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Research Review

Millets: Review on Therapeutic Importance, Processing and Value-added Products

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A B S T R A C T

This paper is based on critical review of researches on nutritional value of millets grown as a food crop in South Asia. Millets are a group of small-seeded grasses, grown around the world as cereal crops/grains. They are hardy and grow well in dry zones as rain-fed crops, under the conditions of fertile soil and moisture. Millets are the crops which are unique due to their short growing season. The shelf life of the whole millets is two or more years when it is properly stored. Millets have remarkable quantity of nutrients when compared to rice and wheat in terms of proteins, minerals and vitamins. Millets are the rich sources of minerals like iron, magnesium, phosphorous and potassium. Although millets are nutritionally richer than cereals it is mostly consumed by the lower economic stratum. Millets have their significant addition to national food security and health benefits. Since millets are nutritionally good it has gained popularity among most of the population the various food processing industries have started to develop new value-added products to meet the demand of the customers. Many traditional products are prepared with millets like malted beverages, infant foods and snack foods. Obesity, diabetes, Cardiovascular diseases are very common among urban populations which can be prevented by consuming millets. Millets are considered as functional foods with more health benefits and value-added strategies. Hence with suitable processing technologies it can be incorporated in value added food products with more demands of urban population.

***Key words*:** Millets, Functional food, Therapeutic significance, Value added products

India is considered as top most producer of millets for the year 2000 and 2009 and millet species like Sorghum, Pearl millet, Finger millet, Foxtail millet, Kodo millet, Proso millet, Barnyard millet and Little millet are commonly cultivated. The small millets are grown in southern and central states in India where the annual rainfall is below 350mm with very low moisture [1]. Millets are one of the oldest food grains and the first cereal grains used for domestic purposes. For centuries, millets are staple diet for nearly One third of the world's population in India. Bajra or pearl millet (*Pennisetum americanum*), ragi or finger millet (Eleusine coracana), navane or foxtail millet (*Setariaitalica*), samai or little millet (Panicum miliare), haraka kodo millet (*Paspalum scrobiculatum*), proso millet (*Panicum miliaceum*), barnyard millet (*Echinochloa frumentacea*) are the various millets cultivated largely in Asian countries. The production of millet grain was 762712 metric tonnes in the world and India ranks top with a production of 334500 tonnes in 2010 [2-3]. Therefore, many countries have now started research on millets and develop millet-based products for nutritional quality and health benefits and promote them to utilize on a large scale. The demand for millets is high among the consumers because of its health benefits in the prevention and management of diabetes, hypertension, cardiovascular diseases, obesity, hyperlipidemia etc. Many researches says that millets have more therapeutic benefits. The bioactive compounds like oligosaccharides, lipids, antioxidants along with nutrients such as vitamins, minerals, essential fatty acids and dietary fibre present in millets have greater impact on positive health of the individuals [4-5]. Millets are rich in phenolic compounds and promotes health benefits towards diet related disorders [6-7]. Millets are gluten free which can be recommended for celiac diseases. Gluten Enteropathy or Celiac disease is a kind of disorder will damage the villi that is the mucosa present in the small intestine when the individual consumes gluten foods. The celiac patients cannot digest the gliadins and glutenins of wheat protein giving after effects [8-9]. The bioactive compounds and vitamins are more in millets which helps in improving the quality of the bone by conserving the calcium concentration of the bone and also increase the status of the antioxidant activity [10-11]. The value-added food products of the millets also have potential antioxidant properties [12-13]. Processing of millets generally reduce the antinutritional properties and increase the bioavailability of the food products. Traditional methods of processing like soaking, roasting, germination, fermentation gave a greater impact on nutritional value of the millet [14-15]. The minerals like Iron and Manganese were significantly increased from 300% and 17% respectively when it gets malted [16-17]. Decortication and dehulling are the general treatment of processing technology applied for millet to increase its organoleptic qualities [18-19]. A fermented

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beverage made with pearl or finger millet flour and rice are mostly consumed by the ethnic communities of Tamil Nadu [20]. Value addition of millet has also had a vital role in increasing the income of the people by developing new products as a source of employment. The aim of the current review has been made to collect the available information from existing literature related to the nutritional importance, therapeutic value- and value-added strategies of millet and to summarize the collected data.

Nutritional significance of millets

Nutritional value of food is the significant parameter for subsistence of human body because the nutritional status is very important for development and expansion of human genetic prospective [21-22]. Millets contain 60-70%, 7-11%, 1.5-5%, and 2-7% of carbohydrate, protein, fat and crude fibre respectively and are also rich in vitamins and minerals and essential aminoacids. They are extremely good source of vitamin B, magnesium, Phosphorous, Iron and antioxidants [23-24]. Millets are rich in essential amino acids like methionine and cysteine [25-26]. Millets are excellent sources of essential fatty acids like linoleic acid, oleic acid and palmitic acids [27-28]. Apart from these fatty acids they also contain arachidic acid, behenic acid, erucic acid in trace amounts. Oil extracted from millets is the rich source of linoleic acid and tocopherols [29]. Millets are underutilized crops, drought resistant and are also gluten free alternatives [30-31]. Vitamins and minerals existing in millets help in the synthesis of energy in the body. Finger millet has high content of calcium (0.38%), protein (6%–13%), dietary fiber (18%), carbohydrates (65%–75%), minerals (2.5%–3.5%), phytates (0.48%), tannins (0.61%), phenolic compounds (0.3–3%) [32]. The seed coat of finger millet is rich in dietary fibre, minerals and phytochemicals. It forms a by-product of millet milling and decortications and it is utilized as composite flour in making biscuits [33-34]. The quality of protein depends upon the essential amino acids and the finger millet constitute 44.7% essential amino acids [35] of the total amino acids, which is higher when compared to 33.9% of essential amino acids in FAO reference protein [36-37]. Pearl millet has the richest content of macro and micro nutrients such as Folic acid, Iron, Zinc, Magnesium and helps to prevent micronutrient deficiencies [38]. Millets are rich in vitamin B, folic acid, Iron, Phosphorous, Iron and potassium and they are rich in antioxidants and have anti-cancinogenic effect. Sorghum is high in antioxidant content [39] and finger millet is 16 times richer in calcium than maize and the Niacin content of pearl millet is high when compared to other cereals [40]. Proximate composition of millets-per 100gm [41-44].

Table 1 Parameters of differnet millets

Millet type	Carbohydrates	Protein	Fat	Crude Fibre	Ash	Calorific value
Pearl millet	69.10 ± 1.52	11.4 ± 0.8	4.87 ± 0.12	2.0 ± 0.55	2.13 ± 0.21	363.0
Foxtail millet	67.30 ± 5.70	11.34 ± 0.91	3.33 ± 0.76	8.23 ± 1.66	3.37 ± 0.12	352 ± 1.41
Finger millet	71.52 ± 3.59	7.44 ± 0.87	1.43 ± 0.12	3.60	2.63 ± 0.06	334 ± 2.82
Banyard millet	56.88 ± 6.86	10.76 ± 1.11	3.53 ± 1.19	12.8 ± 2.4	4.30 ± 0.26	300.0
Proso millet	67.09 ± 4.79	11.74 ± 0.86	3.09 ± 1.18	8.47 ± 3.4	2.73 ± 0.72	352.5 ± 1.62
Kodo millet	63.82 ± 7.94	9.94 ± 1.6	3.03 ± 1.03	8.20 ± 2.3	2.83 ± 0.40	349.5 ± 4.95

Experimental studies on millets

A study conducted in India, the Type 2 diabtetic patients were fed with foxtail millet for 90days improved their glycaemic control [45]. Foxtail millet, split black gram and spice mix were combined and given for the patients and there was a marked reduction in HbA1c, fasting glucose level, insulin as well as Total cholesterol, Triglyceride which showed a positive effect in the cardiovascular health also [46]. Foxtail millet was recommended for 12 weeks of diabetics where the mean fasting levels reduced from5.7 ± 0.9 mmol/L to 5.3 ± 0.7 mmol/L ($p < 0.001$ and also the mean 2h- glucose gradually shown reduction from 10.2 ± 2.6 mmol/L to 9.4 ± 2.3 mmol/L ($p = 0.003$). There was a significant increase in the serum leptin level ($p = 0.012$), decreased insulin resistance ($p = 0.007$), and a marked decrease of inflammation [47]. Biofortified pearl millet (19.6) contains more iron when compared to traditional pearlmillet (4.8mg/dl) which helps in improved iron status especially increased the cognitive development like attention improvement (SRT, GNG, and ANT) and (CFE and CRT) memory amon adolescents [48]. A millet-based diet was administered for 12 weeks for the 65 subjects with Type II diabetes where the results showed there is a significant reduction in Total cholesterol, VLDL cholesterol and triglycerides and also decrease in inflammatory biomarkers like cytokines, C-reactive proteins, TNF-alpha and interleukin-6 to baseline levels [49]. The millet flour is supplemented with fenugreek defatted seed flour where 5, 10 and 15% FDSF increased the amino acids. The pearl millet was supplemented with fenugreek defatted seeds flour which increased the amino acid content especially lysine content [50]. Biofortification of millets is proved to combat micronutrient malnutrition. Harvest plus revealed the significance of biofortification of millet especially pearl millet with high iron content helps to reduce iron deficiency in India. Waxy starch present in foxtail millet, proso millet and banyard millet forms a basis for the production of infant foods. Recently, transcriptomics described that various calcium sensor genes taking part in uptake, translocation and accumulation of calcium in finger millet [51]. Finger millet is rich in carbohydrate, protein, dietary fibre and minerals and considered as staple food for low economic strata [52] and also it contains high content of calcium (0.38%), dietary fiber-10 to 18%, 65% to 75% of carbohydrates and 3.5% of minerals and 6gms of protein with low glycemic index and its recommended for celiac disease and diabetes and for is beneficial for metabolic disorders like obesity and diabetes [53]. The traditional recipes made from pearl millet containing flavonoids like tricin, acacetin, 3, 4 Di-OMeluteolin and 4-OMe tricin denoted the chemo-preventive effect of pearl millet [54]. A recent study revealed that a formulated multigrain diet with finger millet as one of the constituents effectively reduced the lipid and antioxidant metabolism in rat models with high cholesterol intake [55]. Millet fraction and extract possess antimicrobial activity. Pearl millet, sorghum, Japanese banyard millet, foxtail millet, little millet and pearl millet seed protein extracts were undergone evaluation *in vitro* for its ability to inhibit the growth of *Rhizoctonia solani*, *Macrophomina phaseolina*, and *Fusarium oxysporum* [56]. Ferulic acid is a compound present in fingermillet showed a blocking effect on induced carcinogenesis in tongue and colon

of rats [57] and breast cancer cells [58]. A randomized efficacy trial of Iron biofortified pearl millet revealed that consumption of biofortified pearl millet among school children in Maharashtra for 6 months increased their serum ferritin and total body iron levels when compared to the dose of iron achieved by supplementation trials [59].

Therapeutic value of millets

The community nutritional status is considered as an important indicator of national development [60]. Millets can be an important source to combat malnutrition. Millets are the rich sources of phytochemicals and micronutrients [61]. Millet grains release sugar slowly in the blood stream and also delays the rapid absorption of glucose. Because of the major properties of millets, they are considered as nutritious grains. High dietary fiber in millet with low fat provides several nutritional and physiological benefits like Hypocholesterolemic and hypoglycemic effects. Reduced intestinal transit time and fermentation of undigested food components in the gut and discharging them with stools in the colon where it brings down the incidence of colon cancer, constipation & other complications of the intestines. Millets are gluten-free; hence it can be recommended for celiac diseases and gluten-sensitive enteropathy where the patients gut is irritated by the gluten present in wheat [62]. Abundance of phytochemicals and micronutrients present in the pearlmillet which helps in combating diabetes mellitus, cancer, cardiovascular diseases and cholesterol levels [63]. Since millets are rich in phenolics which brings about antioxidant activity towards aging and metabolic syndrome [64-65]. Probiotics are the living microorganisms which strengthen the gut when it is recommended in adequate amounts. When the millets are fermented it acts as a probiotic agent which helps for the management of diarrhea in children [66]. Pearl millet is good source of phosphorus and calcium which are essential for the growth and development of bones [67]. Finger millet has nutraceutical significance with beneficial effects, such as anti-diabetic, anticarcinogenic, anti-diarrheal, anti-inflammatory, atherosclerogenic effects, antioxidant and antimicrobial properties [68]. Banyard millet grains acquire functional constituents like g-amino butyric acid (GABA) and b-glucan, which serve as an antioxidants and in reducing blood lipid level [69-70]. Pearl millet contains insoluble fibre which speed up intestinal transit time and reduce the secretion of bile acids hence regular consumption of pearl millet prevents the formation of gall stones. The germinated seed of foxtail millet is digestive, astringent and stomachic and helps in the treatment of cholera and fever [71]. Millets are dense in iron content, protein and other nutrients and specifically has medicinal properties to cure many disorders [72-73].

Processing and value addition of millets

Converting the grain in the form of edible products and enhancing its quality is referred as processing. Processing of millets plays an important role during its utilization as food product [74]. Millets have hard seed coat hence the process is made by removing the husk. The millets are undergone various process like milling, sprouting, roasting, popping, flaking, Extrusion and fermentation. Depending upon the concept of FAO traditional food processing (such as decortications, milling, germination, fermentation, malting, roasting etc.) is used for preparation of food products of millets to improve their nutritional quality and sensory properties [75]. Food products made from other cereals are supplemented with millets due to its nutritional and economic benefits. Convenience food plays an essential role of majority of the working population. Millets based convenient foods can be made in more reasonable cost and increased shelf life and unique taste. Value added products from millet also add value to business because millet-based foods contribute more health benefits [76-77] with the increasing demands of foods with health benefits, value added products are developed with commercial value. A malt mix (kodo millet and little millet) was prepared with incorporation of fruit powder [sapota and mango] and 50% of sapota powder was found to be acceptable as best combination in sensory evaluation [78].

Soaking of millets reduces the antinutritional factors like phytic acid improves the bioavailability of minerals [79]. The different combination of processing like dehulling, soaking and cooking reduced the antinutrients like polyphenols, phytate and increases the digestibility of protein and improves the bioavailability of minerals such as iron and zinc [80]. Germination process reduces the anti-nutrients such as phytic acid, tannins, and polyphenols. Due to malting process the beta-amylase activity and free alpha-amino nitrogen of the pearl millet has increased when compared to sorghum [81]. Some grains and millet are subjected to dehulling with other treatments and then consumed with increased edible and sensory quality [82-83]. The milling process of the millet grain is the procedure of grinding so it can be easily cooked and it provides an attractive edible food. Milling process significantly reduced the phytic acid and polyphenols and improves the digestibility of starch and protein [84]. Mixture of milled millet flours by 10-30% to wheat flour increased the value of protein, fat and ash [85] (Shobana.S et al.2013). Milling of millets helps to remove some amount of phytates and tannin increase the iron bioavailability [86] (Shonisani Eugenia et al.2019). Popping is a processing technique where the sand is used as a medium for transforming heat which results in gelatinization of starch and the endosperm of the millets bursts and gives excellent flavor [87]. There was a significant increase in the bio-accessibility of zinc-18gm per 100gm in the popped millet [88]. Fermentation improves the flavour, texture and nutritional qualities of a product. It decreases the non-nutritional factors and makes the protein available to the body. The process of fermentation of the pearl millet significantly improved the nutritional value like moisture, ash, fibre, protein and fat [89].

Baking is a method of dry heat cooking normally in an oven, also in hot ashes. 40 percent wheat flour substituted with millet in the preparation of bakery products is good in biscuits and cakes [90]. Cakes are incorporated with 100% millet flour [pearl millet, finger millet or foxtail millet flour] along with good quality fat, sugar, eggs and vanilla or chocolate essence with varied proportions and finally the finger millet cake was highly acceptable [91]. Extrusion is one of the food processing techniques with various ingredients which are forced through a perforated die with a specific design and are cut into required sizes by the machine blades. High quality Extruded products are obtained from the blend of kodomillet and cowpea in the ratio of 70:30 prepared by the twin screw type [92].

CONCLUSIONS

Millets are nutrient dense and comprises of carbohydrate, protein, fat, fibre, vitamins and minerals as well as antioxidant and phytochemicals. Because of the neutraceutical property of millet it is referred as one of the

functional foods which helps to combat malnutrition and prevents the degenerative disorders. Food processing and value addition technologies help to prepare value added products which are acceptable by the rural and urban population. This review focused mainly on the nutritional properties, therapeutic value and various food processing strategies which helps to improve the quality and promote the utilization of millets for future prospects. Although some of the research studies mentioned the processes and the health benefits with scientific reasoning and development of value-added food products which needs further research for therapeutic purposes.

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