., 2020). Proso millet, often known as Chena, it has shorter growing season (Singh et al., 2019). In developed countries, it is utilised as animal feed; in other Asian regions, it is consumed as food (Upadhyaya et al., 2016). It is devoid of gluten and has a high calcium, protein, and dietary fibre content. It is the least expensive source of manganese when compared to other spices, nuts & cereals that are readily accessible. It aids in lowering cholesterol and improving lipid profiles. Proso millet is beneficial for bone health and can help prevent heart disease and breast cancer (Rao et al., 2018). When compared to fruits and vegetables, its carotenoids extract has remarkably strong cellular antioxidant properties. Although dose-dependent, it has stronger anti-proliferative effect against human liver cancer cells. It is high in bioactive phytochemicals that are good for human health. It also contains over 65% phenolic compounds (Zhang et al., 2014).

Foxtail Millet

The Panicoideae subfamily and the Paniceae tribe include this vital ancient dry land crop, which has been farmed in China for more than 10,500 years (Vetriventhan et al., 2016). One of the earliest crops ever planted, it is mostly used for bird feed in semi-arid regions of Africa, Asia and a few other developed countries (Sharma and Niranjan, 2018). The 2nd highest growing millet in India, foxtail millet is sometimes referred to as kangni. Their usual cultivation occurs in semi-arid locations, & less watering is needed. Furthermore, rich in dietary fibre, vitamins, protein, calcium, copper & iron, foxtail millets also have antipest properties. They also aid in boosting the body's ability to withstand sickness (Rao et al., 2018). It is easily digested because it is neither sticky nor acid-forming. It facilitates the body's gradual release of carbohydrates without impeding metabolism (Gupta et al., 2013). Its constituents, which include apigenin, catechin, quercetin, and kaempferol, aid in the prevention of diabetes, heart disease & dyslipidaemia. Owing to the magnesium concentration, this dish is regarded as heart-healthy. It aids in bodily cleansing and has antimicrobial and antitumorigenic properties (Thakur and Tiwari, 2019).

Barnyard Millet

The most ancient millet variety farmed in temperate and tropical climates of Asia, such as India, Korea, Japan, and China, is barnyard millet. Other names for barnyard millet include sawa millet,

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Korean native millet, cockspur grass, prickly millet and watergrass (Upadhyaya et al., 2016). Also called Swank or Shyama, barnyard millet grows quickly and is usually harvested in six weeks (Saini et al., 2021). It is low carbs, high in protein content, & some soluble and insoluble components. Three fatty acids make up the majority of it: linoleic acid, oleic acid & palmitic acid. Because barnyard millet is gluten-free, it also helps to avoid celiac disease. It is particularly efficient in lowering blood sugar levels (Rao et al., 2018). Its main anti-tumorous, anti-rheumatic, and anti-diabetic chemicals include serotonin, luteolin, N-(p-coumaroyl), and tricin (Thakur and Tiwari, 2019).

Little Millet

It is a special kind of minor millet that is widely farmed in tropical regions & is a mainstay food for many low-income people worldwide (Pradeep and Guha, 2011). It is one among the customary crops of Karnataka & is planted all across India. It is mostly mixed-cropped with oilseeds, pulses, and other millets (Rao et al., 2018). Aside from minerals and vitamins, it is similar to other cereals like wheat & rice in terms of protein, fats, carbs & crude fibre. Phytate, tannins, flavonoids, and phenolic acids are among the phytochemicals that it also contains (Pradeep and Guha, 2011). Little millets contain an elevated concentration of vitamin B, iron, and phosphorus. Little millets that have been germinated are the greatest sources of α-amylase, as they have a higher purity and specific yield (Dokka, 2011). About 80% of the phenolic and flavonoid contents of this millet is found in their soluble portion (Pradeep and Sreerama, 2018). It has apigenin, which is anti-cancerous and helps fight celiac disease, cardiovascular disease, diabetes and high cholesterol (Thakur and Tiwari, 2019).

Kodo Millet

A common crop in India, West Africa, Pakistan, Philippines, Vietnam, Indonesia, and Thailand is kodo millet (Deshpande et al., 2015). It is extensively distributed throughout dry & semi-arid locations of India and African nations, having originated in India and being grown on poor soils (Bunkar, 2021). In contrast to alternative millets, this millet contains the greatest content of dietary fibre, making it a perfect meal for those with diabetes. It has a low-fat level, high protein content & a good amounts of vitamins, comprising of pyridoxine (B6), niacin (B3), and folic acid (B9), along with several minerals, including calcium, iron, magnesium, potassium, zinc, and so on. Those who are intolerant to gluten or wheat can use it because it doesn't contain gluten. Lecithin, another ingredient in kodo millets, helps to fortify the neurological system. Kodo millet consumption is beneficial for postmenopausal women with dyslipidaemia or high cholesterol, hypertension, and heart-related conditions (Rao et al., 2018).

Pseudo-Millets

They are not real grasses, unlike millets, but they do have comparable nutritional characteristics, which is why botanists have classed them as pseudo-millets. Rich in protein, minerals, and vitamins, and free of gluten, they are becoming a more and more popular grain substitute because of their adaptability and health advantages.

Amaranth

The biodiversity of amaranth is enormous. It was employed in ceremonial meals connected to human sacrifices by the Aztecs, therefore it was left off the dinner table for many years and after the advent of the Spanish conquistadors in Latin America (Rastogi and Shukla, 2013). Numerous traits, including a high tolerance to dry circumstances and poor soils, resistance to heat, drought, and pests, and the capacity to grow in settings where traditional cereal crops cannot flourish well, are all gifts from nature (Mir et al., 2018). It is a superfood that is high in fibre, protein, and important vitamins and minerals. Its noteworthy contents include iron, calcium, magnesium, vitamin C, and premium proteins. This pseudocereal is a great complement to a varied and nutrient-dense diet since it provides a perfect balance of amino acids (Martínez-Villaluenga et al., 2020).

Buckwheat

The Chinese gene centre is where buckwheat originated. It is regarded as one of the most significant grain crops in Japan, just after rice. With the exception of sand, it can be grown on nearly all types of

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soils and prefers warm climes with low humus needs (Mir et al., 2018). It is a nutritional treasure, with a strong profile that includes fibre, high-quality proteins, and vital elements like copper, manganese, and magnesium. Because it is devoid of gluten, it is a healthy option for anyone following a restricted diet. Additionally, its high flavonoid concentration amplifies its antioxidant capabilities (Martínez-Villaluenga et al., 2020). Both cholesterol lowering and Type-II diabetes prevention are possible benefits (Mir et al., 2018).

NUTRITIONAL COMPOSITION

Millets provide calories and protein, which is vital for ensuring nutritional security for people worldwide (Serna-Saldivar and Espinosa-Ramírez, 2019). Millets are distinct from cereals because of their elevated protein, dietary fibre, calcium & polyphenol contents (Amadou et al., 2013). Millets are a nutrient-dense food that include 12–20% dietary fibre, 6–19% protein, 1.5–5% fat, 2-4% minerals, & a range of other phytochemicals (Bhatt et al., 2022). They are rich in antioxidants, magnesium, and vitamin B (Sarita et al., 2016). Compared to wheat and rice, millets have a larger mineral and essential amino acid content, as well as a higher content of macro and micronutrients (Sharma et al., 2021).

Table 2. Millets' makeup of macronutrients (g/100g).

Millet	Carbohydrate	Protein	Fats	Dietary Fiber	References
Sorghum	67.98	9.97	1.73	10.22	(Longvah et al., 2017)
Pearl Millet	61.78	10.96	5.43	11.49	(Longvah et al., 2017)
Finger Millet	66.82	7.16	1.92	11.18	(Longvah et al., 2017)
Proso Millet	70.4	12.5	3.1	14.2	(Habiyaremye et al., 2017)
Foxtail Millet	66.19	8.92	2.55	6.39	(Longvah et al., 2017)
Kodo Millet	66.6	9.8	3.6	5.2	(Saleh et al., 2013)
Little Millet	65.55	10.13	3.89	7.72	(Longvah et al., 2017)
Barnyard Millet	68.8	10.5	3.6	12.6	(Ugare et al., 2014)
Amaranth	61.46	13.27	5.56	7.47	(Longvah et al., 2017)
Buckwheat	54.50	12.30	3.80	7.0	(Giménez-Bastida and Zieliński, 2015)

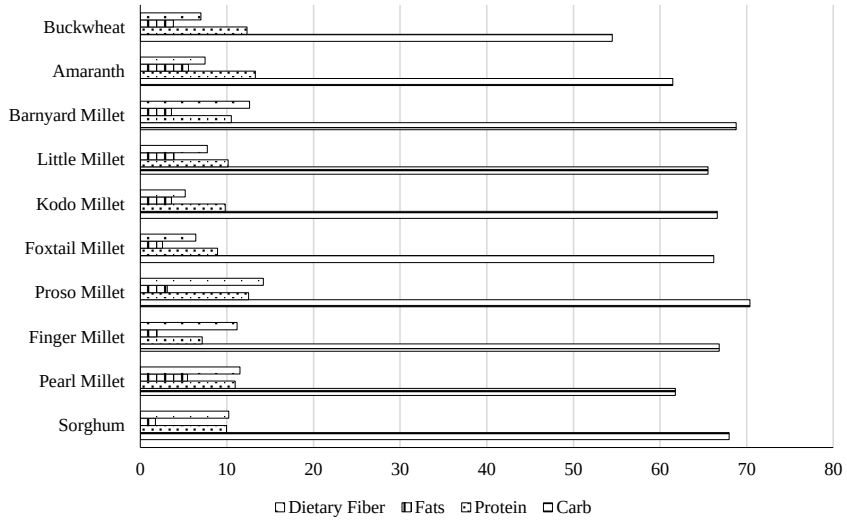

Figure 3. Bar graph comparing macronutrients of various millets.

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SIGNIFICANCE OF MILLETS

They have a relatively brief growth season & require very little irrigation. They don't require additional fertiliser to thrive in hot, dry climates since they can tolerate a broad variety of temperature fluctuations. Previous studies on millets for medicinal purposes have demonstrated their nutritional value in respect of antioxidant activity. Bioactive compounds found in millets may eliminate the chances of a variety of diseases, such as cancer, diabetes, high blood pressure & cardiovascular disease. Minerals, vitamins, and antioxidants included in millets aid in the body's detoxification process. Antioxidant-rich barnyard millet aids in lipid profile and body temperature regulation. Along with improving blood sugar regulation and lowering triglycerides, millet improves the diastolic, systolic, and lipid profiles of those who follow a millet diet. Therefore, a millet diet, particularly one high in finger millet, jowar & foxtail millet, is advised for those with diabetes. Barnyard and foxtail millet both help to heal bodily tissues, help to cleanse the immune system, prevent breast cancer in premenopausal women and guard against conditions including gallstones, breast cancer, and heart attack (Gupta et al., 2013; Kumar et al., 2020; Lee et al., 2010; Sharma et al., 2021; Vedamanickam et al., 2020; Xie et al., 2019). Millets include magnesium, which may help lower the risk of Type II diabetes. Through the release of breaking down enzymes, carbohydrates & affect insulin action, magnesium is a necessary mineral that helps insulin and glucose receptors function (Ambati, 2019). Foxtail millet is high in lysine and carotenoid content and abundant in protein, fibre, minerals, vitamins, phytochemicals, tannins, and polyphenols. Furthermore, it has excellent attributes that can contribute to improving food security in terms of both nutrition & functionality (Singh et al., 2019). Research has shown that eating barnyard millet had a high satiation value, no hunger pangs between millet meals, and a comfortable passage through the colon, all of which helped to alleviate the subjects' constipation (Ugare et al., 2014). The seed coatings of finger millets have nephroprotective, hypocholesterolaemia, hypoglycaemic, antidiabetic, and anti-teratogenic properties (Shobana et al., 2013). Because of their high iron content, which helps fight anaemia, they are the best agents for bio-fortification. As a functional diet, millets are affordable and rich in calcium, which lowers the risk of calcium deficiency in children, expectant mothers & nursing mothers (Saini et al., 2021). Therefore, it is evident that millets are a great addition to a balanced diet and have many health advantages. Rich in fibre, vitamins and minerals, they support a healthy digestive system that helps people lose weight and avoid constipation. They are good for those with diabetes because of their low glycaemic index, which helps to maintain stable blood sugar levels. Millets have a high antioxidant content, which makes them anti-inflammatory and beneficial to cardiovascular health. They're a great option for gluten-sensitive people because they're devoid of gluten. Moreover, consuming them has been associated with a lower chance of developing chronic illnesses including heart disease and several forms of cancer.

CONCLUSION

The results of scholarly publications published between 2004 and 2022 about the diversity, nutritional value, yield, and significance of millet are included in this review. According to the study's findings, millets are regarded as a staple meal in many African & Asian nations because of their high mineral and essential amino acid levels, which surpass those of wheat and rice, and their richness in macro- and micronutrients. They are nutri-cereals that should be used in developing nations like India because of their high nutritional value, rich dietary fibre content, and ability to work effectively as both small-scale & large-scale supplements and the best fortification agent. Iron, manganese, phosphorus, magnesium, calcium, zinc & potassium are among the many nutrients found in millets. Millets are suitable for those with wheat intolerance and constipation since they are alkaline, calming, and gluten-free. Millets are rich in minerals such as iron & calcium & they are also high in vitamins A, D, E, and B especially niacin, B9, and B6. An environment free from sickness may be established in our nation and several illnesses both before and after transition can be readily conquered with the right use of millet.

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