



POTENTIAL OF NEUTRACEUTICAL AND NEGLECTED CROPS TO COPE UP OF CLIMATE CHANGE AND FOOD SECURITY FOR THE FUTURE: A REVIEW

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Abstract

Millets and Underutilized crops play an important role in food security, nutrition, and income generation of many resource-poor farmers and consumers especially in the developing world. Dependence on a few major crops remains a major challenge due to its potential impact and contribution to food security. Higher temperatures, unpredictable rainfall and weather patterns, changes in growing seasons, increased occurrences of drought and extreme weather events will exert a greater strain on agriculture. Some of Underutilized crops are grain amaranth, buckwheat, rice bean, adzuki bean, chenopods and some of the millets are finger millets, barnyard millet, Proso millet, Foxtail millet, Little millet *etc.* These crops have high nutritional values, forage importance and grown in marginal land without much agricultural inputs. Emerging evidence suggests that climate change will cause shifts in food production and yield loss due to more unpredictable and hostile weather patterns. There is now an increasing realization of this fact, and a greater awareness that these crops merit more research and development. The growing demand for food and a variety of food products also calls for interest and investment in underutilized and millets crops by scientist, people and peasants. Underutilized and millets, therefore hold the key to the future of mankind. They are the 'Potential food crops of tomorrows' world.

Key words: Underutilized, millet and climate.

Introduction

Agriculture and climate change are correlated with each other in various aspects, as climate change is the main cause of biotic and abiotic stresses, which have adverse effects on the agriculture of a region. The land and its agriculture are being affected by climate changes. Dependence on a few major crops remain a major challenge due to its potential impact and contribution to food security (Wheeler *et al.*, 2013). Higher temperatures, unpredictable rainfall and weather patterns, changes in growing seasons, increased occurrences of drought and extreme weather events will exert a greater strain on agriculture. Millets and underutilized crops have high nutritional values, forage importance and grown in marginal land without much agricultural inputs. Millets are climate change, compliant crops that resist the challenges. Millets need less water, to grow and can tolerate higher temperatures, crucial for farmers in this era of climate change.

Millets and Underutilized crops are a group of grassy plants, short slender culm and small grains possessing remarkable ability to survive under severe drought conditions. These have been food commodities since ancient times. Because of their important nutritional qualities, there is a need to revive their usage in daily diet. Millets can substitute major cereals for better health benefits. Small millets include finger millet (*Eleusine coracana*), kodo millet (*Paspalum scrobiculatum*), little millet (*Panicum sumatrense*), foxtail

millet (*Setaria italica*), proso millet (*Panicum miliaceum*) and barnyard millet (*Echinochloa colona*) and underutilized crop contain Amaranth, buckwheat *etc.* Each has specific nutritional benefits. All small millets are rich in dietary fiber and have low glycemic index. Known as nutra-cereals, ready-made mixes of foxtail, little and barnyard millets have proven therapeutic value for diabetics. Small millets require only one-fifth of the water needed for rice cultivation. Underutilized or neglected crops species are often indigenous ancient crop species which are still used at some level within the local, national or even international communities. Millets and underutilized crops are one of the cereals besides the major wheat, rice, and maize. They are grown mostly in marginal areas under agricultural conditions in which major cereals fail to give substantial yields (Adekunle, 2012). Millets are important foods in many under developed countries because of their ability to grow under adverse weather conditions like limited rainfall. In contrast, millet is the major source of energy and protein for millions of people in dry country. It has been reported that millet has many nutritious and medical functions (Obilana and Manyasa, 2002; Yang *et al.*, 2012). The term "Millet" (A Nutritional Crop) is applied to various grass crops whose seeds are harvested for human food or animal feed. Millets include five species, *Panicum*, *Setaria*, *Echinochloa*, *Pennisetum*, and *Paspalum*, all of the tribe Paniceae; one genus, *Eleusine*, in the tribe Chlorideae; and one genus, *Eragrostis*, in the tribe Festuceae. Millets are a major food source in arid and semi-

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arid parts of the world. Millets are excellent sources of carbohydrates, protein, fatty acids, minerals, vitamins, dietary fiber and polyphenols. The four major types are Pearl millet (*Pennisetum glaucum*), which comprises 40% of the world production, Foxtail millet (*Setaria italica*) (Yang *et al.*, 2012), Proso millet or white millet (*Panicum miliaceum*), and Finger Millet (*Eleusine coracana*). foxtail millet is an economically important crop grown and consumed all over the world, especially in India, China, and other parts of Asia, North Africa, and the Americas.

Finger millet is important small millet grown in India. It is a staple food in many hilly regions of the country. It is grown both for grain and forage. Grains are rich in minerals and are the richest source of calcium used in many preparations like cakes, puddings, sweet etc. it is also a rich source of iron, protein, fiber and other minerals and is a gluten (elastic texture) free food (Gowda *et al.*, 1994). It is a good food for people who suffering from diabetes, liver diseases, high blood pressure, heart weakness and asthma. Its green straw is suitable for making silage. The major finger millet growing states are Karnataka, Uttarakhand, Maharashtra, Tamil Nadu, Odisha, Andhra Pradesh and Gujarat. Finger millet is the richest source of calcium (300-350 mg/100g). It contains lower levels of protein (6-8%) and fat (1.5-2%). (Upadhyaya *et al.*, 2006). Barnyard millet is the richest source of crude fiber and iron. Its grains possess other functional constituents i.e., Gamma amino butyric acid (GABA) and Beta - glucan, used as antioxidants and in reducing blood lipid levels.

Proso millet is important minor millet grown in India. The crop is able to evade drought by its quick maturity. Under unirrigated conditions, proso millet is generally grown during kharif season but in areas where irrigation facilities are available; this is profitably grown as summer catch crop in high intensity rotations (Zarnkow *et al.*, 2009). Proso millet is free from gluten and has numerous amounts of fatty acids and carbohydrates. It also contains the minerals such as magnesium, manganese, phosphorus etc. It is helpful for the postmenopausal women. It prevents the high blood pressure and provides adequate zinc, vitamin B6 and iron for the daily functioning. It is easily digested as they are non-acid forming. Proso millet contains the highest amount of proteins (12.5%). It is cheaper source of manganese as compared to other conventional sources like spices and nuts. It contains high amounts of calcium which is essential for bone growth and maintenance.

Little millet is an annual herbaceous plant, which grows straight or with folded blades to a height of 30 cm to 1 m. The leaves are linear, with the sometimes hairy laminae and membranous hairy ligules. The panicles are from 4 to 15 cm in length with 2 to 3.5 mm long awn. The grain is round and smooth, 1.8 to 1.9 mm long. It is wonderful millet which is suitable for people of all age groups. The little millet contains 8.7 gram protein, 75.7 gram carbohydrate, 5.3 gram fat and 1.7 gram mineral and 9.3 mg iron in per 100 gram. The major little millet growing states are Orissa, Gujarat, Maharashtra, Karnataka, Andhra Pradesh and Madhya Pradesh. Little millet has high in iron content and high antioxidant activities and it contains about 38% of dietary fiber.

Foxtail millet is also known as Italian millet, and German millet. It is generally grown as a rainfed crop in India. It has an erect leafy stem that grow 60-75 cm tall and bend quite a bit at maturity due to heavy weight of ear head. Foxtail grain contains 10% to 12% Protein, 4.7% fat, 60.6% carbohydrates, 2.29% to 2.7% Lysine and 0.59 (mg) Thiamin. Foxtail millet is high in carbohydrate content and double quantity of protein content as compared to rice. Foxtail millet contains minerals such as copper & iron.

Kodo millet is highly drought resistant crop. It is the coarsest of all food grains. The kodo millet, also known as cow grass, rice grass, ditch millet. Native Paspalum or Indian Crown Grass originates in tropical Africa and it is estimated to have been domesticated in India 3000 years ago. The grain is covered with a horny seed coat which should be removed before cooking. The grain contains 8.3 per cent protein, 1.4 per cent fat, 65.6 per cent carbohydrates and 2.9 per cent ash. In India, it is grown in Rajasthan, Uttar Pradesh, Tamil Nadu, West Bengal, Madhya Pradesh and Andhra Pradesh. Kodo millet is rich in B vitamins especially niacin, pyridoxin and folic acid as well as the minerals such as calcium, iron, potassium, magnesium and zinc. It contains a high amount of lecithin and is an excellent for strengthening the nervous system.

Nutritional Value

As revealed from table 1, the uncommon food grains have exceptionally high nutritive value. While millets are somewhat poor in the protein content, the pseudo-cereals amaranth, buckwheat and chenopod have appreciably high protein value of the pseudo-cereals as could be exemplified from the contents of essential amino acids in it is also much superior compared to those of the common food grains (rice, wheat, maize) and even the millets. Total ash (minerals) present in all the neglected crops is very high. Quality of protein that depends on the composition of its amino acids is of critical value in human nutrition. Food uses of millets and underutilized crops have, however, been confined only to traditional consumers; limited especially to areas of their cultivation, and still have remained underutilized.

Nutritional composition, Processing and value addition

Like other cereals grains small millets and underutilized crops are predominantly starchy. The protein content is more or less equal and comparable to that of wheat, rice and maize. Similar to other cereal grains millet and underutilized crops are also required to undergo certain basic steps of primary processing operations, such as cleaning, grading and separation wherein removal of unwanted materials like, stones, soil particles, stalks, chaffs, grains of other crops etc. This is also possible with the help of hullers used for dehusking of paddy. Specially designed ragi polishers are also used for this purpose in southern part of India. Pre-cleaning operations are accomplished by using cleaners and destoners used for other cereals after making suitable modifications (Gopalan *et al.*, 2004).

Healthy Food and value added products

Millets and underutilized crops serve as a major food component specifically among the non affluent segments in their respective societies. Various traditional foods and beverages such as roti, bread (fermented or unfermented), porridge, snack and fast foods, baby foods, millet wine, millet nutrition powder etc are made up of millets. Incorporation of finger millet flour in the preparation of bakery products like biscuit, nan-khatai, muffins and bread has been attempted and efforts are being made to standardize the recipe and product quality. In a recent study attempts have been made to improve the nutritional quality of cakes with respect to the mineral contents and fibre content by supplementing with malted finger millet flour (Desai *et al.*, 2010). In recent years finger millet has received attention and efforts are under way to provide it to consumers in convenient forms (Malleshi and Desikacher, 1986). Millet can be used in a variety of ways and is a great substitute for other grains such as rice and other starchy grains. These products are either in practice or have been demonstrated/ tested as avenue for enhanced consumption of finger millet.

Multi-grain flour /Composite flour

The concept of multi-grain flour/composite flour is not new to the mankind. Mixing of two-three types of grains or grain and pulses has been in practice since long ago depending upon the availability of such commodities locally or the food habits, but in such cases, the understanding of nutritional security is not necessarily linked. Multi-grain flour by combining wheat and finger millet in the ratio of 7:3 (wheat:finger millet) is one of the simple semi-finished products suitable for making chapatti (roti), as no Indian meal is complete without Indian style bread or roti. Fortification of finger millet in chapattis not only improves the taste but also helpful in controlling glucose levels in diabetic patients very efficiently. The bulkiness of the fibres and the slower digestion rate makes us feel fuller on, fewer calories and therefore may help to prevent from eating excess calories.

Puffing or popping

Puffing or popping of cereals is an old practice of cooking grains since time immemorial to be used as snack or breakfast cereal like corn either plain or with some spices/salt/sweeteners. Popping or puffing of finger millet is one of the popular traditional methods and the popped millet and its flour is a ready-to-eat product with pleasing texture and appealing flavour. Popping improves the nutritional value by inactivating some of the antinutritional factors (enzymes and enzyme inhibitors) and thereby enhancing the protein and carbohydrate digestibility; it also enhances the appearance, colour, taste and aroma of the processed raw material (Mangala *et al.*, 1999). For puffing, the whole finger millet grain is conditioned by mixing additional water so as to reach its moisture content in the range of 18-20% and tempered for about 4-6 hours under shed. The conditioned grains are puffed by agitation on the hot sand surface maintained at about 230 - 250°C for short time following HTST (high temperature and short time) process. Further, during this process, the vapour

pressure of the grain increases and the moisture present in the grain turns into steam; gelatinization of the starch takes places and explodes. Since during popping or puffing grains are dehydrated to the extremely low level of moisture content, nearly 3-5%, the shelf-life is enhanced.

Malting - Weaning food

Traditionally the millet malt is utilized for infant feeding purpose and also to prepare beverages. Finger millet being good malting characteristics, its malting is popular in the area of cultivation particularly in Karnataka and part of Tamilnadu. Malting of finger millet improves its digestibility, sensory and nutritional quality as well as pronounced effect in lowering the antinutrients (Desai *et al.*, 2010). Finger millet has some of the inherent qualities which make it superior compare to other cereals and also qualify for malting and preparation of malted foods. In addition to these, finger millet is a good source of sulphur amino acids and calcium. An example of composite malt flour (malted weaning food) preparation combining finger millet, green gram and bengal gram is described. This blend is nutritional in addition to rich source of protein and calcium. During germination, it is essential to mix or turn the grains to provide good aeration to facilitate better germination. While drying it should be kept in mind that the drying temperature should not exceed 75°C. Higher drying temperature may cause parboiling effect and hardening of the grains which may have adverse effect on milling and quality of the malt flour. These grains (malted) are then roasted uniformly at 70-80°C either by conventional toasting pan or heaters. The pulverization can be accomplished by any size reduction facilities suitable to convert into fine flour. The pulverized malt is then subjected to sieving through the fine sieve to separate the husk and fine malt flour is obtained. The malted weaning food is mixed with powdered sugar, milk powder or whole milk along with flavouring agents to make as milk based beverage. This preparation is a good source of nutrition and suitable for all the age groups. This preparation is popularly known as 'ragi malt' and can be used as health drink or energy drink.

Extruded products

Extrusion technology is another novel way of transforming ingredients into value added products. Extruded products prepared from different grains are very popular now-a-days among the all age groups and their demand is growing, one such example is 'Kurkure', very popular among children. The change in life-style is also bringing a drastic change in the food habits, and the extruded foods being ready-to-eat (RTE) products have become a good choice as snack foods. Finger millet flour or grits exhibit good extrusion characteristics. Extrusion cooking has ability to gelatinize and cook the product to the fullest extent and enables its uses as a RTE food. The flour/grit with 16-18% moisture content has ability to extrude in the barrel temperature range of 100-120°C well with good expansion index with crunchy, porous and smooth surface texture. Like other preparations, the finger millet flour can be blended with other legume ingredient flours in appropriate proportion with further fortification of minerals and vitamins to design a balanced nutritional food.

Milletts and Underutilized crops as Phytochemicals and Nutraceutical

Milletts and underutilized crops are also rich sources of phytochemicals and micronutrients. Phytochemicals such as phenolics (bound phenolic acid-ferulic acid, free phenolic acid-protocatechuic acid), lignans, β -glucan, inulin, resistant starch, phytates, sterols, tocopherol, dietary fiber and carotenoids are present in milletts. The concepts of food consumption are changing from previous to present time. Milletts have many nutraceutical properties that are helpful to prevent many health problems such as lowering blood pressure, risk of heart disease, prevention of cancer and cardiovascular diseases, decreasing tumour cases etc. Other health benefits are increasing the time span of gastric emptying, provides roughage to gastro intestine. Millet is an alkaline forming food.

Milletts and Underutilized crop as Diabetes and Anti-Inflammatory Activity

Lower incidences of diabetes have been reported in millet-consuming population. Millet phenolics inhibits like alpha-glucosidase, pancreatic amylase reduce postprandial hyperglycemia by partially inhibiting the enzymatic hydrolysis of complex carbohydrates. Inhibitors like aldose reductase prevents the accumulation of sorbitol and reduce the risk of diabetes induced cataract diseases. Finger millet feeding controls blood glucose level improves antioxidant status and hastens the dermal wound healing process in diabetic rats. Milletts are rich in phyto-chemicals containing phytic acid which is known for lowering cholesterol. Milletts are gluten-free, therefore an excellent option for people suffering from celiac diseases and gluten-sensitive patients often irritated by the gluten content of wheat and other more common cereal grains. Antioxidants significantly prevent tissue damage and stimulate the wound healing process. It is reported good antioxidant effects of finger millet on the dermal wound healing process in diabetes induced rats with oxidative stress-mediated modulation of inflammation. Milletts fraction and extract have been found to have antimicrobial activity. In developing country, cereal-based foods have low bioavailability of minerals like iron, zinc initiate critical problem for infants and young children. These anti-nutritional factors which acting on iron and zinc bioavailability are certain phenolic compounds, phytates, and fibres. The proportions of these anti-nutrients in diet can be reduced by some household food processing techniques like decortication, germination.

Why one should eat milletts?

1. Milletts are gluten-free, highly nutritious and rich in dietary fibre. They are rich in micronutrients, including calcium, iron, phosphorus, etc.
2. Dietary fibre in milletts has water absorbing and bulking property. It increases transit time of food in the gut which helps in reducing risk of inflammatory bowel disease and acts as detoxifying agent in the body.
3. Effective in reducing blood pressure;
4. Eliminate problems like constipation, excess gas, cramping etc.

Conclusion

Milletts are staple food source that is not only providing major nutrients like protein, carbohydrate, fat etc. but also provide ample of vitamins and minerals. In developing country, occurrence of malnutrition and various health problems like obesity, diabetes, cardiovascular disease, skin problems, cancer, celiac disease etc. are most prominent because of inadequate supply of nutrition. This will not only help in increasing the profitability of its cultivators but will also help in providing income and employment opportunities in rural area. In view of numerous benefits conferred by the milletts and underutilized crops, our farmers should aim at growing more and more of the milletts; and we as consumers, should include milletts and underutilized crops in our daily food basket. Apart from increasing the production and consumption, in today's era of modernization, industrialization and urbanization, we need to adequately process the milletts to create a variety of value added nutritious products as per the taste, texture, flavour of the consumers. Further, the public needs to be made aware of the benefits conferred by milletts and their role in combating the ill effects of westernized sedentary lifestyle so that they can lead a healthy life.

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Table 1: Nutritive value of the food grains from uncommon mountain crops

Food grain	Moisture (g)	Total Ash (g)	Crude Fat (g)	Crude Fiber (g)	Crude Protein (g)	Carbohydrate (g)	Energy (kcal)	Iron (mg)	Calcium (mg)
Finger millet	5.3	5.9	1.1	3.6	7.3	76.8	346	3.8	232.0
Barnyard millet	11.9	4.4	2.2	9.8	6.2	65.5	307	2.9	0.02
Proso Millet	11.9	3.4	NA	NA	7.6	68.9	NA	5.7	10.0
Foxtail millet	NA	3.0	6.0	8.0	9.0	74.0	NA	10.0	30.0
Amaranth	9.3	3.5	7.1	13.40	15.3	63.1	391	22.4	490
Buckwheat	11.0	NA	7.4	NA	13.5	72.9	335	13.2	114
Chenopod	12.0	2.94	7.80	NA	14.18	62.0	395	171.0	250

Table 2: Indispensible amino acids in the uncommon and common food grains (as percentage of protein)

Food grains	Lysine	Methionine	Tryptophan	Leucine
Buckwheat	5.9	3.7	1.4	5.8
Amaranth	5.0	4.4	1.4	4.7
Wheat	2.6	3.5	1.2	6.3
Rice	3.8	3.0	1.0	8.2
Maize	1.9	3.2	0.6	13.0