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Millet: A nutraceutical grain that promises nutritional security

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ABSTRACT

The continued use of crop varieties introduced by Green Revolution that focus entirely on high yield and compromise on nutritional quality, has led to the advent of diet-related diseases in recent times that need to be combated with nutraceutical food products. Nutraceuticals are foods which provide medicinal benefits along with essential nutrients to prevent and treat chronic diseases such as diabetes mellitus, cardiovascular ailments and certain types of cancers. Millet is a rich source of macronutrients and micronutrients such as Starch, Protein, Zinc, Potassium, Calcium, Magnesium, Iron, antioxidants and essential amino acids. These along with the presence of avenanthramides, flavonoids, polycyanins, lignins and polysterols in them, imparts a medicinal value to the diet. Thus, millet consumption improves the nervous system, reduces cholesterol, blood pressure, osteoporosis, osteopenia and blood sugar levels. Being non-glutinous and non-acid forming they are excellent nutraceuticals for coeliac patients and people with digestive disorders. They are highly popular for their low Glycemic Index (GI) property which reduces the post-prandial blood glucose level for special importance in patients with type 2 diabetes. Overall, millet is an abundant and versatile food resource which requires further exploration for the utilization of its nutraceutical benefits.

Key words : *Nutraceutical, Millet, Nutritional Security.*

Introduction

Human dependence on food for good health is well founded. However, careless dietary intakes, solely for the purpose of survival may hamper normal physiological processes which require careful nutritional behavior (Bouis, 2011). The world is suffering with nutritional imbalance due to complete dependence on only 1% of the edible plant resources (Hummer, 2015). Integration of the human diet with food sources that can both nourish and heal is essential. Fortified foods which enhance the therapeutic well-being of humans, in addition to providing the traditional provision of nutrients, have been termed as nutraceuticals or functional foods (Singh, 2019).

The concept of functional foods first originated in Japan in the 1980s, and has been extensively utilized since then. These foods which provide medicinal advantages along with nutritional dosages, and sometimes interchangeably called as 'nutraceuticals', have now been granted the status of Foods for Specified Health Use (FOSHU) (Saito, 2007). A variety of these products, such as whole oats, with the bioactive component β-glucan that reduces total cholesterol, or tomatoes with enhanced lycopene to reduce certain types of cancers, are now gaining popularity in today's market of health promoting foods (Lobo, 2010). A highly recommended functional food of animal origin is the (n-3) fatty acid from fishes such as salmon and tuna, which is known to reduce deaths due to myocardial infarction (Holub, 2004). A number of plant food sources such as cranberries, grapes, garlic and chocolate have also been investigated for their potential as functional foods, however, documentary evidences from them have not yet cleared FDA approvals as health foods. Millet, a cereal grain with a wide range of health benefits including the presence of micronutrients and phytochemicals that reduce the risk of cancer, or a lower Glycemic Index (GI), which makes it a therapeutic food for diabetic patients, is fast gaining the attention of researchers (Dayakar, 2017). All in all, the study and use of functional foods is an active area of research and promises excellent breakthroughs in the field of health and nutrition science.

Millets as Nutraceuticals

Since the past few decades, considerable effort is being devoted to finding new sources of medicines, but ancient food resources which provide therapeutic benefits are not being extensively explored. Millet is one such group of potential nutraceutical, which has been long forgotten in spite of its extensive use in ancient times. They are a group of small-grained grasses belonging to the family Poaceae, which provide food and nutritional security along with medicinal benefits (Singh, 2019). These climate compliant food crops are abundantly available in developed as well as developing countries which are poor in resources but rich in biodiversity. Millet grain species fall into two major categories, namely, the major millets, and the minor millets. Pearl millet (*Pennisetum glaucum*) and Sorghum (*Sorghum bicolor*) classify as major millets. The minor millets category is comprised of Foxtail millet (*Setaria italica*), Proso millet (*Panicum miliaceum*), Finger millet (*Eleusine coracana*), Kodo millet (*Paspalum scrobiculatum*), Barynard millet (*Echinochloa frumentacea*) and Little millet (*Panicum sumatrense*) (Singh, 2019).

As compared to the three major cereal grains of the world, namely, wheat, rice and maize, millets not only provide the highest number of calories following wheat and rice, but also supplement the diet with micronutrients, essential amino acids, polyphenols, avenanthramides, flavonoids, polycyanins, lignins and polysterols (Belton, 2004). Millets have secured their place as the sixth most quantitatively important cereal grain in the world following maize, rice, wheat, barley and sorghum, owing to the presence of significant amounts of protein, amylose, dietary fiber, minerals, such as, Calcium, Iron, Magnesium, Potassium, antioxidants and essential amino acids, such as lysine (Table 1).

Nutritional and Medicinal Property of Millets

Calcium is an essential mineral that is required for overall cellular function, and is specifically required in pregnant and nursing mothers, young children and the elderly population to prevent malnutrition. Consumption of millets rich in calcium, such as finger millet, improves the overall health of these populations groups (Dayakar, 2017). The incidence of osteoporosis and osteopenia is dramatically reduced with the consumption of calcium rich millets, such as finger millet. The micronutrients in millets impart a multidimensional value to them, making them nutritious sources of energy which can act as a personalized medicine or health promoting food. Due to the presence of polyphenols and tannins, millets possess anti-hypertensive properties, which may prevent certain types of cancer. The phytocyanins, phytosterols and polyphenols present in them boosts the human immune system and delays age-onset diseases (Bravo, 1998). These therapeutic compounds also act as antioxidants and detoxifying systems to reduce the risk of degenerative ailments such as Parkinson's disease and certain other metabolic syndromes. These long forgotten grains originally grown and consumed in Eurasia and Africa have helped in treating diseases originating from nutritional deficiencies since ancient civilizations (Devi, 2014).

The nutraceutical significance of a millet grain arises from its intelligently packed combination of macronutrients and micronutrients. Although, all the millet species have nutraceutical properties, each species differs in the type of medicinal benefit they provide. Typically, a millet grain contains macronutrients and micronutrients in the range of 7-12% protein, 18-20% dietary fiber, 60-75% carbohydrates and 2-5% fat (Dayakar, 2017). This combination of nutrients makes them suitable nutraceuticals that provide a balanced source of nutrition and medicinal value, especially in populations recommended to have specialized dietary requirements, such as for patients suffering from coeliac disorders and diabetes. When compared to other cereal grains such as maize, the millet grain proteins possess an excellent profile of amino acids. Pearl millet is rich in niacin, and finger millet is abundant in sulphur

Table 1. Proximate composition of various small millet cultivars.

Millet/cultivars	Protein ($g\ kg^{-1}$)	Starch ($g\ kg^{-1}$)	Amylose ($g\ kg^{-1}$)	Fat ($g\ kg^{-1}$)	Moisture ($g\ kg^{-1}$)	Ash ($g\ kg^{-1}$)	Ca ($g\ kg^{-1}$)	P ($g\ kg^{-1}$)	Na ($g\ kg^{-1}$)	K ($g\ kg^{-1}$)	Mg ($g\ kg^{-1}$)
1. Foxtail millet											
Krishnadevaraya	125±1.5	468±13.1	111±3.6	37±2.3	85±5.0	31±0.6	0.20±0.06	4.10±0.24	0.60±0.09	5.43±0.59	2.03±0.22
Prasad	113±4.8	512±17.5	165±3.6	37±2.5	84±9.0	32±0.6	0.19±0.06	7.15±0.66	0.54±0.08	7.72±0.34	3.02±0.40
SiA3085	116±1.8	467±2.2	163±10.1	39±0.9	85±6.5	31±1.0	0.20±0.06	4.88±0.71	0.54±0.10	6.23±0.49	2.28±0.08
SiA3156	126±5.5	521±13.2	149±6.6	36±1.2	86±7.5	31±0.6	0.19±0.06	6.23±0.11	0.58±0.09	7.95±0.11	2.83±0.17
Suryanandi	119±1.5	499±4.4	150±1.2	39±2.6	85±6.0	30±1.0	0.21±0.04	5.97±0.63	0.58±0.10	7.20±0.49	2.91±0.11
Srilakshmi	126±4.8	466±2.2	144±1.8	37±1.0	83±8.0	33±2.0	0.23±0.06	7.08±0.55	0.62±0.10	9.23±0.83	3.42±0.28
Narasimharaya	129±2.5	482±6.6	144±6.0	36±1.0	85±6.5	32±0.6	0.19±0.06	4.16±0.86	0.61±0.10	6.21±0.76	1.61±0.18
Group mean	122[a]	488[a]	146[a]	37[a]	85[#]	31[#]	0.20[a]	5.65[a]	0.58[#]	7.14[a]	2.59[a]
3. Barnyard millet[1]											
Oodalu	126±2.2	482±10.9	89±4.2	39±0.09	86±7.0	38±1.0	0.20±0.06	6.17±0.43	0.68±0.04	7.92±0.78	3.08±0.19
VL172	101±1.5	542±4.4	119±3.6	36±0.10	85±6.5	36±2.0	0.22±0.04	5.33±0.37	0.69±0.05	7.34±0.39	2.40±0.11
Group mean	113[a]	512[b]	104[c]	38[a]	86[#]	37[#]	0.21[a]	5.75[a]	0.69[#]	7.63[a]	2.74[a]
6. Finger millet[1]											
Ragi Vakula	97±2.2	622±11.0	167±1.8	21±0.2	86±6.0	39±2.0	0.91±0.08	5.09±0.76	0.65±0.04	11.23±0.02	3.74±0.21
Chempavati	106±3.5	656±10.9	114±1.8	21±0.2	87±6.5	36±2.0	0.92±0.05	5.44±0.49	0.53±0.04	9.86±0.94	2.54±0.16
FMAVT 2	92±2.5	511±11.0	128±4.8	24±0.6	87±6.0	35±1.0	0.90±0.04	5.84±0.87	0.68±0.10	8.37±0.52	3.13±0.24
Group mean	98[b]	596[e]	146[a]	22[c]	87 [#]	37[#]	0.91[b]	5.46[a]	0.62[#]	9.82[d]	3.14[b]

Pasha, 2018 (*Journal of the Science of Food and Agriculture, 98*(2), 652-660)

containing amino acids. Pearl millet contains high protein (12-15%), while finger millet has a higher calcium (300-350 mg/100 g) level and a lower fat content (2-5%). All the minor millets are rich in iron and phosphorous (Dayakar, 2017). However, the amount of lysine contained in millets is insufficient as recommended for the daily recommended intake, but this is the same with other major cereal grains as well. In their whole grain form of consumption, the dietary fibre and polyphenols contained in the seed coat of millets contributes to increasing their nutraceutical significance. Processing technologies such as malting, cooking, decortication and hydration help reduce the level of unwanted antinutrients present in millet grains, which are known to limit the bioavailability of vitamins and minerals (Taylor, 2016).

Kodo millet and Little millet have the highest percentage of dietary fibre (37%-38%) among all cereal grains and have already been categorized as nutraceutical products. Kodo millet contains high levels of the fatty acid, Lecithin, which is essential for improving the health of the nervous system. Kodo millet contains high percentages of B vitamins such as vitamin B6, folic acid and niacin, along with minerals such as zinc, calcium, magnesium and potassium. These enable kodo millet to act as a therapeutic food for women in the postmenopausal stage, preventing them from developing conditions such as high cholesterol and high blood pressure. Little millet has been found to contain high levels of carotenoids in the range of 78-366 mg/100g, and has been identified as a nutritious source of fodder. Its drought resistance capabilities and ability to grown in adverse agronomic conditions intensifies its role as a nutraceutical during crop failure. Millets are also considered to be a wonder grain for coeliac patients, who suffer from gluten allergy (Dayakar, 2017).

Medicinal Benefits to the Diabetic Community

Millets have gained immense popularity as nutraceuticals owing to their being foods with a higher dietary fibre and a lower glycemic index of 50.0, especially in the dehulled varieties of barnyard millet, and in the heat treated samples (41.7) (Ugare, 2014). In individuals with diabetes, the absence or delayed secretion of insulin exacerbates postprandial hyperglycemia (Kahn, 2000). Foods with a low glycemic index, such as millets can help normalize the fasting blood glucose concentration, improve glycated protein concentrations, and elevate insulin sensitivity in diabetic and non-diabetic subjects (Brand-Miller, 2003; Livesey, 2008). They play a role in the treatment and prevention of chronic diseases such as type 2 diabetes (Esfahani, 2009), by reducing post-prandial glucose and insulin levels by evading digestion in the small intestine and being fermented in the large intestine to be transformed into volatile fatty acids, etc., thus preventing a rapid increase in post-meal blood sugar levels (Jenkins, 1977). Studies on barnyard millets as low glycemic index foods have revealed their nutraceutical significance in lowering the post-prandial blood glucose level to prevent and treat type 2 diabetes. These studies used millets as food combinations with amaranth and buckwheat.

Finger millet has been shown to treat dermal wounds and accelerate the healing process due to its antioxidant property and ability to clinically reduce blood sugar levels. Its anti-diabetic property has been evaluated by its ability to inhibit aldose reductase (AR) activity (Pradhan, 2010). Gallic acid, p-coumaric acid, p-hydroxy benzoic acid, trans-cinnamic acid, syringic and ferulic present in finger millets causes it to have a role in inhibiting cataractogenesis in the human eye (Chethan, 2008). While Proso millet improves insulin response and glycemic value, pearl millet is known to increase insulin sensitivity to alleviate the symptoms of diabetes and maintain a controlled level of glucose in the blood of patients suffering from type 2 diabetes (Dayakar, 2017).

Millet Biodiversity for Nutritional Security

Crops such as millets are excellent resources to combat food and nutritional requirements emerging in recent times. These cereal grains have the potential to feed the world population with adequate calories along with providing nutritional and therapeutic benefits. In the twentieth century, Green Revolution had revolutionized the face of agriculture by providing high-yielding varieties of wheat, rice and maize, which immediately resolved the problem of food insecurity but over time had led to nutritional insecurity and the excessive use of foods that do not offer any therapeutic benefits, thus leading to nutrient-deficiency related diseases (Zhao, 2009). There is an inherent need to incorporate nutritious grains, which also supplements our diet with medicinal value, and whose continued use over time can lead to the treatment and prevention of chronic diseases such as cardiovascular ailments, diabetes mellitus and certain types of cancers.

Diets which are comprised of a single cereal grain may lead to malnutrition. It is advisable to diversify diets with alternate sources of carbohydrates that are enriched with micronutrients and bioactive components (Cheng, 2018; Buchanan-Wollaston, 2017; Massawe, 2016). This is especially required in developing countries which are deprived of resources but rich in biodiversity. The semi-arid tropics of India and sub-Saharan Africa are major consumers of millets as their primary source of carbohydrate (Kawase, 2005). In such regions millets serve as excellent commodities for diet diversification to alleviate malnutrition in the local population and provide them with cheaper alternatives of nutraceutical benefits (Cheng, 2018). Although millets are highly nutritious as compared to wheat, rice and maize, the vast biodiversity of millets present in hot and cold semi-arid regions has not been extensively explored or substantially utilized. There is a need to explore and utilize millet biodiversity present in geographically and environmentally distinct regions as well. Millets grown in cold semi-arid regions, exhibiting low temperatures are potential candidates for revealing germplasm that produces higher levels of nutrients such as protein and amylose. Lower temperatures increase amylose accumulation by stimulating enzyme activity. In earlier studies, the amylose concentration in wheat and rice was found to be higher due to an increased Granule Bound Starch Synthase activity, which was higher in rice grains grown at 15 °C compared to 25 °C (Umemoto, 1995). Similar increase in amylose concentration was reported in maize crops which experienced higher number of cold days during growth (Fergason, 1962). These evidences indicate that millet populations growing at cold temperature regions may have differences in their mechanism of starch biosynthesis and eventual amylose concentration as compared to the populations growing in warm or hot semi-arid regions.

Recommendations

In spite of the vast diversity of millet species in India only Pearl millet has been categorized for iron biofortification by the International Crops Research

Institute for the Semi-Arid Tropics (ICRISAT). The authors recommend exploring and utilizing the vast diversity of other major and minor millet species in India for biofortification purposes. Farmers are encouraged to grown and propagate local landraces and cultivars with phenotypic differences such as improved grain number (kernels per spikelet), grain weight, larger grain size and light-colored pericarp (low tannin).

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