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Nutraceutical Potentials of Millets (Shri-Annam): An Overview

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ABSTRACT

Millet is rich in polyphenols and other biologically active compounds, it is also believed to play a role in lowering the rate of fat absorption and slow release of sugar (low glycemic index), thereby reducing the risk of heart disease, diabetes and hypertension. Due to the increased awareness of millet's health-promoting profile, there has been an inclination to consume it. This report addresses the agricultural requirements, nutritional information and health benefits offered by these grains. It also examines traditionally produced millet-based products and the latest research conducted around the world. Millet is nutritionally similar or even superior to the major cereals. The additional benefits of millet such as gluten-free protein, high fibre content, low glycemic index and richness in bioactive compounds make it a suitable health food.

Key words: Bioactive compounds, Gluten free, Health promoting, Millet.

Sustainable crop substitutes are required to meet the world hunger (Cereal demand) and to progress income of farmers. Function of millets cannot be unobserved for achieving sustainable means for nutritional security. International crops research institute for the semi-arid tropics (ICRISAT) is focusing on increasing the productivity of millets and has included finger millet (*Eleucine corcana*) as sixth mandatory crop. Millets abode crucial nutrients and the protein content of millets grains are considered to be equal or better-quality in contrast to wheat (*Triticum aestivum*), maize (*Zea mays*), sorghum (*Sorghum bicolor*) and rice (*Oryza sativa*) grains. The role of millets in producing the new foods like multigrain and gluten-free cereal foodstuffs is well known (Saleh *et al*., 2013).

Because millet is rich in polyphenols and other biologically active compounds, it is also believed to play a role in lowering the rate of fat absorption and slow release of sugar (low glycemic index), thereby reducing the risk of heart disease, diabetes and hypertension. Due to the increased awareness of millet's health-promoting profile, there has been an inclination to consume it. This report addresses the agricultural requirements, nutritional information and health benefits offered by these grains. It also examines traditionally produced millet-based products and the latest research conducted around the world.

Agricultural importance of millet

The demand for food will increase proportionally with the growth of the world's population. Currently, about 50% of the total caloric intake of the world population is derived directly from cereals. Rice, wheat and maize have become the most important staple foods, while sorghum and millet play a lesser role. Awika (2011) reported that expansion of the area under crops with high water demand such as rice, sugarcane (*Saccharum officinarum*) and cotton (*Gossypium*) has resulted in a 0.009% increase in the distance between the ground level and the water table; this loss is approximately equivalent to a loss of 7191 Litre of groundwater per hectare. There is a reduced possibility of increasing the production of major staple crops as the world is already facing the challenges of increasing drylands and lowering groundwater levels (Awika, 2011).

Millet can be a good alternative to wheat, especially on acidic soils. Rice is very sensitive to saline soils and has poor growth and yield on soils with salinity greater than 3dS/m. On the other hand, millet species such as pearl millet (*Pennisetum glaucum*) and finger millet can grow up to soil salinity of 11-12 dS/m. Millets have low water requirements, both in terms of growing season and total water requirements during growth.

The rainfall requirement of certain millet species such as pearl millet and panicle millet (*Panicum miliaceum*) is as low as 20 cm, several times lower than that of rice, which requires an average of 120-140 cm of rainfall. Most millets mature within 60-90 days after sowing, making it a water-efficient crop. Among millets, panicle millet (*Echinochloa frumentacea*) has the shortest maturity time of 45-70 days, which is half that of rice (120-140 days). Millet belongs to the group of C_4 cereals (major C_4 crops such as maize, sugarcane, sorghum and pearl millet).

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C_4 cereals absorb more carbon dioxide from the atmosphere and convert it to oxygen, have high water use efficiency, require low input and are therefore more environmentally friendly. Thus, millets can help offset climatic vagaries by reducing atmospheric carbon dioxide and contributing to climate change mitigation (Saleh *et al*., 2013).

Nutritional significance

The world is in a clinch with various health disorders and chronic diseases. According to the Global Nutrition Report 2016, 44% of the population in 129 countries (countries with available data) have very high levels of adult under-nutrition, overweight and obesity. An unbalanced diet is responsible for most of these diseases. According to the estimates of the Food and Agriculture Organisation of the United NationsUnited Nations Food and Agriculture Organisation, about 795 million people (10.9% of the world population in 2015) are undernourished.

On the other hand, more than 1.9 billion (39% ofthe world population) adults ≥18 years of age were overweight and another 13% were described as obese. The average body mass index (BMI) of the world population in 2014 was 24 kg/m^2, which is higher than the standards for optimal health (21 to 23 kg/m^2) reported at WHO (2016). Obesity-related complications such as cardiovascular disease and diabetes have already been declared an epidemic by the World Health Organisation.

India hosts the largest undernourished population in the world. About 194.6 million people, or 15.2% ofIndia's total population, are undernourished. According to the 2017 World Hunger Index report, India ranks 100th out of 119 countries. India's score is even worse than Nepal, Sri Lanka and Bangladesh (Von Grebmer *et al*., 2017). According to reports, protein-energy malnutrition (PEM) leads to 4,69,000 deaths and 84,000 deaths due to the lack of other essential nutrients such as iron, iodine and vitamin A (Lozano *et al*., 2012). Obesity is also a major health problem in India with a prevalence rate of 11% in men and 15% in women. Millets rank sixth in global agricultural production of cereal grains and are still a staple food in many regions of the world. They are a rich source of many essential nutrients and therefore promise to provide additional benefits in combating nutrient deficiencies in third world countries.

Macronutrients

Millet is nutritionally similar or even superior to the major cereals. The additional benefits of millet such as gluten-free protein, high fibre content, low glycemic index and richness in bioactive compounds make it a suitable health food (Kannan *et al*., 2013). The average carbohydrate content of millet varies from 56.88 to 72.97 g/100 g. The lowest carbohydrate content was found in panicle millet (Siroha *et al*., 2021). The protein content of all millets is comparable with an average protein content of 10 to 11%, with the exception of finger millet, for which a protein content of 4.76 to 11.70 g/100 g has been reported in various studies (Singh and Raghuvanshi, 2012). Finger millet protein is rich in essential amino acids such as methionine, valine and lysine and of the total amino acids present, 44.7% are essential amino acids. This content is higher than the required 33.9% essential amino acids in the FAO reference protein (Mbithi-Mwikya *et al*., 2000; Millward, 2012). The protein content of panicle millet is comparable to that of wheat, but the content of essential amino acids such as leucine, isoleucine and thiamine is much higher in panicle millet. The lipid content of millet as a group is comparable to that of wheat and rice (2.0% in wheat and 2.7% in rice) and ranges from 1.43 to 6 g/100 g. Among millets, the lowest lipid content was found in finger millet, while the highest lipid content was found in pearl millet (Manisseri and Gudipati, 2012; Mathanghi, 2012). Millet is the richest source of dietary fibre, *i.e*., both crude fibre and dietary fibre. With an average content of 12.8 g/100 g, panicle millet is the richest source of crude fibre. The highest dietary fiber contents, 38% and 37%, were found for small millet (*Panicum sumatrense*) and kodo millet (*Paspalum scrobiculatum*) were reported. This content is 785% higher than that of rice and wheat, making millet a low glycemic food and thus a good choice for diabetics. *In vitro* studies of the soluble polysaccharides of finger millet (mainly arabinose and xylose) have shown that they are potent prebiotics and also have wound healing potential (Shobana and Malleshi, 2007; Englyst *et al*., 1992). This resistant starch contributes to the dietary fiber that acts as a prebiotic, thus enhancing the health benefits of millet (Das and Rakshit, 2016). Resistant starch also contributes to the production of desirable metabolites such as short-chain fatty acids in the colon, especially butyrate, which helps to stabilize cell proliferation in the colon, thus providing a prevention mechanism for colon cancer (Pontieri *et al*., 2014).

Micronutrients

The minerals and vitamins are called micronutrients because they are required in very small amounts. Minerals play an important role in bone formation, blood clotting, sending and receiving signals, maintaining a normal heartbeat, energy production in cells, oxygen transport, metabolism and synthesis of fats and proteins, functioning as co-enzymes, immunity of the body and proper functioning of the nervous system (Aggarwal *et al*., 2012). The mineral content of millet ranges from 1.7 to 4.3 g/100 g, several times higher than that of staple foods such as wheat (1.5%) and rice (0.6%). Calcium and iron deficiency are common in India. The calcium content of finger millet is about eight times higher than that of wheat and as the richest source of calcium (348 mg/100 g), it has the ability to prevent osteoporosis. Foxtail millet and pearl millet are rich in iron and their consumption can meet the iron needs of pregnant women suffering from anemia. The iron content of foxtail millet is 17.47 mg/100 g, which is only 10 mg below the required daily value. Foxtail millet contains the highest level of zinc (4.1 mg/100 g) among all millet species and is also

a good source of iron (2.7 mg/100 g) (Soetan *et al*., 2010). These nutrients, *i.e*., zinc and iron, play an important role in strengthening the immune system. Millet is also a good source of β-carotene and B vitamins, especially riboflavin, niacin and folic acid. The thiamine and niacin content of millet is comparable to that of rice and wheat. The highest thiamine content in millet, 0.60 mg/100 g, is found in foxtail millet. The riboflavin content of millet is several times higher than in staple foods and foxtail millet (4.20 mg/100 g) has the highest content of riboflavin, followed by foxtail millet (1.65 mg/100 g) and pearl millet (1.48 mg/100 g). Inclusion of millet in the diet may help to correct nutrient deficiencies. Platel (2013) has suggested the use of millet flour as a means of fortifying iron and zinc in India.

Phenolic compounds

Phenolic compounds form a very large group of compounds containing the phenolic functional group as the main constituent. They can be divided into phenolic acids, flavonoids and tannins.

Phenolic acids are further subdivided into hydroxybenzoic acids, hydroxycinnamic acids, hydroxyphenylaceticacids and hydroxyphenylpropanoic acids. Chandrasekara and Shahidi (2011) determined and characterized the free, hydrolyzed (esterified and etherified) and bound phenolic compounds in millet using HPLC-DAD-ESI-MSn. The highest amounts of hydroxybenzoic acid derivatives (62.2 µg/g) and flavonoids (1896 µg/g) were found in the soluble fraction of finger millet. Lesser millet (173 µg/g) and field foxtail millet (171 µg/g) had the highest content of hydroxycinnamic acid and its derivatives insoluble form.

The highest contribution to the total phenolic content is in the form of insoluble phenols bound to the cellwall. Flavonoids are more abundant in freeform.

Millet phenols have been reported to have antioxidant, antimutagenic, antiestrogenic, anti-inflammatory, antiviral and platelet aggregation inhibitory activities (Devi *et al*., 2014). The total antioxidant capacity of finger, small, foxtail and panicle millet is higher due to their high total carotenoid and tocopherol content, which varies from 78 to 366 and 1.3 to 4.0 mg/100 g, respectively, among different millet varieties (Dykes and Rooney, 2006). The beneficial effect of phenols in diabetes is due to the partial inhibition of amylase and α-glucosidase in the enzymatic hydrolysis of complex carbohydrates and delays the absorption of glucose, which ultimately controls postprandial blood glucose level.

Other health benefits

Sireesha *et al*. (2011) demonstrated the anti-hyperglycemic and anti-lipidemic effects of the aqueous extract of foxtail millet (*Setaria italica*) in streptozotocin-induced diabetic rats. In the study, they reported that a dose of 300 mg of the aqueous extract of *Setaria italica* seeds per kilogram (kg) of body weight resulted in a significant decrease (70%) in blood glucose levels in diabetic rats after 6 hours of administration of the extract. They also found lower levels of triglycerides, total LDL (low-density lipoproteins) and VLDL cholesterol (very low density lipoproteins) and an increase in HDL cholesterol (high density lipoproteins) cholesterol in the rats treated with diabetes compared with the rats untreated with diabetes, demonstrating the hypolipidemic effect of the aqueous extract Choi *et al*. (2005) investigated the effect of dietary proteins from Korean foxtail millet and found that they improved insulin sensitivity and cholesterol metabolism. In this experiment, a remarkable reduction in insulin concentration was demonstrated in rats fed field millet.

Effect of processing millets

Processing millet reduces the nutrient-hostile factors in millet and improves the bioavailability of nutrients. Traditionally, many processing methods have been used, such as roasting/chopping, soaking, sprouting and fermenting (Jaybhaye and Srivastav, 2015). All of these methods have been reported to have a significant impact on the nutritional value of the grain. Malting millet improves access to nutrients and has been reported to increase the bioavailability of iron by 300% and manganese by 17% (Platel *et al*., 2010). Antinutritional factors decreased significantly with increasing germination duration, which was attributed to the hydrolytic activity of the enzyme phytase, which increases during germination.

The phytate content of millets can be reduced by germination because the hydrolysis of phytate phosphorus to inositol monophosphate occurs during germination, which contributes to the reduction of phytic acid acidity. Tannins are also leached out during soaking and germination of grains, which leads to a reduction in tannins (Handa *et al*., 2017). Influence of processing on dietary fiber, tannin and *in vitro* protein d. Cooking and pressure cooking also lead to a reduction in tannins. Fermentation is known to reduce anti-nutritional factors and thus improve protein digestibility. Irradiation has also shown an inhibitory effect on anti-nutrients and improves protein digestibility (Pushparaj and Urooj, 2011). Extrusion cooking or high temperature short time processing (HTST) has been shown to reduce antinutrients such as phytates and tannins and increase mineral bioavailability (Mathanghi, 2012).

CONCLUSION

From the above review it is concluded that Millets abode crucial nutrients and the protein content of millets grains are considered to be equal or better-quality in contrast to wheat (*Triticum aestivum*), maize (*Zea mays*), sorghum (*Sorghum bicolor*) and rice (*Oryza sativa*) grains. The role of millets in producing the new foods like multigrain and gluten-free cereal foodstuffs is well known. Millet can be a good alternative to wheat, especially on acidic soils. Rice is very sensitive to saline soils and has poor growth and yield on soils with salinity greater than 3 dS/m. On the other hand, millet species such as pearl millet (*Pennisetum glaucum*) and finger millet can grow up to soil salinity of 11-12 dS/m. Millets have low water requirements, both in terms of growing season and total water requirements

during growth. Because millet is rich in polyphenols and other biologically active compounds, it is also believed to play a role in lowering the rate of fat absorption and slow release of sugar (low glycemic index), thereby reducing the risk of heart disease, diabetes and hypertension. Due to the increased awareness of millet's health-promoting profile, there has been an inclination to consume it.

Conflict of interest

we both authors do not have any conflict of interest.

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