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Wonder Millets - Pearl Millet, Finger Millet and Foxtail Millet Nutritional Profile and its Role in Health Promotion: A Review

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ABSTRACT: Millets play a big part in the traditional diets of many parts of the nation. Millets have a number of desirable qualities, including being resistant to drought, producing well in locations with limited water supplies, and having high nutritional values. Millet grain is ideal as food and feed since it is rich in minerals and phenolic compounds that have positive health effects. Millets include phenolic characteristics that include phenolic acids, flavonoids, and tannins, all of which are good for human health. When choosing millet for use as food or feed, the variety of millet that is available is necessary. The varied nutritional and phenolic components contained in pearl, finger and foxtail millets are excellent markers of this. In addition, finger millet has a phenolic profile that is remarkably distinct, more varied, and plentiful as compared to pearl millet. Seven of the eight essential amino acids, which the human body is unable to manufacture, are found in foxtail millet. Millet grains contain phytochemicals, they improve human health by reducing phytates and cholesterol levels. Dieticians and nutritionists must work to encourage the people to consume more millets in general and in particular considering their nutritional profile and phytochemical contribution. Due to sound nutritional benefits of millets, the best approach for combating the global panacea of pandemics like hidden hunger, diabetes, obesity, celiac disease, vitamin deficiency and so an. It will also help to reach nations target to end hunger by 2030. The main challenge is to transform the food system to achieve food and nutrition security. One of the ways to reach closer to our goal is to provide an affordable healthy and nutritious diet to all.

Keywords: Millets, nutrition, finger millet, foxtail millet, pearl millet, phenolic compounds, phytochemicals.

INTRODUCTION

One of the earliest crops to be farmed is millets, which are cereal grains belong to Poaceae grass family. Millets have a low glycemic index and are a good source of protein, fibre, minerals, iron, and calcium. Nutri-cereals are grown with little rainfall (200–600 mm) i.e. in arid and semi-arid regions. These are renowned for being nutrient-rich and possessing qualities such as drought resistance, photo-insensitivity, and resilience to climate change. About 21 states in the country, including Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Kerala, Telangana, Uttarakhand, Jharkhand, Madhya Pradesh, and Haryana, cultivate millets as a crop. Presently, India is the fifth-largest exporter of millets worldwide. India accounted for about 41% of all global manufacturing in 2020. It exported millets valued US $26.97 million in 2020–21. From 14.52 million tonnes in 2015–16 to 17.96 million tonnes in 2020–21, millets were produced. During the same time period, bajra production rose as well, from 8.07 million tonnes to 10.86 million tonnes (APEDA).

Resilient grains like millets give an affordable and nourishing alternative as the global agrifood systems face challenges to feed a growing global population, and efforts to promote their cultivation and need to be scaled up. Increased millet yield can help smallholder farmers support their families and also give young people and women respectable jobs. The revenue raised can promote economic expansion. The risks of production shocks can be reduced if millets are used as a nutritious cereal option. The International Year of Millets (IYM) 2023 push towards increasing millet production will contribute to the 2030 Agenda for Sustainable Development (FAO, 2022).

The word "millet" is commonly used to number of cereal crops, including annual food and fodder grasses that typically produce small seeds, such as foxtail millet (*Setaria italica*), pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracana*), etc. Generally speaking, finger millet (*Eleusine coracana*) and pearl millet are the two most common millets used for food and feed (*Pennisetum glaucum*). According to studies, the sub-humid uplands of East Africa and sub-Saharan Africa, respectively, are the origins of both finger millet

and pearl millet (Garí, 2020). Foxtail millet was cultivated from wild green foxtail (*Setaria viridis*) in northern China a thousand years ago (Yang *et al.*, 2012).

The most crucial factor in protecting human health and whole physical well-being is the nutritional value of food. Given that maximising human genetic potential and fostering development depend on nutritional well-being (Radhika, 2011). To maintain complete human health and fitness to address the issue of severe malnutrition, dietary quality of food should be taken into account. Along with improving yields and home practises, food production diversification must be promoted on a national and household level (Singh and Raghuvanshi 2012). Due to public misconceptions, some agricultural products are not used as the primary source of nutrition for humans. Among these millets are one. Animal and bird feed is made from millets. According (Yang *et al.,* 2012) to numerous nutritional and therapeutic benefits of millet.

According to Ramashia *et al.* (2019), millet grains are non-acid producing, easy to digest, and have a low glycemic index (Chandrasekara *et al.*, 2012). Since of the grain's low glycemic index, it is said to be a healthy choice for those with diabetes and celiac disease (a condition brought on by consuming gluten-containing cereal proteins) because it helps control blood sugar levels (Jideani and Jideani 2011). When compared to other cereal grains, the grains have a high percentage of dietary fibre, carbs, iron, and calcium. Magnesium and phosphorus are also present in significant concentrations in millet grains (Kaur *et al.,* 2014). According to (Krishnan *et al.*, 2012), polyphenols and phytates found in millet grains are known to affect the bioavailability of minerals. In addition to their nutritional value, millet has been linked to a number of potential health advantages, including the ability to delay stomach emptying and provide gastrointestinal bulk. Other potential advantages include the ability to prevent cancer and cardiovascular disorders (Kaur *et al.*, 2014; Truswell, 2002; Gupta *et al.*, 2012).

Nutritional profile of millets. Millets are comparable to conventional cereals in terms of their nutritional value, protein content, and macronutrient composition. As a result of their high quantities of calories, calcium, iron, zinc, lipids, and high-quality proteins, they considerably contribute to the diets of both humans and animals. They are also abundant providers of vitamins and dietary fibre.

Pearl Millet. Resistance starch, soluble and insoluble dietary fibres, minerals, and antioxidants were all shown to be notably plentiful in pearl millet. It has a dry matter content of 92.5%, ash at 2.1%, crude fibre at 2.8%, crude fat at 7.8%, crude protein at 13.6%, and starch at 63.2% (Ali *et al.,* 2003). The energy content of pearl millet is high (361 Kcal/100g). Starch, dietary fibre, and soluble sugars are the main types of carbohydrates found in pearl millet grains. Compared to other starches, pearl millet starches have a higher swelling power and solubility due to their amylose content, which ranges from 20 to 21.5% (Lestieme *et al.,* 2007). The starch content of different varieties of pearl millet ranges from 62.8 to 70.5%, and the soluble sugar content ranges from 1.2 to 2.6%. There are 1.2 to 2.5% of free sugars such glucose, fructose, sucrose, and raffinose (Jambunathan and Subramanian 1988; Gupta and Nagar 2010). The grain of pearl millet is gluten-free. Typically, pearl millet has a protein content of 9 to 13%. The essential amino acid profile of pearl millet protein reveals higher levels of lysine, threonine, methionine, and cystine (Adeola *et al.,* 2005). Pearl millet has the highest total lipid content of any millet, ranging from 1.5 to 6.8% (Taylor, 2004). In comparison to oleic and linoleic acids, the fatty acids in pearl millet are richer in palmitic, stearic, and linolenic acids (Adeola *et al.,* 2005). Linoleic acid is very high in pearl millet (46.3%), with over 75% of the fatty acids being unsaturated.

Because it contains significant amounts of calcium, phosphorus, magnesium, and iron, pearl millet is a valuable source of minerals (Burton *et al.,* 1972). Pearl millet had an ash level that varied from 1.6 to 3.6% (Serna *et al.,* 1994). Thiamine, niacin and riboflavin are all vital nutrients found in pearl millet grain (Taylor, 2004). 2.8 mg of niacin, 0.21 mg of riboflavin, and 0.38 mg of thiamine are all present in pearl millet grains (Hulse *et al.,* 1980).

Finger Millet. Contrarily, finger millet has a total carbohydrate level that varies from 72 to 79.5%, according to research (Bhatt *et al.*, 2003). Additionally, Wankhede *et al.* (1979a) reported that the comprehensive profile of the carbohydrates was in the range of 59.5 and 61.2% for starch, 6.2-7.2% for pentosans, 1.4-1.8% for cellulose, and 0.04-0.6% for lignin. According to Chethan and Malleshi (2007), finger millet has a protein content of between 5 and 8%. Anitha *et al.* (2019) found that the protein content of finger millet was 6.32%. The necessary amino acids present in protein are thought to influence the protein's quality. Given that it has higher levels of lysine, threonine, and valine than other millet varieties, finger millet has a rather balanced composition of important amino acids (Ravindran, 1991). Finger millet contains a total of 5.2% lipids, of which 2.2% are free lipids, 2.4% are bound lipids, and 0.6% are structural lipids. On the other hand, oleic, palmitic, and linoleic acids were found to be the primary fatty acids found in fnger millet (Kunyanga *et al.,* 2013). The overall fatty acid profile of finger millet is composed of 25.6% saturated fatty acids and 74.4 unsaturated fatty acids. According to genotypes, finger millet has natural calcium content that ranges from 162 mg/100g to 487 mg/100g, making it one of the most nutrient-dense cereals (Sankara Vadivoo *et al.,* 1998).

Foxtail Millet. The biological value of the digestible protein in foxtail millet is higher than that of rice and wheat, and it contains seven of the eight essential amino acids, which human bodies cannot generate. In comparison to finger millet, foxtail millet contains more seed protein (14–16%), crude fat (5-8%), and micronutrients (Ravindran, 1991). This is beneficial for the health of the intestines and stomach since it contains 2.5 times as much edible fibre as rice. Its bran, which is high in linoleic acid (66.5%) and oleic acid (13.9%), contains 9.4% crude oil. The starch level of this millet was found to be 65.59-74.12 g/100g, the crude protein

content was 11.85-20.58 g/100g, and the amino acid content was 0.25-4.31 g/100g, making it different from other cereals in terms of its health benefits (Sharma and Niranjan 2017). In addition, foxtail millet has 0.26 mg of vitamin B_1, 0.78 mg of vitamin E, 0.78 mg of vitamin B_2, 0.09 mg of vitamin B_6, 0.23 mg of vitamin B_6, 2.21 mg of niacin, 37.7 micrograms of folate, 364 mg of potassium, 2.39 mg of pantothenic acid, 18.2 mg of calcium, 1.3 mg of sodium, 0.59 mg of copper and 143 mg of magnesium.

Table 1: Nutritional Composition of Millets (per 100 g edible portion, Dry weight basis).

Source	Pearl millet	Finger millet	Foxtail millet
Carbohydrate (g)	60.0 – 76.0	60.0 – 80.0	59.0 – 70.0
Crude Protein (g)	12.0 – 14.0	7.0 – 10.0	11.2 – 15.0
Fat (g)	4.8 – 5.7	1.3 – 1.8	4.0 – 7.0
Crude fiber (g)	2 – 2.5	3.6 – 4.2	4.5 – 7.0
Ash (g)	2.0 – 2.2	2.6 – 3.0	2.0 – 3.5
Energy (Kcal)	363 - 412	328 – 336	330 - 350

(Source: Himanshu *et al.*, 2018)

Table 2: Mineral Composition of Millets (mg/ 100g).

Minerals	Pearl millet	Finger millet	Foxtail millet
K	440 – 442	408 – 570	250 – 400
Na	10.0 – 12.0	7.0 – 11.0	4.6 – 10
Mg	130 -137	110 – 137	100 – 130
Ca	10.0 - 46.0	240 – 410	10.0 – 30.0
P	350 – 379	240 – 320	270 – 310
Mn	1.15 – 1.8	5 – 5.5	2.19 - 26
Zn	2.95 – 3.1	2 – 2.3	2.14 – 9
Cu	0.62 – 1.06	0.4 – 4	1 – 3.0
Fe	7.49 – 8.0	3.9 – 7.5	3.26 - 19

(Source: Himanshu *et al.*, 2018)

Amino Acid Profile. Compared to wheat, rice, and oats, pearl millet has a higher amount of the essential amino acids leucine (10.7 g/100 g protein) and isoleucine (4.4 g/100 g protein). The number of essential amino acids, particularly lysine, which is often low in cereals, means that even though the protein quality in pearl millet grains satisfies the nutritional needs of an adult, it does not satisfy the protein needs of infants and children, according to FAO (1995). However, compared to maize, rye, wheat, and sorghum, pearl millet has a considerably greater lysine level (3.1 g/100 g protein).

Ragi is a rich source of amino acids, which are necessary for both body repair and regular bodily function. Tryptophan, Threonine, Valine, Isoleucine, and Methionine are all amino acids found in finger millet. Isoleucine assists in muscle recovery, and contributes to the creation of blood, bones and promotes skin health. Valine is a necessary amino acid that promotes metabolism, improves in muscle coordination, and helps in tissue repair. It supports the body's nitrogen balance. Methionine is another essential amino acid that is not present in most cereals but is important for a number of bodily functions, promotes in the removal of fat from the body, and provides the body's primary source of sulphur. The body's natural antioxidant, glutathione, is produced with the help of sulphur.

The amino acid that is lacking in foxtail millet is lysine. All millet varieties, not just foxtail millet, lack lysine. However, it includes all other amino acid. Glutamic acid, leucine, alanine, and proline were the main amino acids found in fox tail millet. There was no variation in composition between the glutinous and nonglutinous varieties of foxtail millet. The grains and seeds of Panicoideae especially show the amino acid pattern characterized by high alanine and leucine contents in marked contrast to those of other subfamilies in Gramineae. Even though the millet is deficient in lysine but not in tryptophan, though corn belonging to the same subfamily is limited in both lysine and tryptophan (WHO, 1965).

Bioactive compounds. Bioactive compounds are the compounds which available from food and having protective effect against degenerative diseases in its isolated form. It acts as a nutraceutical component.

Phenolic Compounds. The term "phenolic compounds" refers to a broad class of substances that are distinguished by the presence of an aromatic ring made up of one or more hydroxyl groups and various replacements. The three main types of phenolic substances are lignans, flavonoids, and phenolic acids. Regarding the polyphenol levels of the different finger millet types, Chethan and Malleshi (2007) found significant variances, with brown varieties having 1.2-2.3g% and white varieties having 0.3-0.5g%. They are well-known antioxidant molecules that serve as essential sources of antioxidants and prevent a variety of diseases, including cancer and cardiovascular disease, that are well-known antioxidants compound (Chandrasekara and Shahidi 2010). Dietary phenolic compounds may have a positive impact on health by lowering the risk of chronic diseases.

Phenolic Acids. Phenolic acids are aromatic compounds with one benzene ring and a carboxylic acid activity. Fumaric acid (1350 µg/g) and ferulic acid (199 µg/g) are both present in pearl millet. Pearl millet had higher levels of phenolic acids (64.8 mg/kg) than sorghum (27.3 mg/kg) when phenolic acid levels were compared with those of other grains. Ferulic acid,

vanillic acid, caffeic acid, syringic acid, and p-coumaric acid are among the prevalent phenolic acids present in finger millet grains. One of the most prevalent phenolic acids in finger millet grains is ferulic acid (trans-4-hydroxy-3-methoxycinnamic acid). It is abundant in the aleurone, pericarp, and embryo cell walls of different grains, but only in minor levels in the starchy endosperm (Chethan *et al.*, 2008).

Flavonoids. Plant secondary metabolites known as flavonoids typically have a 15-carbon backbone. Two phenyl rings and one heterocyclic ring make up its structure. Flavonoids that are good for your health include catechin, quercetin, anthocyanin, tannin, etc. Because of their pharmacological activity as radical scavengers, they are crucial for maintaining human health (Cook and Samman 1996). According to Hilu *et al.* (1978), finger millet leaves contain eight different forms of flavones: tricin, orientin, isoorientin, saponarin, orientin, and isovitexin. The yellow-green colouring that occurs at basic pH in millet flour was discovered to be caused by glucosylvitexin, glucosylorientin, and vitexin, which Reichert discovered in pearl millet in the ratio of 29:11:4. (Reichert, 1979). The only millet known to contain condensed tannins is finger millet. Compared to white finger millets' (0.04-0.06%) catechin equivalents, tannins in brown finger millets range from 0.12 to 3.47 percent (Ramachandra, 1977).

Phytic Acid. The phytate content of common millet varieties range between 170 and 470 mg/100 g whole grain and also shown 27–53% reduction in phytate content on dehulling.

Carotenoids and Tocopherols. Carotenoids are one of the many pigments that can be found in food sources. It has been determined that there are more than 600 of them. It is generally known that carotenoids have provitamin-A action. Carotenoids, however, are one of those crucial substances that function as antioxidants and offer defence against a number of ailments. According to a recent study by Asharani *et al.* (2010) the average total carotenoids content in edible millet flour was 199, 78, 173, and 366µg/100 g for finger, tiny, foxtail, and proso millets, respectively.

Vitamin E is a fat-soluble component widely found in nature consists of a family of eight different molecules. Total tocopherol content in finger (3.6–4.0 mg/100 g), foxtail and little millet varieties (~1.3 mg/100 g). Vitamin E acts as antioxidant, anti-inflammatory, decrease superoxide production in mitochondria, and anti-atherosclerotic compound.

Phytosterols. Phytosterols are desmethyl sterols, which share a common ring structure with cholesterol. These are essential structural and functional components of plant cells. Phytosterol esters have the potential to reduce blood serum LDL cholesterol levels up to 14% but no effect on HDL levels. Daily consumption of phytosterols reduces the risk of heart diseases up to 40% that depends on age and some other factors. However, the presence of sterols reduces absorption of alpha and beta-carotene and also of Vitamin E. Etherification, emulsification, and solubilization mechanisms adversely affect their bioavailability. Sterol content of finger millet was reported to be 0.149% on seed weight basis, (Mahadevappa and Raina (1978) whereas other millets contain only trace amount.

Table 3: Mode of Action of Nutrients and Health benefits of Millets.

Nutrients	Mode of Action	Health Benefits	Source
High fiber content	Sugars are slowly released	Helps in diabetes Helps in constipation, Intestinal cancer	Verma and Patel *et al.* (2012)
Gluten free	Complex Carbohydrate	Helps in Celiac disease	Dayakar *et al.* (2013)
Phytochemicals	Phenolic acids and flavonoids	Overall health management	Shahidi *et al.* (2013)
Nutraceuticals	Antioxidant activity Anti-microbial	Prevent disease risk Helps as prebiotic and probiotic Anti diabetic Anti tumorigenic	Devi *et al.* (2014)

(Source: Ambati and Sucharitha 2019)

HEALTH BENEFITS

Obesity. Obesity is now a prevalent issue that is linked to a number of other disorders, including diabetes, high blood pressure, and cardiac issues. According to studies, eating foods high in fibre helps to improve bowel function, lower the prevalence of obesity, and lower the chance of developing chronic diseases by enhancing the body's digestion and absorption. Millets aid in controlling weight and lowering obesity in addition to satisfying hunger. Millets' high fibre content reduces issues including constipation, gas, bloating, and cramping in the stomach. The retention of gastrointestinal conditions like ulcers and colon malignancies is reduced with proper digestion and absorption (Reddy, 2017).

The biggest rising issue in India is obesity, which is linked to many chronic illnesses like diabetes and cardiovascular disease (CVD). Recent research demonstrates that eating foods high in dietary fibre reduces the prevalence of obesity (Alfieri *et al.*, 1995). Consuming foods high in dietary fibre lowers the chance of developing chronic diseases by improving intestinal function and slowing the digestion and absorption process (Ali *et al.*, 1982).

Diabetes. People who eat millet have been found to have lower diabetes rates. By partially blocking the enzymatic breakdown of complex carbs, millet

phenolics prevent postprandial hyperglycemia, much like alpha glucosidase does (Shobana *et al.,* 2009). Aldose reductase inhibitors limit the buildup of sorbitol and lower the incidence of diabetes-related cataract disorders (Chethan *et al.,* 2008). In diabetic rats, finger millet feeding reduces blood glucose levels, enhances antioxidant status (Hegde *et al.,* 2005) and speeds up the healing of diabetic rats (Rajasekaran *et al.,* 2004).

Due to the high fibre content of finger millet, diets demonstrated a low glycemic response. They also aid in the healing of dermal wounds. Strong evidence from studies supports the role of finger millets protein in preventing cataractogenesis in humans.

We know that millions of individuals worldwide suffer from diabetes, which is a disease. millets aid in the prevention of Type II Diabetes, Because it contain a significant amount of magnesium,. By generating a large number of carbohydrate-digesting enzymes that regulate insulin action, magnesium is a significant mineral that aids in improving the efficacy of insulin and glucose receptors (Reddy, 2017).

Cardiovascular disease. Millets are a good source of magnesium, which has been found to reduce the symptoms of heart attacks and migraines. There are many phytochemicals in millets, including phytic acid, which is known to reduce cholesterol (Coulibaly *et al.,* 2011). In hyperlipidaemic rats, finger millet lowers plasma triglycerides, which may protect against cardiovascular disease (Lee *et al.,* 2010). According to studies, regularly consuming whole millet grains lowers the incidence of CVD.

Additionally, millets contain plant lignans, a type of prebiotic fibre that is fermented by bacteria in our digestive tract and can be converted to animal lignans by the microflora inside digestive track. These animal lignans have been found to be protective against a number of chronic diseases. They are fermented to produce enterolactone, a substance with a reputation for preventing heart disease and some types of breast cancer (Reddy, 2017).

Cancer. The "antinutrients" phenolic acids, tannins, and phytate are abundant in millets. However, in animals, these antinutrients lower the risk of breast and colon cancer. According to in vitro studies, millet's phenolic content may be useful in preventing the onset and progression of cancer (Chandrasekara and Shahidi 2011).

Celiac Disease. Celiac disease is a genetically susceptible problem triggered by the consumption of gluten. As the millets are gluten free, they help in reducing the celiac disease by reducing the irritation caused by the common cereal grains which contain gluten (Saleh *et al.,* 2013).

By controlling the digestive process, one can retain more nutrients and lower their risk of developing more severe gastrointestinal disorders like gastric ulcers or colon cancer. Millets' high fibre content aids in the eradication of conditions including constipation, excessive gas, bloating, and cramps. Celiac disease is an immune-mediated enteropathy condition that, in susceptible people, is typically brought on by consuming gluten. Millets are suitable for people with celiac disease since they are gluten-free and have a lot of potential in foods and beverages. They can also help meet the growing demand for gluten-free products.

CONCLUSION

Millets are small seeded annual grasses that are cultivated as grain crops, primarily on marginal lands in dry areas in temperate, subtropical and tropical regions. Millets are less expensive and nutritionally superior to other grains. It provides bunch of nutrients like high protein, fibre, vitamins and minerals like iron content. In developing country, occurrence of malnutrition and various health problems like obesity, diabetes, cardiovascular disease, skin problems, cancer, celiac disease etc. are most prominent because of inadequate supply of nutrition. This is mainly due to unawareness of people and lack of knowledge to people about nutritional value of agriculture crops and its role in human health.

The main aim of review is to make awareness among people to recognize the importance of food and to introduce the millets as a nutritious food, fulfilling the nutritional need and to reduce the problems of malnutrition and other health problems. millet foods are having significant health benefits, with their rich content of nutrients like fibre which helps in metabolic disorders like Diabetes, Obesity, Cardiovascular diseases etc, their good protein content which helps in child growth and development, with calcium content which helps in the bone development in both children and geriatric people, with good iron content helps in ailing of anaemia and with gluten free characteristics helps the celiac disease patients and helps in gluten insensitivity. Phytosterols and policosanols are cardio-protective compounds present in the waxy layers of the millet. This study showed that millets act as medicine and it is best source of nutraceutical for human.

FUTURE SCOPE

Millets are important crops in semiarid and tropical regions of world due to their resistance to pests and diseases. They provide more significant health benefits due to their high fiber, minerals, vitamins, macro-micronutrients and phytochemicals. Millets are highly nutritious crop as it contain considerable amounts of vitamins and minerals. So it will help to combat food insecurity and malnutrition. Due to high nutrient value of millets, it will help to prepare different value added products from it and it will be one of the way to reach target to end hunger by 2030 by providing affordable healthy and nutritious diet to all.

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Conflict of Interest. None.

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