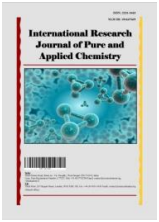

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Climate Resilient Millets for Food and Nutrition Security for All Seasons: Time to Promote

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Authors' contributions

This work was carried out in collaboration among all authors. Author WJS has written the review article. Author BAK has written the abstract. Authors JHK and PJMR have monitored the writing of review article. Authors PSR, KRK, PNMP and DS have contributed with various references to be included in the review. All authors read and approved the final manuscript.

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ABSTRACT

Millets are climate-resilient crops adaptable to wide variety of ecological conditions requiring less water for irrigation with better growth and productivity in low nutrient soils. They require low artificial fertilizers application and show minimal vulnerability to environmental stresses. There is need to revive the importance of millet groups as health foods to enhance food and nutritional security. Millets contain high amounts of proteins, fiber, niacin, thiamine and riboflavin, methionine, lecithin and little of vitamin E. They are rich in minerals like iron, magnesium, calcium and potassium also. Millets due to their nutritive value have potential health benefits to prevent cancers, decrease the occurrence of cardiovascular diseases, reduce tumor proliferation, lower blood pressure, risk of heart diseases, cholesterol content, rate of fat absorption, delayed gastric emptying and increased gastrointestinal bulk. Value-addition to millet grains as ready-to-eat and ready-to-cook items offers good opportunity to farmers for enhanced income generation, promotes production and marketing leading to nutritional security, employment and revenue generation.

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1. INTRODUCTION

Millets are small-seeded grasses that grow well in dry zones of Asia and Europe. They are cheaper than rice and wheat and hence called poor people's food. They are three to five times nutritionally superior to staple grains concerning proteins, minerals and vitamins [1].

Although millets are nutritionally superior to major cereals, they are still confined to the traditional consumers and populations of lower economic strata. But the unpredictable climatic conditions and ever-growing population necessitates the nutritionists to develop millet-based value-added functional and health foods that not only fight hunger and poverty but are also readily acceptable amongst the general public [2].

Millets are nutrient-dense with a sweet and nutty flavour, are easily digestible and non-allergic grains available for consumption along with their disease tolerance to be cultivated under highly adverse conditions with less labour [3]. They alkalize the body due to their higher mineral content thus reducing the proliferation of lifestyle diseases [4].

Small millets have high resilience for adapting to different ecological conditions along with being ideal crops for climate and contingency plantings. The unique nutritional and nutraceutical properties of millets help in providing nutritional security to larger sections of disadvantaged and economically susceptible groups worldwide [5].

Millets are climate-resilient as they adapt to a wide range of ecological conditions requiring less irrigation with better growth and productivity in low nutrient input conditions depending minimal on artificial fertilizers and vulnerability to environmental stresses [6].

Ensuring food security for the nation is a major policy goal and is defined as “when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO, 2001). Millets contain high amounts of proteins, fibre, B-complex vitamins that include niacin, thiamine and riboflavin, essential sulphur-containing amino acid methionine, lecithin and little of vitamin E. They are rich in iron, magnesium, calcium and potassium. The seeds also contained phytonutrients like phytic acid, that lowers cholesterol and phytates that reduce the risk of cancers [7].

The world is dealing with agrarian and nutritional challenges as agricultural lands with irrigation facilities have been exploited to the maximum. The need of the hour is to focus on drylands to further increase grain production for the exploding population and owing to the low fertility of these drylands, to produce sufficient grains can be a big challenge. Millets as climate change compliant crops score highly over staple grains like wheat and rice of marginal growing conditions and high nutritional value. These Nutri-cereals are abode with vitamins, minerals, essential fatty acids, phytochemicals and antioxidants that can help to eradicate the plethora of nutritional disorders. Its cultivation can keep drylands productive and ensure future nutritional security [8].

The revival of millet cultivation in Karnataka, Andhra Pradesh and Telangana can be a step towards sustainable cropping practices that help in biodiversity. Many factors make millets more sustainable as crops because compared with rice, millets require nearly 2.5 times less water than rice as per ICRISAT.

2. EMPIRICAL REVIEW

Deepak et al. [9] stated that in the present century, climate change, water scarcity, food scarcity, ever booming world population, rising food prices and societal factors impact and threaten agriculture and nutrition security worldwide. Hence, to overcome hunger and poverty, millets can be an awesome food source as they are nutrient-dense, rich in antioxidants, alkaline-forming, gluten-free and adaptable to diverse soil and climatic conditions. They can play an important role in improving immune system due to their medicinal and nutraceutical properties, prevent degenerative health conditions and provide food security to people in arid and semi-arid regions. Food processing techniques can be used to enhance nutritional quality, improve the digestibility and bioavailability of food nutrients along with reducing anti-nutrients.

Bommy and Maheswari [10] stated that in India, millets can produce multiple securities relating to food, nutrition, fodder, fibre, health, livelihood and ecology. Most millets have edible stalks favoured as fodder for cattle along with being storehouses of nutrition for them and hence provide nutrition security.

Traditional medicine such as Siddha and Ayurveda considered food as medicine and medicine as food with the main motto being that medicine is for prevention of disease rather than cure. The traditional system of medicine believed that proper intake of food supplements can prevent mankind from dreadful diseases. *Navadhanyam* is cereals and millets that play a vital role in meeting the special needs of pregnant and lactating women as well as patients recovering from illness as it has essential nutrients and therapeutic value. Except for maize all other cereals and pulses can be soaked overnight and consumed as sprouts for increased dietary fibre, vitamins and minerals [11].

Millets due to their nutritive value have potential health benefits to prevent cancers, decrease the occurrence of cardiovascular diseases, reduce tumour proliferation, lower blood pressure, risk of heart diseases, cholesterol content, rate of fat absorption, delayed gastric emptying and increased gastrointestinal bulk (Truswell, 2002) [12].

The millets are non-glutinous grains that can be used by people suffering from celiac diseases and gluten allergy as a replacement to wheat in diets. The consumption of millets do not form acid in the digestive tract, hence are easy to digest and non-allergic [13].

Millets are gluten-free, a rich source of antioxidants and cholesterol-lowering waxes benefiting people to combat lifestyle diseases. They can save foreign exchange required to import staple cereals and provide farmers with a market for the millet-based products. The growing demand in today's world for gluten-free products as many are suffering from celiac diseases open new markets for millet-based products [14].

Kaushik et al. [15] highlighted the pre-milling, conditioning, yeast and acid treatments increased the flour extraction rate more than that of tempering and highest was obtained with acid-treated grains and lowest for conditioned grains although the quality of acid-treated grains was poor. Yeast treatment was acceptable giving slightly lower extraction rate but good flour quality than acid treatment.

Chandrashekara and Shahidi [16] investigated the effect of processing on antioxidant activity of millet grains as they are usually dehulled and subjected to hydrothermal treatment before consumption. The hulls were used as a potential source of antioxidants and total phenolic compounds ranged from 2.0 to 112.0 µmol ferulic acid equivalent/g of the defatted meal. All varieties effectively inhibited 1,1-diphenyl-2-picrylhydrazyl (DPPH) and superoxide radicals. The antioxidant activity of the phenolic compound was in the order of hull > whole-grain > dehulled grain > cooked dehulled grain. Results showed that dehulling of grains and hydrothermal treatments did affect the phenolic content and antioxidant potential of millets.

2.1 Processing of Millets – Germination and Fermentation

The processing techniques like roasting and grinding rendered the grains more digestible without loss of nutritious component [17]. The puffing and roasting were almost similar processes but the volume expansion in puffing was higher [18]. Fermented finger millets showed improved biological value, net protein utilization, thiamine, riboflavin and niacin content [19].

Germination and fermentation of pearl millet increased the protein, ash, crude fibre, phosphorus, calcium and iron levels. The phytic acid levels were significantly reduced ($p \leq 0.05$) compared with the non-germinated control. Germination can be a promising method to improve the nutrient density of pearl millet and combined with fermentation can reduce phytic acid content significantly [20].

Ranal and de Santana [21] measured the dynamics of germination like process time, rate of germination, homogeneity and synchrony that helps to predict the degree of success of grain-based on germination time to harvest seed. Supplementation of germinated foods to infants showed a general improvement in their haemoglobin level due to better iron bioavailability [22].

The amylase activity and carbohydrate profile for foxtail, barnyard and proso millets after germination showed increased reducing sugar content due to degradation of starch. This

decrease in the starch content was not reflected in the total carbohydrate content of the sample [23].

Caulibaly and Chen [24] found that minerals, vitamins, enzymatic activity and mobilization of soluble sugars increased due to germination of foxtail millet. Protein content remained same and fat decreased thereby improving the shelf life of foxtail millet flour. The enzyme inhibitors, chemical and natural pesticides were removed by soaking, rinsing and germination along with making them easy to digest and assimilate by the body.

Nkhata et al. [25] determined that fermentation and germination improved nutrients and phytochemicals accessibility to digestive enzymes. The activation of endogenous enzymes like α-amylase, pullulanase, phytase and other glucosidase was observed with degraded antinutritional factors. Weil [26] depicted that during germination amylolytic activity occurred with the production of maltose, maltotriose and dextrin due to starch hydrolysis.

The sprouting increased vitamins C, A and E whereas phytates, tannins and oxalate levels were reduced in foxtail millets. The organoleptic attributes of this millet improved and was acceptable as other sprouted legumes and cereals [27]. The germination and high-pressure processing have significantly improved the functional properties of foxtail millet flour [28].

Chauhan and Sarita [29] reported that millets are an excellent source of starch making them energy-dense and can replace wheat and rice. Millets have important nutraceutical and therapeutical properties like anti-diabetic, anti-hyperlipidaemia, anti-allergic for gluten sensitive persons, anti-carcinogenic, anti-cataractogenesis, anti-inflammatory, anti-lithiatic, anti-ageing, nephroprotective and helps in wound healing, strengthening the nervous system, increasing haemoglobin level. Millets also contained anti-nutrients that are reduced by germination.

2.2 Significance of Millets

There is a need to revive the importance of millet groups as health foods to enhance nutritional security. Among all the millets, foxtail millet is an important underutilised grain grown in different parts of India and even grown in adverse climatic conditions. It is a good source of β carotene with 126-191 µg/100g [30]. This millet proved to be suitable for people suffering from metabolic disorders [31].

Millets are nutritionally important due to high calcium (0.39%), dietary fibre (18.0%) and phenolic compound (0.03-3.0%) and characterized to be potential prebiotic to enhance the viability or functionality of probiotics with significant health benefits [32].

Kalinova [33] cited the importance of proso millets which was a rich source of starch, trace elements, dietary fibre, vitamins and contained health benefits compound that decreased the level of low-density lipoprotein cholesterol in the blood and prevented injury to the liver due to antioxidants and β-glucans.

Millets are typically rich in protein with high quantity sulphur-containing amino acids like methionine and cysteine. The milling of millets removes the bran and germ layers that are rich in fibre and phytochemicals resulting in their significant loss. They are a good source of antioxidants like phenolic acids and glycated flavonoids with characteristics potential to be prebiotics and can enhance the viability of probiotics [34].

The value-added millet-based products provided maximum health benefits to consumers due to high nutrient content that include proteins, essential fatty acids, B-vitamins and minerals [35]. Millets with their better amino acid profile along with vitamin A, minerals, fibre, starch and low glycemic index are grown in semi-arid areas. Value-addition to millet grains as ready-to-eat and ready-to-cook items offers a good opportunity to farmers for income generation and promote production and marketing leading to nutritional security, employment and revenue generation [36].

3. CONCLUSION

Millets hold great potential for food and nutrition security in the ever-burgeoning agricultural costs, unpredicted climate change and proliferating population to feed worldwide. These are nutritious with health benefits requiring significantly lesser inputs and cost of cultivation along with naturally being tolerant to most biotic and abiotic stresses. These features accentuate Poaceae family of millets as crops of choice in the present scenario.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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