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ACCEPTANCE OF MILLETS IN ASPECTS OF NUTRITIONAL PROFILES, HEALTH AND ENVIRONMENTAL BENEFITS

Saroj Kumar Debnath[1]*, Dipsundar Sahu[1], Debajyoti Das[1], Ranjita Ekka[1], Tushar Kanti Mandal[2], G Babu[3]

*[1]Research Officer (Ayurveda), [2]Assistant Director (Ayurveda), [3]Director, Central Ayurveda Research Institute, Kolkata, West Bengal, Central Council for Research in Ayurvedic Sciences, Ministry of AYUSH, Government of India.

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ABSTRACT

Millets are one of the oldest crops known to humans. Millets are small-seeded grasses belonging to the botanical family Poaceae. In Ayurvedic classics they are named as *Kshudra dhanya*. Common Millets available in India are Sorghum, Pearl Millet, Finger Millet, Foxtail Millet, Barnyard Millet, Kodo Millet, Little Millet, Proso Millet. Millets are good for the environment as they are the carbon neutral crops and also minimum fertilizers as well as pesticides are used for their cultivation. Millets are the most dependable crops to small farmers due to their short crop rotation characteristic and they are the resilient and climate adaptable crops in dry, hot and drought environments. Millets have significant role in traditional diets of different regions throughout the India. Millets are rich sources of nutrients like carbohydrate, protein, good-quality fat, dietary fibre and have sufficient amounts of minerals like calcium, potassium, magnesium, iron, manganese, zinc and B complex vitamins. Hence, millets may be an excellent choice of food for fortification of under nutrition or combating malnutrition and exerting health-promoting benefits and also they play efficient role in body immune system. Millets are rich with phytochemicals, hence millet have health promoting effects specifically anti-diabetic, anti-obesity and anti-hyperlipidaemic and also show therapeutic effects due to their anti-inflammatory and anti-oxidative properties. Phytochemicals and the dietary fibre of millets can hinder the absorption of minerals and different food processing methods are commonly used to eliminate the anti-nutritional factors of millets.

INTRODUCTION

Millets are one of the oldest crops known to humans. Millets are small-seeded grasses belonging to the botanical family Poaceae. In Ayurvedic classics they are named as *Kshudra dhanya*. Millets are nutritionally rich, drought tolerant and mostly grown in the arid and semi-arid regions. They can also grow in adverse weather conditions with marginal irrigation requirements. Millets first domesticated in Asia and Africa and later spread across the globe as a cereal crop for the evolving civilizations.

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Millets are used as staple food in many parts of the world and constitute an important source of food and fodder for resource-poor farmers. Millets play a vital role in ecological and economic security of India. India is the largest producer of millets in the world. Millets have been entitled as the Nutri-Cereals by the Government of India due to their nutritional superiority compare to regular staples like wheat and rice. Millets are also known as coarse cereals or cereals of the poor. The smart food campaigning of millets by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the Indian Council of Agricultural Research - Indian Institute of Millets Research (ICAR-IIMR) in the context of their goodness nutritionally, environmentally and for small holder farmers. The United Nations General Assembly at its 75th session in March 2021 declared 2023 the International Year of Millets for propagation of millets cultivation and adaptation of millets as a staple foods for the benefit of public and environment. Millets have

important role in traditional diets of different regions all over the country. Millets possess not only good nutritive values but also rich with phytochemicals. Millet foods have health promoting effects specifically anti-diabetic, anti-obesity and anti-hyperlipidaemic due to these phytochemicals actions and millets also help to increase the body immunity.

MATERIALS AND DISCUSSION

Common millets available in our country are Sorghum or Jowar, Pearl Millet or Bajra, Finger Millet or Ragi, Foxtail Millet or Kakum, Barnyard Millet or Sanwa, Kodo Millet or Kodon, Little Millet or Kutki, Proso Millet or Chena. Millets are primarily categorized as major and minor or small millets. Major millet are Sorghum or Jowar (*Sorghum bicolor*), pearl millet or Bajra (*Pennisetum typhoides*), finger millet or mandua or Ragi (*Eleusine coracana*), and small millets are foxtail millet or kangni (*Setaria italica*), little millet or sama or kutki (*Panicum miliare*), kodo millet (*Paspalum scrobiculatum*), barnyard millet or sawan or jhangora (*Echinochloa frumentacea*), proso millet or cheena (*Panicum miliaceum*), and brown top millet or korale (*Brachiaria ramosum*).[1]

Millets good for the Environment: Millets can cultivate in arid regions, requiring only 300– 400mm of water (Asmat Ullah, 2017) compared to 1400–1500mm of water for cultivation of rice. Millets are the carbon neutral crops on the basis of carbon absorption from the environment equivalent to carbon emissions during their cultivation and it is good for environment compared to rice and wheat production. Millets are energy-efficient crops on the basis of less use of fertilizer, pesticides and irrigation requirements compared to rice and wheat cultivation. Hence, millets cultivation is comparatively good for the environment than other staple foods.[2]

Millets good for the Farmer: Millets cultivation helps to small farmers due to short crop rotation as maximum types of millet necessary 60–90 days only to mature while other staple cereals need 100–140 days. Millets are effective to utilize the available nutrition and also productive to improve the farm conditions. Millets are important dependable crops to poor farmers as millets are resilient and climate adaptable crops in dry, hot and drought region and also minimum fertilizers as well as pesticides are used for their cultivation. Millets may be important crops in drought seasons and supportable future food source during bad climatic situation (Vadez et al., 2012, Schill, 2012, World Bank, 2013).[3]

Nutrients in Millets: Millets are good sources of nutrients like carbohydrate, protein, good-quality fat, dietary fibre and have sufficient amounts of minerals like calcium, iron, potassium, magnesium, manganese, zinc and vitamin B complex. The protein in millets ranges between 10% and 12% while the protein in foxtail millet (12.3%) is more than wheat and rice. The dietary fibre (10–12%) of millets is also more compared to some of the other staple cereals. The total polyunsaturated fatty acid in bajra (1984mg/100g) and maize (1606mg/100g) are comparatively more compared to other staple cereals. Finger millet or Ragi contains high calcium content (364mg/100g) which is 10 times more than calcium of wheat or rice. The iron content in pearl millet or bajra (6.42mg/100g) and in barnyard millet (5.0mg/100g) is also more than other staple cereals (Longvah et al., 2017). Different important phytochemicals like phytates, polyphenols, tannins and other phenolic compounds are present in millets. These phytochemicals show therapeutic effects due to their anti-inflammatory and anti-oxidative properties.[4]

Nutritional value of Millets, Nutritive value of Indian Foods, Gopalan[5]

Crop / nutrient	Protein (g)	Fibre (g)	Minerals (g)	Iron (mg)	Calcium (mg)
Sorghum	11	6.7	2.7	3.4	13
Finger millet	7.3	3.6	2.7	3.9	344
Foxtail millet	12.3	8	3.3	2.8	31
Kodo millet	8.3	9	2.6	0.5	27
Little millet	7.7	7.6	1.5	9.3	17
Pearl millet	10.6	1.3	2.3	16.9	38
Proso millet	12.5	2.2	1.9	0.8	14
Barnyard millet	11.2	10.1	4.4	15.2	11

Millets for Proper Nutrition: The presence of carbohydrates 65% and protein around 6.0–12.5% and fat 1.5–5.0% in millets make them calorie-dense food. A study had been done in peri-urban region of Karnataka to evaluate the effect of millets into the mid-day meal of the school children. It had been found that mid-day meal was an important food for the daily calorie consumption of the children and millets into the diet had been shown in the statistical improvement of the stunting and body mass index of the children (Anitha et al., 2019). Hence, millets may be an excellent choice of food for fortification of under nutrition or combating malnutrition and exerting health-promoting benefits.[6]

Mitigation process of Anti-nutritional factors in Millets: Phytochemicals and the dietary fibre of millets reduce the absorption of minerals due to bind with them. Different food processing methods like decortication, germination, soaking, malting, roasting, fermentation, grinding and autoclaving are generally used to remove anti-nutritional factors, hence by using these food processing methods improve the nutritional value of millets (Aknabi et al., 2019; Kaur et al., 2014; Vinoth and Ravindran, 2017; Nkhata et al., 2018 and Kumar et al., 2018). Germination helps in advancement of sugars, improve protein digestion, decrease trypsin inhibitors, rise crude fibre, vitamins and minerals, and reduce oxalates, polyphenols, phytates and tannins. Fermentation helps to decrease trypsin inhibitors, phytic acid and tannins, and to improve protein digestion (Vinoth and Ravindran, 2017 and Nkhata et al., 2018). Malting method helps to enhance the bio-accessibility of nutrients like iron (300%) and manganese (17%) and boiling, soaking as well as pressure cooking methods of food processing were shown to decrease tannin content. The food processing methods like extrusion, irradiation and cooking at high temperature for short time enhance protein digestion, the bioavailability of minerals and reduce tannins and phytates (Nkhata et al., 2018). Bio-fortification helps to decrease anti-nutrients at the early phase i.e., during growth and development. It is a new approach that may be initiated to improve the bioavailability of the nutrients and the nutritional status (Kaur et al., 2014).[7]

Common Indian recipes of Millets: Millets have significant role in traditional diets of different regions throughout the country. Laddu, kheer, burfi, khaja, cake, pudding, halwa are sweet recipes of millets. Idli, mudde, muthia are steamed recipes of millets. Khakra, roti, paniyaram, dosa, adai, uttappam, pancake are roasted recipes of millets. Patties, samosa, cutlet, murukku, finger chips, pakoda, bhakarwadi are fried recipes of millets. Tomato rice, masala rice, biryani, pulao, upma, khichdi, soup, noodles are cooked recipes of millets and bhel, biscuit are snacks of millets.

Recipe combinations of Millets: Millet grains can be substituted for or added to various rice based recipes. Millet flours can be substituted for or added to various atta or besan or batter based recipes. Different recipes can be made from millets with other multi-grain combination and also adding various vegetables, meats, eggs etc.

Health Benefits from Millets: The dietary fibre present in millets is 22% which is comparatively more than other cereals like wheat containing 12.6%, rice containing 4.6%, maize containing 13.4% of dietary fibre. Dietary fibres are classified into soluble fibres and insoluble fibres. Chethan, et al., (2007) reported that insoluble dietary fibre 15.7% and soluble dietary fibre 1.4% present in finger millet. Shobana, et al., (2007) reported that finger millet contains total dietary fibre 22.0%, insoluble dietary fibre 19.7% and soluble dietary fibre 2.5%.[8]

Millets - Obesity

Obesity is an important alarming problem in our country and it is related to different ailments such as diabetes and cardiovascular diseases. Recent research works have shown that consumption of high dietary fibre reduce the incidence of obesity (Alfieri *et al.,* 1995). Foods containing good amount of dietary fibre improve the bowel movements and reduce the digestion process and absorption, hence decrease the risk of chronic disorders (Ali *et al.,* 1982). Millets helps in satiating the hunger satisfaction and helps in weight management.[9] Sufficient quantity of millet grains contain good amount of dietary fibre and non-starch polysaccharides that help in weight management. Millets are an excellent choice of food for diabetics due to the slow release of glucose (Dayakar Rao et al., 2017).[10]

Millets - Diabetes

Millets contain good amount of dietary fibre and so they have low glycaemic property. The glycaemic property of different foods vary with nature of food processing, ingredients, form (e.g. flour or grain), etc. and maximum millet recipes have low glycaemic index.[11] In 2010 National Institute of Nutrition (Indian Council of Medical Research) in collaboration with the Indian Institute of Millets Research, Hyderabad, under National Agricultural Innovation Project assessed Glycemic Index of sorghum based foods. The reports have shown that low glycemic index is in sorghum based foods and decrease the level of postprandial blood glucose. High fibre present in Finger millet diets and they show low glycemic response. They also increase the process of wound healing in dermal area. Studies have shown that finer millets protein inhibit the human cataractogenesis.[12] Millets help in prevention of Type II Diabetes due to their significant levels of magnesium. Magnesium helps to produce many carbohydrate digestive enzymes which control the effect of insulin by enhancing the efficacy of Insulin and glucose receptors (O.S.K.Reddy, 2017).[13] Millets have shown the reports to decrease the postprandial hyperglycemia by decreasing the α-glucosidase and pancreatic amylase and also by decreasing the enzymatic hydrolysis of complex carbohydrates. The enzymes aldose reductase helps to prevent the accumulation of sorbitol and decreases the complication of diabetes and cataract. Hence millets help to maintain the blood glucose level and promote in the process of wound healing in dermal area with the effect of antioxidants (Rajasekaran NS, *et al.,* 2004).[14]

Millets - Cardiovascular Diseases

Studies suggested that regular consumption of whole millet grains reduces the risk of cardiovascular diseases. Millets are rich in phyto-chemicals which contain phytic acid that helps in reducing cholesterol and preventing cardiovascular disease by decreasing triglycerides (Lee, *et al.,* 2010). Millet is good source of magnesium, which is an important mineral for lowering blood pressure and risk of heart attacks, particularly in atherosclerosis cases. Millets are also a good source of potassium, which helps to reduce the blood pressure by acting as a vasodilator. Decrease the blood pressure and maintain the health of circulatory system is the effective ways to prevent the cardiovascular diseases.[15]

Millets - Cancer

It is well documented that sorghum has Anti-carcinogenic properties. The polyphenols and tannins present in sorghum have anti-mutagenic and anti-carcinogenic properties (Grimmer *et al*., 1992) and can act against human melanoma cells and melanogenic activity.[16] High fibre content of millets helps to decrease the problems like constipation, bloating, flatulence and stomach pain and also helps to decrease the chances of gastro-intestinal illnesses likes ulcers and colon cancers (O.S.K.Reddy, 2017).[17] Millets are good source of phenolic acids, phytates and tannins which help in decreasing the risk for colon and breast cancer. It has been shown that phenolics of millets are effective to prevent the cancer initiation and progression *in vitro* (Chandrasekara A, *et al.,* 2011). Linoleic acid of millets has anti-tumor activity (nobihoru, *et al*., 2007).[18]

Millets contain many antioxidants, in addition to their beneficial effects on neutralizing free radicals which are important cause of cancer and they can also reduce other harmful substances from the body, such as kidney and liver. Quercetin, curcumin, ellagic acid and various other effective catechins can help to decrease harmful substances into the body by encouraging proper excretion and neutralizing enzymatic activity in the body (O.S.K.Reddy, 2017).[19] China and other parts of the world (Van Rensburg, 1981) have shown that oesophageal cancer incidences were low with sorghum consumption. The authors studied 21 communities in each country over a period of 6 years and found that consumption of sorghum showed lower mortality from oesophageal cancer than consumption of wheat and corn.[20]

Millets - Celiac Disease

Celiac disease is a genetic disorder and it is triggered due to consumption of gluten. Millets are gluten free, so they can help to decrease the celiac disease by reducing the harmful effects caused by common cereals which contain gluten. (Saleh ASM, *et al.,* 2013*).*[21]

Millets - Prebiotics

Millets contain good amount of slow digestive starch and fibres which are good for the gut cohabited with bacteria, like lactobacillus acidophilus, actinobacteria, rhamnosus GG and Bifido species. The non-starch polysaccharides found in millets form a major part of dietary fibre which produce short-chain fatty acids due to fermentation of resistant starch and produce as excellent Prebiotics. Various cultures promotes the growth of Gram-negative bacteria by fermentation of millets and then millets act as an effective probiotic food in the gut.[22]

Millets - Bioactive Ingredients

Millets have several bioactive phytochemicals like feraxans, lignans, β-glucan, inulin, resistant starch, sterols and phenolic compounds (e.g., ferulic acid, caffeic acid and quercetin). Studies have shown the role of polyphenols as antioxidant, anti-carcinogenic, anti-inflammatory, antiviral and neuroprotective activities which have supported to be the beneficial against many diseases like cancer, cardiovascular disease, diabetes, high blood pressure, high cholesterol, inflammatory diseases, metabolic syndrome and Parkinson's disease (Dayakar et al., 2018).[23] The millets have shown antimicrobial and DNA damage protection activities by their phytochemical content (Aknabi et al., 2019 and Kaur et al., 2014).[24]

CONCLUSION

Millets are small-seeded grasses belonging to the botanical family Poaceae. In Ayurvedic texts they are named as *Kshudra dhanya*. Millets are the carbon neutral crops and also minimum fertilizers as well as pesticides are used for their production. Millets cultivation helps to small farmers as they are resilient and climate adaptable crops in dry, hot and drought environments as well as their short crop rotation characteristics. Millets are good sources of nutrients like carbohydrate, protein, good-quality fat, dietary fibre and have sufficient amounts of minerals like calcium, iron, potassium, magnesium, manganese, zinc and different vitamins. Millet foods have significant health benefits due to rich content of different nutrients like dietary fibre helps in metabolic disorders like diabetes, obesity, hyperlipidaemia, cardiovascular diseases etc, good protein content helps in child growth and development, sufficient amount of calcium content helps in bone development in children, geriatric persons and osteoarthritis patients, good iron content helps to reduce iron deficiency anaemia and their gluten free helps the celiac disease patients and gluten sensitivity patients. Phytosterols and policosanols are cardio-protective compounds present in the millet. Millets have more antioxidants which may protect the cell against the effects of free radicals. Millets are rich with phytochemicals, hence they have

good effects like anti-diabetic, anti-obesity, anti-hyperlipidaemic due to the actions of these phytochemicals and they also have efficient effect in immune system of the body. Different important phytochemicals like phytates, polyphenols, tannins and other phenolic compounds are present in millets and these phytochemicals show therapeutic effects due to their anti-inflammatory and anti-oxidative properties.

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***Address for correspondence**
Dr. Saroj Kumar Debnath
Research Officer (Ayurveda), Central Ayurveda Research Institute, Kolkata, West Bengal, India, Central Council for Research in Ayurvedic Sciences, Ministry of AYUSH, Government of India
Email: sarojkumardebnath@gmail.com
Ph: 94774 04010