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Research Article

Millets: A Crop(s) for Climate Resilience and Food Security

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Abstract

Millets is a class of small seed grasses, belong Poaceae (Gramineae) family, Widely cultivated in arid and semi-arid region around the world as cereal crops. This is one of the oldest cereals introduced to mankind. Millets possess good properties of adaptability in harsh environment. Millets have excellent plant defense mechanism to survive in biotic and abiotic stress conditions compare to other cereals. In comparison to the mainstream crops, millets have the ability to offer rich macronutrients (protein, fibre, vitamins, starch) and micronutrients (Ca, Fe, Zn, Cu, Mn, Mg) when used as a staple crop diversifier. They are incredibly nutrient-dense and have been shown to be essential in both preventing and treating number of diseases. Millets contain phenolic compounds that are good for human health, including as flavonoids, tannins, and phenolic acids. Millet grains include phytochemicals that improve human health by reducing cholesterol and phytates in the body. By consuming these grains, one's diet may become healthier and illness risk may be reduced. The primary objective of this review is to illustrate the importance of millets in the context of nutritional and climate status for the benefit of human and their livestock.

Keywords: *Millets, Nutrition, Micronutrients, Drought stress, Salt stress*.

Introduction

Cereals are one of the main food source in human diet and its production has reached to unprecedented levels of 2715 million tons in 2019 (FAO, 2020). Recent decrease in fresh water scarcity, fertile cultivable lands, increased global population and anthropogenic mediated environmental contamination are the main limiting factors for global food grain production. Further unpredictable environmental factors have emerged that limit regional agricultural activities and responsible for decreased productivity. These developments linked with socio-economic impacts will lead to the elevated global food prices (Yousaf, *et al*., 2021).

In contrary, millets are the group of cereals that are the main source of food in Arid and Semi-Arid regions of Africa and Asia, including India and China. Due to increased earning capacity and change in food habits, the cultivation and consuming of millets has been reduced until recently. This has led to the increased global diabetic percent and understanding the fact that the millet capacity with low glycemic index has made them a big comeback. Millets are the class of cereals that are classified into two groups, minor and major cereals. The minor millets includes nine species, barnyard millet (*Echinochloa frumentacea* L.), brown-top millet (*Urochloa ramosa* (L.) T.Q.Nguyen), Finger millet (*Eleusine coracana*), foxtail millet (*Setaria italica* L.), kodo millet (*Paspalum scrobiculatum* L.),

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little millet (*Panicum sumatrense*), proso millet (*Panicum miliaceum* L.) along with Teff (Eragrostis tef) and fonio (*Digitaria exilis*) which were recently included (AmAdou, *et al.*, 2011 and Sagar Maitra, 2020). While major millet comprise of pearl millet (*Pennisetum typhoides* L.), sorghum (*Sorghum bicolor* L.). Among the millets, brown top millet is one of the more expensive coarse cereals available in retail stores and has recently caught the interest of health-conscious consumers. Brown-top millet was one of the oldest cultivated crops in Neolithic India (Boivin, *et al*., 2014).

These millets are known for their inherited capacity to withstand variety of environmental stresses, short life cycle and grows in relatively marginal lands and yield nutritive-rich seed. Due to the limited scientific interest until recently, they were classified as underutilized crops that grown in tropical and semiarid regions across world (Chandra, *et al*., 2016). Further, change in agro climatic conditions, unpredictable drought spells, and increased awareness on millet diet, the millet growing area has been increased. These changes have increased the scientific and industrial interest too, to identify promising germplasms with enhanced nutritional properties (Bunkar, *et al*., 2021).

Nutritional Aspect and Food Security

Millets are treated as coarse grains that are mainly used as animal feed in developed countries. While, the same has been used to fulfil dietary needs of humans in developing countries (Singh, *et al.*, 2023). Millets are crops of nutritional importance that grow in Arid and Semi-arid regions of Africa and Asia. The global millet production since 2018 has shoot up and India stood in front line of the global millet production with 40% of the total world produce followed by Niger (11 %), China (9%), Nigeria (6%) (Yousaf, *et al*., 2021; www.upad.fas.usda.gov). Small millets are symbol of Nutri-rich seeds, with high dietary fibre, minerals, and vitamins with gluten free carbohydrates. The nutritional value of the millet grain was marked as "Functional Foods" due to the fact that, they are rich source of has been identified with higher amounts of antioxidants, polyphenols, and dietary fiber than other conventional food grains. This make them the dietary alternative for the patients suffering with type-2 diabetes (Almaski, *et al*., 2019). These loaded cereals are a choice of a person's suffering with heart diseases, diabetes and celiac diseases (Khoury, *et al.*, 2018) as well reduce the risk of tumor occurance, control blood cholesterol and improve gastrointestinal health (Chandrasekhara and Shahidi, 2012; Sruthi and Rao, 2021). The bioactive components of the millets including tannins, phenols, phytates etc., are some of the critical secondary components that will have positive effect on the health (Bunkar, *et al*., 2021). Millets contain high phosphorous that is required for many cell functions including ATP synthesis and maintain bone density. It is estimated that a cup of cooked millet meal can provide 24% of total dietary needs of human (Kumari and Sumathi, 2002). Millet flour may be used to make porridge by mixing it with other ingredients (Habiyaremye, *et al*., 2017).

High nutritive finger millet has been employed in traditional treatment methods for of a variety of health artifacts including leukemia (Chandra, *et al*., 2016). The phytochemical components of the finger millet have been shown to have several health benefits. The array of such compounds includes, alkaloids, phenols, steroids, and tannins along with high mineral and crude fiber content. Finger millet seeds were reported to have higher concentrations of Valine, Lysine and Threonine compared to other millets (Sruthi and Rao, 2021). Reports confined with analysis of the 85 and 259 foxtail millet germplasms of respectively in China provinces revealed high genetic variability with respect to total starch (65.59 to 74.12), fat (2.82 to 4.47), crude protein (11.85 to 20.58) g/100g total seed (Chen, *et al.*, 2013; Sharma and Niranjan., 2017). Finger millet has higher seed nutrients like calcium, proteins, dietary fiber, tannins, phenolic compounds etc., Trypsin inhibitory factors were reported to have many health benefits that includes, anti-ulcer, anti-inflammatory, anti-diabetic etc., (Chandra, *et al*., 2016).

Sorghum and pearl millet are classified as major millets loaded with nutritional contents. Pearl millet has 40% more lysine and methionine and 8% to 60% higher amounts of crude proteins than maize. Lysine content in pearl millet is 21% higher than in maize and 36% higher than in sorghum. Sorghum contain 1.9% fat, 10.4% crude protein, 1.6% crude fiber, 72.6% carbo hydrate and 1.6% minerals. The distribution patterns of protein fractions have a high correlation with the quality of the protein. In-depth details on the protein fraction are as follows: of total nitrogen, 22–35% are prolamin and prolamin-like substances, 22-28% are albumin and globulin, and 28–32% are glutelin and glutelin-like substances (Rathore, *et al*., 2016). Sorghum and pearl millet germplasms lines were noted to have high genetic variation for nutritional quality traits. Further, it is reported to contain high levels of fat and protein in a range of 3.4% to 7.1% and 9.2% to 13.6% for fat and protein respectively and for starch and ash is 61.0% to 70.3% and 1.1% to 2.4% compared to sorghum (Rai, *et al*., 2008). The genetic variability range for the protein content, starch, fiber and fat were reported to be in a range of 7.9% to 11.5%, 63.4% to 72.5%, .6% to 2.4%, and 1.9% to 3.0% respectively in sorghum.

Barnyard millet are reported to have fat, protein, crude fiber and carbohydrates at the rate of 3.9%, 10.1%, 6.7%, 2% and 68.8% respectively per every 100 grams of grain (Ugare, *et al*., 2014). Kodo millet was reported to have fat, protein and carbohydrates at the rate of 1.45%, 8.35% and 65.65% respectively, along with other vitamins and minerals including potassium, zinc, calcium and magnesium. Glutamin is the found in higher concentrations that makes 8.3% of the total aminoacids found in kodo millet. High iron and dietary fibre content has been reported in kodo millet in a range of 25.86 – 39.60 ppm and 37-38% respectively. Despite having a low-fat content, they are rich in polyunsaturated fatty acids (Bunkar, *et al*., 2021). About 70% of the nutrients in proso millet are starch, the most prevalent type of nutrient. The crude fat concentrations of the various kinds ranged from 3.5% to 4.5%, whereas the wholegrain millets' ash and fibre contents varied from 2.68 to 3.61% and 9.59% to 14.78%, respectively. The protein amount ranged from 11.2% to 15.2% (Bagdi, *et al*., 2011). Variations of waxy proso millet exerted an average protein value of 13.38%, whereas variations that were not waxy had an average protein content of 12.05%. Glutamine, Leucine and Alanine were remarkably abundant in proso millet, on an average 32.55 mg/g, 16.19 mg/g, and 12.25 mg/g, respectively. The essential fatty acids oleic and linolenic were reported to be in higher concentrations with an average percent of 22.16% and 61.74% (Shen, *et al*., 2018).

Table 1: Macronutrient content of different millets

Millets	**Protein g/100 g**	**Carbohydrates**	**fiber**	**Fat**
Foxtail millet	11.85–20.58	65.59% to 74.12%	18.8%	2.82% to 4.47 %
Barnyard millet	10.1%	68.8%	12.5%	3.9%
Kodo millet	8.35%	65.65%	9%	1.45%
Pearl Millet	9.2% to 13.6%	61.0% - 70.3%	2%	3.4% to 7.1%
Proso millet	11.2% to 15.2%	74 %	9.59% to 14.78%	3.5% to 4.5%
Finger Millet	6–13%	65-75%	18%	1.3%
Sorgum	7.9% -11.5%	63.4% - 72.5%	1.6% to 2.4%	1.9% to 3.0%

Climate Resilience Aspect

Agriculture crops experience a variety of stresses, including drought, salt, high temperature, water logging and heavy metals that limit plant growth and yield compensation upto 50% depending on the stage of its occurrence. Millets are known for their exceptional ability to yield high nutritive seeds in response to low soil inputs and can adopt to a variety of environmental conditions including biotic and abiotic stresses. The yield loss of crop depend on the duration of stress and growth stage at which it occurs. Millets, can produce high quality grains as well can provide fodder to animals in World's most hostile environments. Drought resilience is one of millets' positive qualities. These plants' cranz anatomy inhibits photorespiration, therefore little water is necessary for them to carry out their essential functions (Tadele, 2016). Millet maintains its superiority in terms of leaf, dry matter increase, net assimilation rate, and greater plasticity even in the face of drought. Phenological expression only affects growth and yield in less stressful conditions; it is not visible. It has been noted that under stressful circumstances, the average flowering time is delayed by 10 to 15 days in millet (Seetharama, 1982).

Among major millets, highly drought tolerance has been recorded in pearl millet, that surpassed sorghum. Water utilization capacity of pearl millet is higher than maize and its salt tolerance capacity is much higher than barley. Genetic variability of pearl millet for salt tolerance is higher (Rai, *et al*, 2008) as well highest terminal drought tolerance has been noted under field salt and drought stress conditions (Charu Lata, 2015). Stay green trait of the pearl millet line, H77 has successfully utilized for large scale EST generation and identified many genes that involved in terminal heat stress tolerance (Maibam, *et al*., 2020). Among the minor millets, kodo millet is widely recognized for having the strongest tolerance to drought and for producing good yield in a shorter growing season, between 80 and 135 days (Bunkar, *et al*., 2021). Finger millet variety such as *RAU-8, PSE-110, GE-400, GE-40, GE-5079, GE-1052, GE-1559, GE-4955, GE-4006, GE-214* and *VL-315* exhibit more heat tolerance and give more yield under high temperature stress (Yogeesh, *et al*., 2016). Some varieties of finger millet (GBK043137 and GBK042094) tolerate more water deficiency compare to other finger millet varieties. Heat Shok Protein facilitates plants in mitigation of heat stress. Five major HSP - *HSP60, HSP70, HSP90, HSP100* and small HSP have been identified. Small HSP gene s*HSP*17.8 found to show, higher thermo tolerance ability in finger millet (Ramakrishna, *et al*., 2018).

The large-scale production of foxtail millet genomic resources is now feasible due to the availability of the Setaria genome sequence. Single gene, SiARDP from foxtail millet when overexpressed in *Arabidopsis* shows that it interacts with AREB gene and play crucial role in drought stress mitigation. Drought priming experiments using mannitol perform better under drought and shows higher water holding capacity and maintain vital cellular activities (Mukami, *et al*, 2019). Genes containing the SET gene domain modify the physiological and molecular mechanisms in plants by catalyzing histone lysine methylation and modifies the structure of chromatin. There has been reported SET domain proteins in foxtail millet. SiSET genes regulate tolerance to abiotic stresses such as cold, dehydration, and salt, as well as hormonal effects, is attributed to *SiSET* genes. The *SiSET14* gene in foxtail millet enhance resistance to cold (Yadav, *et al*., 2016).

Conclusion

Millets are considered as superfood because these are rich in micro and macronutrient due to the fact that they are rich source of fiber, protein, lipid, carbohydrate and minerals. Gluten free nature of these millets is best dietary choice of celiac patients. Further, ability to grown in marginal lands and climate resilience make it a choice of crop to grown in variety of soils / environmental conditions including drought, salinity and heat. Because of these stupendous properties millets are considered as a model plants. Since the declaration of 2023 as a 'Year of Millet', it has attracted scientists, plant breeders and former towards its importance for nutritional and climate purpose. Millets are the right choice and might be helpful in eradication of global 'hidden-hunger' which is generally referred as malnutrition.

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