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Role of Underutilized Millets and their Nutraceuticals Importance in the New Era-A Review

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ABSTRACT

In the present situation of scarcity of food and nutrition there is a high need of including oldest staple foods that is “millet” other than wheat and rice. Millet would be worth to add in our daily diet as it is healthy, nutritious and versatile grain. Along with, nutritional values and health benefits similar to major cereals like rice, wheat and maize, the use of millets are still limited. Millets are rich in photochemical, antioxidants and various nutrients such as dietary fiber, iron, calcium and magnesium that are essential in fighting from various illnesses. This review focuses on the awareness of nutritional and nutraceutical potential of millets grain and their utility in human consumption. Millets also contains anti-nutrients such as phytates, tannins, polyphenols and trypsin inhibitors that prevents the absorption of nutrients in the body. The existence of anti-nutrients in millets can be reduced by using different processing methods like soaking, germination, roasting and fermentation. Millets can be used by developing various food products after its processing so that it can reach people in wide range. Millet based products can be used by people which helps in combating various kinds of nutritional deficiencies, disorders and diseases. Millets being low cost comparatively to other cereals can be a great source of ending hunger, poverty, nutritional insecurities among the lower section of the population.

KEYWORDS: fortification; photochemical; antioxidants; nutritional insecurities.

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INTRODUCTION

In the world, different factors such as changes in climate, increasing population, scarcity of water, rising food prices, increasing illness among people are proving menace to agriculture, food and nutritional security across the world, especially for the poorest people who live in arid and sub arid regions. This has become a challenge to scientists and nutritionists to find out the different ways of developing, processing and to utilize other food sources for people so there can be elimination of hunger, poverty and nutritional deficiencies. Major source of world's food are cereal grains that plays an important role in our diet¹.

Presently, half of the world's total energy intake comes from cereals directly². There is a lesser extent of sorghum and millets whereas rice, wheat and maize have moved out as the major staple cereals. This indicates the requirement of migrating towards another alternative of current cereals staples.

In relation to world agriculture production, millet is one among six cereal crops. It has the property of resisting pest and diseases, productivity under drought conditions and most importantly nutritious³. Therefore, attention from many developing countries is drawn toward millet grains in terms of its utilization as food. It comes in the category of oldest food crops which are known to us. Millet was earlier consumed as a staple food crop in India, Korea and China. Now-a-days, these cereal are consumed as main crop in several parts of India, Nigeria, Africa and many other countries⁴.

There are different varieties of small-seeded millets like *Pennisetum glaucum* (pearl millet), *Eleusine coracana* (finger millet), *Paspalum setaceum* (kodo millet), *Penicum miliaceum* (proso millet), *Setaria italic* (foxtail millet), *Panicum sumatrense* (little millet), and *Echinochloa esclenta* (barnyard millet). They are known as coarse cereals beside *Zea mays* (maize), *Sorghum bicolor* (sorghum), *Avena sativa* (oats), and *Hordeum vulgare* (barley)^{5,6}. Names of these millets vary from state to state.

Table No. 1: "Different names of various millets"

English	Hindi	Telugu	Kannada	Tamil	Bengali	Mrathi	Gujrathi	Oriya
Barnyard	Sanwa	Udhalu	Oodhalu	Kuthiravally	Shyama	-	-	Khira
Proso	Chena	Variga	Baragu	Pani varagu	Cheena	Vari	Cheno	Bachari bagmu
Kodo	Kodon	Arikelu	Haarka	Varagu	Kodo	Kodra	Kodra	Kodua
Little	Kutki	Samalu	Same	Samai	Sama	Sava	Gajro	Suan
Sorghum	Jowari	Jonna	Jola	Cholam	Jowar	Jawari	Jowari	Juara
Pearl	Bajra	Sajja	Sajje	Kanbu	Bajra	Bajri	Bajri	Bajra
Finger	Ragi	Ragi	Ragi	Keppai	Marwa	Nagli	Nagli	Mandia
Foxtail	Kakam	Korra	Navane	Tenai	Kaon	Kang	Kang	Kanghu

Source: Millets network in India, FIAN⁷, India.

CROP DISTRIBUTION

India is the world's largest producer that harvests about 11 million tons per year. About two-thirds of India's production millets cover by pearl millet. These are grown in drier areas of the states such as Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana. finger millet is produced mainly in the state of Karnataka, Orissa and Tamil Nadu. Less than 2 percent of world cereal consumption is represented by millets. Millets proved to be staple food for semi-arid tropical countries. The low precipitation and poor soil limits the cultivation major food crops⁸. Karnataka is one of the leading state in the production of millets⁴. Millets require very less amount of water in both conditions of the growing period and overall requirement during growth. Most of the millets act as water saving crop as they get mature within 60–90 days after sowing. Barnyard millet (*Echinochloa frumentacea*) took less time for maturation (45–70 days) among millets, which is directly half of the maturation time of rice (120–140 days⁹).

NUTRITIONAL COMPOSITION

Table No. 2: "Nutritional Composition of Millets"

Grains	CHO (g)	Protein (g)	Fat (g)	Total Dietary Fiber (g)	Iron (mg)	Calcium (mg)
Rice Milled	78.2	7.9	0.5	2.8	0.65	7.49
Whole wheat	64.0	10.6	1.5	11.2	5.3	41
Finger Millet	66.8	7.2	1.9	11.2	4.62	364
Proso Millet	70.4	12.5	1.1	-	0.8	14
Foxtail Millet	60.9	12.3	4.3	-	2.8	31
Little Millet	65.6	10.4	3.9	7.7	1.26	16.06
Kodo Millet	66.2	8.9	2.6	6.4	2.34	15.27
Barnyard Millet	65.5	6.2	4.4	-	5.0	20
Pearl Millet	61.8	11.0	5.4	11.5	8.0	42
Sorghum	67.7	10.0	1.7	10.2	3.95	27.6

Source: Nutritive value of Indian foods, IFCT 2017¹⁰

MACRONUTRIENTS

Nutritionally, most of the millets are analogous to major cereal grains. The extra beneficial properties of millet such as gluten-free properties, high fibre content, low glycemic index and eminence in bioactive compounds have made them a pertinent healthy food for people¹¹.

There has been reported that most less carbohydrate content is present in barnyard millet^{1,12}. The regular carbohydrate content in millets varies in the range from 56.88 to 72.97 g/100g.

Many studies^{13,14,15} have shown an average protein content in millets ranges between 10-11%, finger millet is exception that contains protein around 4.76-11.70 g/100g. In Finger millet, about 44.7% essential amino acids are present like methionine, valine and lysine¹⁶. Essential amino acid in reference protein given by FAO (33.9%) is lesser than the present amino acid content in finger millet¹⁷. Though the protein present in proso millet is similar to wheat, but the amount of essential amino acids like leucine, isoleucine and thiamine is much higher in proso millet.

The fat present in millets ranges from 1.43 to 6 g/100g as compared to wheat and rice (2.0% and 2.7% respectively). Among millets, finger millet contains the lowest lipid content whereas pearl millet have the highest^{12,15,18}.

Millets are abundant in fiber (crude and dietary). The richest source of crude fibre among millets is Barnyard millet with an average content of 12.8 g/100 g¹. Little millet (*Panicum sumatrense*) and kodo millet (*Paspalum scrobiculatum*), have the highest dietary fiber content (38% and 37%) respectively. This content is 78.5% higher than rice and wheat. This makes millets low glycemic and hence a better option for diabetic patients. This resistant starch contributes towards dietary fibre, which acts as a prebiotic and hence enhances the health benefits of the millets¹⁹.

MICRONUTRIENTS

Requirement of nutrients in very small amount in our body but play vital roles are known as micronutrients such as vitamins and minerals. The mineral content present in millets ranges from 1.7 to 4.3 g/100 g which is much higher than other regular cereals such as wheat and rice. Calcium and iron deficiency is highly prevalent in India²⁰. A good portion of adult population is now suffering from osteoporosis.

Millet such as finger millet, the richest source of calcium, it has the ability to prevent illness like osteoporosis. The content of calcium present in finger millet is around eight times than wheat. Consumption of iron rich source millets such as barnyard millet and pearl millet helps pregnant women suffering from iron deficiency anaemia. Barnyard millet, rich in iron content that is 17.47 mg/100 g, is only 10 mg lower than the required daily value.

Among all millets, foxtail millet is one that contains highest amount of zinc content (4.1 mg/100 g) and also a good source of iron (2.7 mg/100 g)²¹. Zinc and iron also plays a significant role in improving the immunity of body.

Millets are abundant in vitamins such as β -carotene and B-vitamins especially riboflavin, niacin and folic acid. Foxtail millet also contains the highest thiamine content that is 0.60mg/100g, among millets. Riboflavin content in millets is several fold higher than the staple cereals. Barnyard millet (4.20 mg/100 g) has the highest riboflavin content followed by foxtail millet (1.65 mg/100 g)

and pearl millet (1.48 mg/100 g). The richness of these micronutrients in millets helps in eliminating nutritional deficiencies.

HEALTH BENEFITS

Presently, world is facing several health issues and chronic diseases. According to Global Nutritional Report, 2016 about 44% of population from 129 countries are suffering from serious levels of obesity, overweight and under nutrition¹¹. The common cause behind all these diseases is nutrient imbalanced diet. United Nation Food and Agriculture Organization provided data in which they reported 795 million people that is around 10.% of world population of 2015 were undernourished. Whilst on other side more than 1.9 billion adults ≥ 18 years of age were facing overweight and rest 13 % were obese^{22,23}. World Health Organization has already declared health issues like cardiovascular diseases and diabetes as epidemic problems. India covers world's largest undernourished population. About 194.6 million people, i.e. 15.2% of total population of India, are undernourished. As per the data from 2017 Global Hunger Index report, India is on 100th position among 119 countries. The score of India is even poorer than Nepal, Sri Lanka and Bangladesh²⁴. According to the total world agriculture production of cereal grains, millets hold 6th position. These are still using as staple food in several regions of world. Millets provides an additional advantage of using them as they helps in fighting against nutritional deficiencies due to their richness in many vital nutrients.

MILLETS IN DIABETES

A study has reported that the high sugar level in a diabetic person decreased due to regular consumption of multigrain flour (millet and wheat in a 30:70 ratio). Those who consumed chapatti of multigrain flour were found to have decreased blood sugar levels²⁵. Also regular consumption of low-fat dairy food products proved helpful in decreasing the risk of type-2 diabetes by 13%. Therefore, inclusion of millets in daily diet can be useful in preventing diabetes or in maintaining blood sugar level of diabetics.

MILLETS IN CARDIOVASCULAR DISEASE

The main reason behind of heart attacks and strokes is unhealthy diet. Millets can be helpful in decreasing the rates of cardiovascular disease. Finger and proso millet have shown reduction in plasma triglycerides in hyperlipidemic rats²⁶. Additionally, phenolic extracts from millets such as kodo, finger, proso, foxtail, little, and pearl millets were evaluated to find their inhibitory effects on peroxidation of lipids. All varieties exhibited effective inhibition of lipid oxidation in food systems

used in this study and kodo millet exhibited superior inhibition of lipid peroxidation, similar to butylated hydroxyanisole at 200 ppm²⁷.

MILLETS IN CANCERS

On the basis of literature, antinutrients such as tannins, phytates and phenolic acids are present in millet grains. It has been proved that these available antinutrients in millets help in reducing the risk for colon and breast cancer in animals. Also, in a recent study, it has been reported that millet phenolics may be effective in the prevention of cancer initiation and progression *in vitro*. UK Women's Cohort Study established that a fiber rich diet of whole grains like millet, fruits provide protection against breast cancer in meno-pausal women²⁸. Whole grains are rich in fiber that offered the most protection. Resistant starch also helps in the release of required metabolites such as short-chain fatty acids in the colon, especially butyrate, which helps in stabilizing colonic cell proliferation as a preventive mechanism for colon cancer²⁰.

MILLETS IN CELIAC DISEASE

Celiac disease is an immune-mediated enteropathy triggered by the ingestion of gluten in genetically susceptible individuals. Demand for gluten free foods raised with the increasing number of people suffering from celiac disease. This gave birth for a new market of products made from grains other than wheat or white fine flour. In this challenging market oat, sorghum, and millets have gained a special position²⁹.

Recently various studies have been reported that celiac disease have become the most common and constant disorder that affects human in many areas of the world³⁰. Those who stick to gluten free diet must consume food made up of grains such as rice, corn, millet, sorghum, buckwheat, amaranth, oats, quinoa and wild rice³¹. Therefore, millets being gluten-free are considerably useful in making food products for celiac disease sufferers³².

MILLETS IN AGING

Millets are potentially useful in protecting against ageing. There is a major factor that causes complications such as diabetes and ageing. The chemical reaction named non enzymatic glycosylation. Millet grains show antioxidant activities due to richness in antioxidants and phenolic compounds. These antioxidant properties help in preventing ageing and metabolic syndrome. The methanolic extract from finger millet and kodo millet has been found to inhibit glycation and cross-linking of collagen³³.

MILLETS IN GALLSTONES

A study has been carried out by some researchers that eating foods that are high in fiber (both soluble and non soluble) helped women to prevent gallstones. A study reported that the women eating high fiber foods lowered the 13% risk of developing gallstones compared to women consuming the fewest fiber-rich foods³⁴.

ANTI-NUTRIENTS IN MILLETS

Beside nutritional properties, millet also contains some anti-nutrients such as phytates, polyphenols, tannins, trypsin inhibitors. These naturally-occurring compounds, anti-nutrients are the substances that reduce nutrient digestion, absorption and utilization and may produce other adverse effects in humans and animals. These anti-nutrients can be reduced with the help of traditional processing methods like decortication, soaking, roasting, germination, malting and fermentation³⁵. Processing affects anti-nutritional factors such as fibre, phytate and enzyme inhibitors, which in turn can enhance or reduce the bioavailability of micro and macro-nutrients³⁶.

PROCESSING ON MILLETS

Anti-nutritional factors in millets can be reducing by using different processing techniques. An improvement in the bio-accessibility of nutrients in millets can be seen after applying processing methods. Various traditional processing practices are applied on millets such as roasting, popping, soaking, germination and fermentation³⁷. To derive minerals such as iron, manganese, calcium at maximum level from millets malting has been reported as a good processing method³⁸. Germination of grains also decreases the anti-nutritional factors as hydrolytic activity of enzyme phytase increases during this method. Germination also reduces the phytate content. The reduction in content of tannins is the result of soaking and germination of grains^{39,40}. Traditional processing methods such as boiling and pressure cooking helps in the reduction of tannin content in millets. Anti-nutritional factors also get reduced by the fermentation method. It improves the protein digestibility. Irradiation has also shown inhibitory effects against anti-nutrients and it enhances the protein digestibility⁴¹.

FORTIFICATION AND SUPPLEMENTATION

The easiest, cheapest best way to fight against micro nutrient deficiencies is fortification. As the millet is less expensive than other cereals, can be use as a vehicle of fortification for the downtrodden people. Minerals and vitamins can be used as forticiants in millets⁴². Millets like finger millet, pearl millet, barnyard millet are used in various food items. They are the most nutritious cereals among the various crops. In bakery products also millets are being incorporated. Some of the bakery outlets are using millets flour as it is more nutritious than refined flour. Zinc

deficiency is considered equally to be as widespread as that of iron deficiency. One of the cost effective ways in combating micro-nutrient deficiencies is the fortification of staple foods with highly required minerals⁴³. Iron fortification in millet flours will be beneficial against iron deficiency diseases. A study has reported that a discoloration was seen in the dumplings prepared from the same flours but the overall quality of items like chapati prepared was acceptable to the sensory panelists⁴⁴.

FOOD FORMULATION

Various research agencies have drawn their attention on nutritional quality of millets across the world. They are also increasing their focus to improve different millet varieties to enhance their harness in processed food products.

Millet Based Products and Formulations are given as under:

(A) COMPOSITE FLOUR

One way to use nutritional quality of millets is through preparation of composite flour that is mixture of different flours. Physical, chemical, nutritional and functional changes can be observed by the blending of flours. Blended snacks of pearl millet are of low cost⁴⁵. In a study, finger millet was incorporated in the preparation of noodles for the patient of diabetes. Finger millet flour was blended with wheat flour in different proportion ranging from 30-50%. The study found that the glycemic index having 30% finger millet in the above noodle preparation was lower as compared to control⁴⁶. Hence, millet blending evidently showed that it is an easy way to enhance nutritional and functional levels of food product in the promotion of its utilization.

(B) BAKED PRODUCTS

Researches have shown that about 40% incorporation of wheat flour with millets in developing baked products is good such as in biscuits and cakes⁴⁷. The supplementation of malted flour of finger millet have been tried to increase the nutritional level of cake with respect to fiber and minerals⁴⁸. Some attempted for cookies made up of 100% pearl millet or sorghum but their texture became hard, tough and gritty.

(C) EXTRUDED PRODUCTS

An extrusion technology is a new method of ingredients' transformation into value added products. Now-a-days my extruded products prepared by using different grains are gaining popularity among the all age groups. Their demand is growing; day by day kurkure is a popular example among children. Extrusion helps in improving digestibility as it leads to gelatinized starch and denaturation of protein. Also anti nutritional factors get inactivated⁴⁹. Production of extruded product with millets is appropriate like in noodles, vermicelli. Millets leads to lowering the glycemic

index as it contains unavailable carbohydrate content in higher amount which helps in decreasing sugar release. One of the extruded products is Pasta, usually made from durum wheat. Many other ingredients have been used in enhancing overall (nutritional as well as functional) quality of extruded products such as amaranth, buck wheat, lupin flour and millet flours⁴⁶. Some millet has high functional characteristics due to which they are being used at industrial scale for various products formation.

(D) FERMENTED PRODUCTS

Idli and dosa are the most popular fermented food in India which are widely consumed. Other fermented food products are also famous all over the world. On the fermentation of pearl millet, there are various chemical changes takes place in its composition such as in ash, moisture, fat, fiber and protein content. There has been also found reduction in minerals such as sodium, potassium, copper, magnesium, iron and zinc at marked level⁵⁰. Different products of fermented millet flour like weaning mixtures, vermicelli, cutlets and biscuits are having great demands in consumer's market. In our diet, for the protein improvement, availability of minerals and digestion of starch, fermentation using pure culture can be included.

(E) FLAKES AND POPS

When millets get popped or puffed, they can be used as snacks in varieties such as salty, sugary or spicy snacks. Grains first soaked, roasted to their equilibrium moisture content till the starch present gets gelatinized fully. After that they get dried to the level where only 18% of moisture remains. Then they are conditioned, shaped, decorticated and finally flaked with the help of heavy duty rollers. By flaking and puffing, the structural changes can be seen in starch or matrix of protein. Flaking and puffing helps in increasing the availability of minerals in the body. It also reduces phytates, polyphenols and improves the digestibility of protein and carbohydrates in body. It also enhances texture. By this process it has been seen a reduction in phytic acid (21-50%) and in tannins (3-18%)⁵¹. On the other hand, it helps in increasing significantly the zinc bio availability which is 18/100g in pearl millet⁵². As the moisture content gets reduced to 3%-5% the shelf life gets increased⁵³. The products made by pearl millet will get more scores in comparison to wheat and rice due to richness of micronutrients and phytochemicals.

CONCLUSION

It has been concluded from the review that millets possess components like dietary fiber, phytochemicals, vitamins and minerals which promotes health. It also showed various health benefits in curing several diseases and disorders such as diabetes, cardiovascular diseases and digestive

disorders. Through this review, awareness about the anastomosis of millets in our daily meals is generated to combat the effects of westernized, sedentary lifestyle which will enhance healthy living. Modern processing techniques are required for the improvement of the micronutrients' bioavailability and its quality. Making food products from millets is much needed as it delivers convenience, nutrition, long shelf-life at reasonable price for underprivileged people. Additionally, this review article helps in spreading awareness about utilization of millets in rural as well as urban areas. New markets can be open for farmers to develop such nutritious food products from millets and improve their economic status.

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