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Antioxidant Properties of Pearl Millet (*Pennisetum glaucum*)

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ABSTRACT

Pearl millet (Pennisetum glaucum), also known as Bajra, is one of the four most important millets grown in tropical semi-arid regions of the world primarily in Africa and Asia. Pearl millet is rich in several nutrients as well as non-nutrients such as phenols. It has high energy, high fiber, has less starch, low glycemic index and is gluten free. The protein content ranges from 8 to 19 per cent and the lipid content is about 3 to 6 per cent. It can be used in a variety of ways including both leavened and unleavened breads, in porridges and can also be boiled or steamed. It is also utilized as an ingredient in alcoholic beverages. Even though this millet is cost effective and abundantly available, it is underutilized and the health facts of bajra remain unknown to every person. Owing to the benefits of pearl millet, its consumption should be encouraged among the people of all age groups to improve their dietary habits and nutritional status. Moreover, literature on antioxidant properties of millets is scanty. Therefore the present review reports the phenolic content and antioxidant activity of pearl millet.

1. Introduction

The concepts of food are changing from a previous emphasis on survival, hunger satisfaction, absence of adverse effects on health and health maintenance to a current emphasis on the use of nutraceutical foods which promise to promote better health and well-being, thus helping to reduce the risk of chronic illnesses such as cardiovascular diseases, cancer and obesity. An important factor of the nutraceutical food which is required to reduce the risk of chronic illness is "antioxidants". In recent years the powerful antioxidant properties of phenolics aroused more interest. (Kundgol, 2014).

An antioxidant can be defined as: “any substance that, when present in low concentrations compared to that of an oxidisable substrate, significantly delays or inhibits the oxidation of that substrate” The physiological role of antioxidants, as this definition suggests, is to prevent damage to cellular components arising as a consequence of chemical reactions involving free radicals (Halliwell and Gutteridge , 1995). Antioxidants play an important role in the body’s defence system against Reactive Oxygen Species (ROS), which are the harmful by-products generated during normal cell aerobic respiration (Ou et al, 2002). In foods, antioxidants prevent undesirable changes in flavour and nutritional quality of a product (Zielinski and Kozłowska, 2015). Cereals and millets are the most commonly consumed food items in India. They contain a wide range of phenolics which are good sources of natural antioxidants.

Millets are small seeded cereals that are cultivated as subsistence crops mainly in semiarid and tropical regions in Asia and Africa. Millet belongs to the grass family, Graminae. The term "millet" is used to refer several types of small seeded annual grasses belonging to species under the five genera in the tribe Paniceae, namely Panicum, Setaria, Echinochloa, Pennisetum and Paspalum, and one genus, Eleusine, in the tribe Chlorideae (FAO, 2001). According to FAO (1972) and Hulse et al (1980), the most important cultivated millet species are: pearl millet (Pennisetum typhoides), proso millet (Panicum miliaceum), foxtail millet (Setaria italica); Japanese barnyard millet (Echinochloa crusgalli var. Frumentacea); finger millet (Eleusine coracona) and kodo millet of India (Paspalum scorbiculatum) (Dogget, 1989).

Millets are important crops of Asia and Africa (especially in India, Nigeria and Niger), with 97 per cent of millet production in developing countries [McDonough et al, 2000]. Millets, considered as important food staples in human history. They have been in cultivation in East Asia for the last 10,000 years. India is the world's largest producer of millet [Lu et al, 2009]. In the 1970s, India used bajra as a food staple among all millet crops. By the 2000s, the annual millet production had increased in India, yet per capita consumption of millet had dropped about 50 to 75 per cent. As of 2005, most millet produced in India is being used for alternative implications such as alcohol production and livestock fodder [Basavaraj et al, 2010].

Millets are nutritious food and they are rich in phytochemicals, fiber and minerals. Magnesium in millet can help to reduce the effects of migraines and heart attacks. Niacin (vitamin B3) in millet can help to lower cholesterol. Phosphorus in millet helps with fat metabolism, body tissue repair and creating energy. Fiber from whole grains has been shown to protect against breast cancer and childhood asthma. It contains a wide range of phenolics, phytic acid and tannins which are good sources of natural antioxidants and contribute to boost health, prevent ageing and metabolic diseases. A wide variety of traditional foods and beverages are produced in countries where millets are grown for consumption. Millet foods produced from meal or flour include flat bread (fermented or unfermented), couscous and porridges, in addition to snack foods (Anoma, 2011).

2. Significance of pearl millet

Pearl millet (Bajra) is recognized as being the most widely grown of all the millet types and is grown extensively in the tropics and a staple food for the low income groups in some countries of the world. Globally the millet production is more concentrated in the Asian and African countries. It is the basic staple food in the poorest countries and used by the poorest people. For human consumption it can be used in a variety of ways including both leavened and unleavened breads, in porridges, and can also be boiled or steamed.

Pearl millet is grown on more than 29 million hectares in the arid and semi-arid tropical regions of Asia (11 million hectares), Africa (16 million hectares) and Latin America. It is believed that pearl millet was first domesticated in India and then moved to Africa, but most of the earlier scientists believed that Africa is the centre of origin of pearl millet and that it was introduced to India from Africa (FAO, 1972).

Bajra constitutes more than 55 per cent of global millet production and is grown in over 40 countries, predominantly in Africa and the Indian subcontinent. India produced 9.18 million tonnes of bajra in the year 2013-14. The major producing countries are Senegal, Mali, Nigeria, Sudan and India. The major producing states in India are Rajasthan, Uttar Pradesh, Maharashtra and Gujarat. Pearl millet production in India was characterized by subsistence cultivation during 1970s with a small marketable surplus. Rajasthan has the highest area under pearl millet with the highest production in the country. The state occupies nearly 44.34 lakh ha. area with average production of about 41.55 lakh tonnes and productivity of 1067 kg/ha in 2013-14 (Sharma and Burark, 2015).

Nutritionally, pearl millet makes an important contribution to human diet due to high levels of calcium, iron, zinc, lipids and high quality proteins. Pearl millet contains about nine to 13 per cent protein, which is higher than in rice (7.2 per cent) barley (11.5 per cent), maize (11.1 per cent) and sorghum (10.4 per cent) (Desikachar, 1975). Pearl millet contains up to eight per cent fat which is more than that in wheat, rice, barley and sorghum (Lai et al 1980). The ash content of pearl millet ranges from 1.6 to 3.6 per cent (Serna et al 1995). Besides, it is also a rich source of dietary fiber and micro nutrients. Starch is the major constituent of pearl millet (Malik et al 2002 and Anu et al 2006).

Pearl millet is an important source of thiamin, niacin and riboflavin. Because of its high oil content, pearl millet is a good source of fat – soluble vitamin E (2 mg/100 g). Pearl millet contains vitamin A typically about 24 Retinol Equivalents (Taylor 2004). These lipid soluble vitamins are mainly located in germ. As a food source it is non-glutinous and non- acid forming, so is soothing and easy to digest. While, extensive information is available on proximate composition and mineral accessibility, information on antioxidant activity and its influence on processing in pearl millet is scanty. Research on the effect of processing on retention of bioactive components with potential antioxidant activity is very important.

The consumption of pearl millet was found to be very poor in India inspite of being nutritionally superior to other grains. The majority of people in India are under poverty line and thus, food choices for a balanced diet are further restricted by poverty and insufficient supply of nutritious foods. Therefore, it becomes important to focus on promoting maximal use of locally available inexpensive foods rich in protein, calcium, iron, fibre etc (Mehra and Singh, 2017).

3. Antioxidant properties of pearl millet

Several methods have been developed to measure “antioxidant activity”. Commonly used assays are Reducing Power Assay (RPA), Ferric Reducing Antioxidant Power (FRAP) and 1, 1-Diphenyl-2-Picrylhydrazyl (DPPH) free radical scavenging activity.

Pushparaj and Urooj (2014) investigated the effect of various processing methods (milling, boiling, pressure cooking, roasting and germination respectively) on the antioxidant components as well as the antioxidant activities in the commonly used pearl millet cultivars—Kalukombu (K) and Maharashtra Rabi Bajra (MRB) showed that the antioxidant activity of pearl millet was influenced both by the processing methods and the cultivars. K and MRB showed low inhibition values of DPPH (about 60 per cent), RPA (about 0.32) and FRAP (about 2.69). Between the cultivars, K exhibited a higher content of antioxidant components reflecting its higher antioxidant capacity. The Bran Rich Fraction showed high antioxidant activity in terms of RPA which was due to the tannin, phytic acid and flavonoid levels. The millet subjected to various heat treatments exhibited higher antioxidant activity (DPPH scavenging activity and RPA) mainly due to its flavonoid content. An inverse relationship was found between radical scavenging activity and yield. It was noteworthy that significantly ($P \leqslant 0.05$) high radical scavenging activity in heat treated millet

had the lowest yield, whilst germinated millet which showed the lowest activity had the highest yield.

Odusola et al (2013) carried out a study to determine the nutritional composition and antioxidant ability of pearl millet. Methanol extract of the millet sample was evaluated for antioxidant properties in the study. An assessment of its antioxidant potential was determined using reducing property, total phenolic content and scavenging activity on 2, 2-Diphenyl-1-Picrylhydrazyl (DPPH). The results revealed that the pearl millet possesses high phenolic content, moderate reducing ability and high free radical scavenging activity.

Pearl millet contains high level of antioxidants namely the phenolic compounds and may have anticancer property. Sharma and Kapoor (1996) have reported the phenols in pearl millet grains as 608.1mg/100g and that in pearl millet flour as 761mg/ 100g. Phenolic compound especially flavanoids, have been found to inhibit tumour development (Huang and Ferraro, 1992). These compounds are concentrated in the pericarp and testa. Since traditionally, the entire pearl millet grain is milled, products made out of the flour would provide the health benefits of the flavonoids and phenols.

The antioxidant properties of the biscuits produced from the flour blends at ratios: 15:85 (A), 20:80 (B), 25:75 (C), 30:70 (D), 35:65 (E), 40:60 (F), 45:55 (G) of pearl millet (PM) and tiger nut (TN) revealed that the total phenolic content (TPC-mg/GAE) of PM – TN flour blends ranged from 2.65-4.95 (A-G), with an average TPC of 3.85. In PM – TN biscuits, total phenolic values ranged from 1.20-3.42 (A-G), with an average of 2.39. The 2,2-azino-bis(3-ethyl benzothiazoline-6-sulfonic acid) diammonium salt (ABTS) radical scavenging activities (μmolTEAC/g) of PM–TN flour blends ranged from 26.7-36.4 (A-G), and the values for biscuits ranged from 28.5-38.6 (A-G). There was a highly significant correlation, $r = 0.811 (p < 0.001)$ and $r = 0.913 (p < 0.001)$ between phenolic content and antioxidant activity for flour and biscuit, respectively (Omoba et al, 2015).

Gupta and Nagar (2010) studied to evaluate the effect of cooking, fermentation, dehulling and the use of utensils on flavonoids (quercitin and pelargonidin) — antioxidants present in pearl millet rabadi (Basundi), along with proximate composition and sensory acceptability of the product. The results showed an increased ash and flavonoids and reduced crude fibre after cooking in all samples, while fermentation enhanced the crude protein and reduced fat and crude fibre after 16 h in fermented-cooked-fermented rabadi prepared in steel and earthen pot and cooked-fermented rabadi in earthen pot. Enhanced flavonoids were observed in all samples after 16 h fermentation. Fermented-cooked-fermented samples were better with high ($\rho<0.05$) protein in steel pot rabadi and high ($\rho<0.001$) ash and quercitin ($\rho<0.1$ in earthen pot rabadi. Major nutrients were unaffected after dehulling except the crude fibre, which decreased and quercitin increased significantly ($\rho<0.1$). Remarkable rise in quercitin was observed when rabadi was fermented-cooked and fermented in earthen pot. Sensory evaluation showed the acceptance of all samples in the range of liked extremely (fermented-cooked-fermented-steel pot) to liked slightly (fermented-cooked in earthen pot).

Pearl millet have therapeutic effects in some health problems like anaemia, constipation, diarrhoea, diabetes, CVD, celiac diseases, cancer and it is referred to as anti-inflammatory and it also acts as a probiotic food. Several studies revealed that fortification of diet with food components rich in phenolic acids has been shown to impart antimutagenic, antiglycemic and antioxidative properties. The antioxidants like poyphenols, phytates, tannins and condensed tannins (proanthocyanidins) which are present in pearl millet are considered as “life span essential” due to its role in maintaining body functions and health throughout and phase of the life described by Chandrasekara & Shahidi (2010).

4. Conclusion

Pearl millet is a tropical cereal that has great diversity in its content of phenolic compounds as well as antioxidant activity. Pearl millet may serve as a natural source of antioxidants in food applications and as a nutraceutical and functional food ingredient in health promotion and disease risk reduction. However, more studies in animal models and with human subjects should be performed to verify their activity and health benefits.

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