**MILLETS – A NEW GENERATION NUTRI-CEREAL**

**WHAT IS MILLET?**

Millets (Nutri-Cereal) are a highly varied group of small-seeded [grasses](https://en.wikipedia.org/wiki/Grasses), widely grown all over the world as [cereal](https://en.wikipedia.org/wiki/Cereal) [crops](https://en.wikipedia.org/wiki/Crops) or grains for human food and for fodder. Most species generally referred to as millets belong to the tribe [Paniceae](https://en.wikipedia.org/wiki/Paniceae" \o "Paniceae), but some millets also belong to various other taxa. They constitute an important source of food and fodder for millions of resource-poor farmers and play a crucial role in ecological and economic security of India. These millets are also called as “cereals of the poor” or “coarse cereals”

Millets are small-seeded grains, the most common, major, and important for food being pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine carocana*), sorghum (*Sorghum bicolor* L.), under minor millets, kodo millet (*Paspalum scrobiculatum*), proso millet (*Panicum miliaceum*, teff (*Eragrostis tef*), foxtail millet (*Setaria italica*), little millet (*Panicum sumatrense*) and fonio (*Digitaris exilis*).

Millets were coarse grains yesterday now they are termed as “Nutri-Cereal” due to its high nutritional value as well as they are resistant to most of the pests and diseases and well adapt to the harsh environment of the arid. Indian millets are mostly grown in the arid and semi-arid regions. They are group of nutritiously rich and drought tolerant grains of the India.

Most millets are three to five times have high nutritional value than most cereals (rice, *Oryza sativa*; wheat, *Triticum aestivum*; maize, *Zea mays*) in terms of vitamins, fibre, proteins, and minerals (calcium and iron) and are gluten-free; hence, they are known as “superfoods.” The nutrition rich millets are the viable solution to reduce the increasing incidences of malnutrition, metabolic disorders and can provides nutrition and food security of the country.

**SCENARIO OF MILLET PRODUCTION IN INDIA**

Millets are drought-tolerant crop that can be grown in dry, arid climates where other crops would fail to grow. Millet is a popular grain and staple food in many parts of the world especially in Asia and Africa. According to the World Food Programme, it was estimated that 1.2 billion people consumed millet as a part of their daily diet. Millets are important crops in the [semiarid tropics](https://en.wikipedia.org/wiki/Semi-arid_climate) of Asia and Africa especially in [South India](https://en.wikipedia.org/wiki/South_India), [Mali](https://en.wikipedia.org/wiki/Mali), [Nigeria](https://en.wikipedia.org/wiki/Nigeria), and [Niger](https://en.wikipedia.org/wiki/Niger), with 97% of millet production in [developing countries](https://en.wikipedia.org/wiki/Developing_country).  It is a highly nutritious grain which is high in fibre and essential nutrient like minerals. Due to its high nutritional value, millets will continue to be an important food crop in the years to come.

India is one of the leading producers and suppliers of millet, and there are several millet sourcing points located throughout the country. The main millet-growing states in India are Rajasthan, Maharashtra, Karnataka, Andhra Pradesh, and Madhya Pradesh. In addition to the major millet producing states, there is also several smaller millets producing regions located throughout India. These regions include the states of Uttar Pradesh, Bihar, and Madhya Pradesh. Millets are favoured due to its [productivity](https://en.wikipedia.org/wiki/Agricultural_productivity) and short growing season under dry, high-temperature conditions. These states have many millet farmers who grow the crops for both domestic and international markets.

Millets are [indigenous](https://en.wikipedia.org/wiki/Indigenous_(ecology)) to many parts of the world. The most widely grown millets important crops in India and parts of Africa are [sorghum](https://en.wikipedia.org/wiki/Sorghum) and [pearl millets](https://en.wikipedia.org/wiki/Pearl_millet), [finger millet](https://en.wikipedia.org/wiki/Finger_millet), [proso millet](https://en.wikipedia.org/wiki/Proso_millet" \o "Proso millet), and [foxtail millet](https://en.wikipedia.org/wiki/Foxtail_millet) are also important crop species.

India is the largest producer as well as exporter of cereal products in the world. India's export of cereals stood at Rs. 96,011.42 Crore / 12,872.64 USD Millions during the year 2021-22. Rice (including Basmati and Non-Basmati) occupy the major share in India's total cereals export with 75% (in value terms) during the same period. Whereas, other cereals including wheat represent only a 25 % share of total cereals exported from India during this period.

Millets may have been consumed by humans for about 7,000 years and potentially had "a pivotal role in the rise of multi-crop agriculture and settled farming societies." India is among the top 5 exporters of millets in world. World export of millet has increased from $400 million in 2020 to $470 million in 2021 (ITC trade map) India exported millets worth $64.28 million in the year 2021-22, against $59.75 million in 2020-21. Share of Millet based value added products is negligible. The Indian government has also been promoting millet production as part of its National Food Security Mission. As a result of these factors, millet production in India is expected to continue to grow in the coming years.

**TYPES OF MILLETS**

Millets have been classified into two groups based on their grain size—major millets and minor millets.

|  |  |
| --- | --- |
| **Major Millet** | **Botanical Name** |
| Pearl Millet | Pnnisetum glucum. L. |
| Sorghum | Sorghum Bicolor |
| Finger Millet | Eleusine Coracana |
| Foxtail Millet | Setaria italica |
| **Minor Millet** | **Botanical Name** |
| Barnyard Millet | Echinochloa frumentacea |
| Kodo Millet | Paspalum scrobiculatum |
| Proso Millet | Panicum miliaceum L. |
| Little Millet | Panicum sumatrense |
| **Pseudo Millet** | **Botanical Name** |
| Buck wheat (Kuttu) | Fagopyrum esculentum |
| Amarathus (Chaulai) | Amaranthus viridis |

**NUTRITIONAL VALUE OF DIFFERENT MILLETS**

Indian millets are rich in protein, vitamins, and minerals and nutritionally superior to wheat and rice. Millets are also gluten-free, non-acidic, non-allergic and have a low glycemic index value, making them ideal for the patients with celiac disease, obese, overweight peoples and for type -II diabetics.

Millets comprises 65–75% carbohydrates with larger proportion of non-starchy polysaccharides and dietary fibre compared to staple cereals such as rice and wheat. Millets provides many health benefits such as improving gastrointestinal health, blood lipid profile, and blood glucose control due to high dietary fibre content. Millets are healthy options for patient of gluten enteropathy and diabetes because they have minimal gluten and low glycemic index value. Millets are also rich in health-promoting phytochemicals such as phytocyanins, lignins, phytosterols, polyphenols, and Phyto-oestrogens. These phytochemicals in the human body act as antioxidants, immunological modulators, and detoxifying agents, thus preventing age-related degenerative diseases such as cardiovascular diseases, type-II diabetes, and many types of cancer.

MAJOR MILLETS

1. **Pearl Millet**

Pearl millet (Bajra) is one of the most cultivated crops in India. It grows in a short-duration and can be grown in both rain fed and irrigated conditions. Pearl millets are good source of energy with containing rich amount of proteins, minerals, vitamins and dietary fibre.

Pearl millet contains carbohydrates which is lesser than the staple cereals, and it is mainly contains high amylose starch which is 20–22%, and the insoluble dietary fibre fraction of pearl millets helps in exhibiting a lower glycaemic response. Pearl millet protein is gluten-free and contains a higher prolamin fraction, making it suitable for patient with gluten sensitivity. The score of amino acids in pearl millet is good however, it is low in threonine, lysine, tryptophan, and other sulphur-containing amino acids. Pearl millet is high in omega-3 fatty acids and important nutritional essential fatty acids such as alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA). It also contains other micronutrients like mineral and vitamins, especially iron, zinc, copper, potassium, magnesium, phosphorous, manganese, and B- complex group of vitamins.

1. **Finger Millet**

Another significant staple crop in Eastern Africa and Asia is the finger millet, commonly known as ragi in India (India, Nepal). The plant has many spikes or "fingers." at the top of the stem. The grains are tiny (1-2 mm in diameter) in size. Finger millet grains are rich in minerals especially calcium which plays an important role in growing children, pregnant women as well as people suffering from obesity, diabetes, and malnutrition, dietary fibre, polyphenols, and proteins. Ragi is rich in potassium which helps in proper functioning of the kidneys and brains and allows the brain and muscles to work smoothly.

Finger millet has the highest content of carbohydrate among the selected millets. However, carbohydrates consist primarily of slowly digestible starch, dietary fibre, and resistant starch and thus offer a low glycemic index value compared to most common cereals such as rice and wheat. The protein content in finger millet is around 7%, which is less than that of other millets, but it has a good amino acid score and contains more lysine, threonine, and valine than other millets. Subsequently, micronutrients like minerals such as calcium, iron, magnesium, potassium, and zinc, as well as B-complex vitamins, especially niacin, B6, and folic acid, are abundantly present in finger millets.

1. **Foxtail Millet**

Finger millet is a fast-growing crop, which requires less than 12 hours of daylight to grow. Foxtail millet is one of the solid crops that can be grown in poor, dry conditions, and can tolerate high temperatures. It is rich in carbohydrates which helps in balancing the blood sugar level in the blood. It is rich in minerals especially iron. Foxtail millet may also improve overall immunity and malnutrition. It contains high amount of potassium for the proper functioning of the kidneys, control high blood pressure and brains and allows the brain and muscles to work smoothly. Due to its copious dietary fibre content, resistant starch, vitamins, minerals, and essential amino acids, except for lysine and methionine, Foxtail millet has a greater nutritional value compared to major cereals like wheat and rice but it is richer than most cereals. Among the selected millets, foxtail millet has highest protein content. Foxtail millet also contains a high amount of stearic and linoleic acids, which helps in maintaining a good lipid profile.

1. **Proso Millet**

Proso millet has a higher nutritional value when compared with staple cereals as it contains a higher concentration of minerals and dietary fibre. Proso millet is a rich source of vitamins and minerals such as iron, calcium, potassium, phosphorus, zinc, magnesium, vitamin B-complex groups of vitamins, niacin, and folic acid. Proso millet provides minerals, dietary fibre, polyphenols, vitamins, and proteins. As it is gluten-free crops it suits for the gluten sensitive people and for celiac disease patients. Proso millet contains high lecithin which supports the neural health system. It is high in vitamins (niacin, B-complex vitamins, folic acid), minerals (Potassium, Calcium, Zinc, Iron) and essential amino acids (methionine and cysteine).

Proso millet contains essential amino acids in significantly higher quantities, except for lysine, the limiting amino acid. However, proso millet has an almost 51% higher essential amino acid index than wheat. Moreover, the products prepared from proso millet exhibit a lower glycemic response than staple cereal-based products. A review reported that products prepared from proso millet shows a significantly lower glycemic index values (GI) when compared to wheat- and maize-based products.

**MINOR MILLETS**

1. **Barnyard Millet**

Barnyard Millet is popular in millets and commonly known as Sanwa. It is packed with high amounts of dietary fibre that helps improve bowel movement prevents constipation and aiding weight loss. Due to its high content of calcium and phosphorus, which helps to strengthen bone density.

1. **Kodo Millet**

It is an ancient millet grain that originated in tropical Africa and was domesticated in India some 3000 years ago. Indian Crown Grass, Native Paspalum, Ditch Millet, or Rice Grass are a few names by which kodo millet is known. In India, it is also known as Kodra and Varagu. India, Pakistan, Vietnam, Thailand, the Philippines, Indonesia, and West Africa are among the countries that cultivate millets. It serves as the major source of food in the Deccan Plateau of Gujarat (India). In India such as Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Bihar, Maharashtra, Gujarat, and Orissa the kodo millet is mainly grown. Kodo millets are the coarsest and digestion-friendly millets. Kodo Millet, also known for Kodon Millet, is a digestible variant of millet with higher amounts of lecithin (amino acid) which has a significant effect on strengthening the nervous system. Kodo millet contains B complex group of vitamins, especially niacin, B6, and folic acid, among other vitamins and minerals. It also contains calcium, iron, potassium, magnesium, and zinc minerals. Being a gluten-free millet, so it is suitable for gluten-intolerant individuals. As kodo millet easy to digestible thus can be beneficial for infant and geriatric product formulation. It can relieve cardiovascular disorders such as hypertension and dyslipidaemia when eaten regularly by postmenopausal women.

Kodo millet provides an energy value like the other millets and staple cereals like wheat and rice. However, apart from finger millet, kodo millet is lower in protein content than that of other selected millets and it provides gluten-free protein. Kodo millets are rich in vitamins and minerals, especially B-complex vitamins, B6, niacin and folic acid, iron, zinc, calcium, magnesium, and potassium. Kodo millet is packed of polyphenols, flavonoids, and antioxidant compounds which provides many health benefits. It is rich in phytates and phytochemicals makes it anti-cancerous food and helps to control body weight and reduces knee-joint pains and arthritis.

1. **Little Millet**

In India, little Millet (Panicummiliare) is grown throughout and it is a traditional crop of India. It is also known as other names such as Moraiyo, Kutki, Shavan, and Sama.It is a relative of proso millet but the seeds of little millet are much smaller than proso millet. It is packed with vitamin B complexes and rich in essential minerals such as calcium, iron, zinc, and potassium. Little Millet is largely used in Southern states of India and from these millets numerous traditional dishes are prepared. It is a healthier substitute to rice and does not cause weight gain.

The nutritional value of little millet is comparable to other cereal and millet crops, it contains around 8.7% protein and balanced number of amino acids, and it is a rich source of sulphur-containing amino acids mainly (cysteine and methionine) and lysine, which is lacking in most of the cereals. It is generally considered to induce a lower glycemic response due to the presence of high amount of dietary fibre, resistant starch, and slowly digestible starch. It is also a good source of micronutrients such as iron, potassium, and niacin. Recently, many value-added products have been prepared using little millet to capitalize on the health benefits of little millet.

**Nutritional value of Major Millets (for 100g of Each Millet)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Major Millet** | **Protein**  **(g)** | **Fiber**  **(g)** | **Minerals**  **(g)** | **Iron**  **(mg)** | **Calcium**  **(mg)** |
| **Sorghum** | 10 | 4 | 1.6 | 2.6 | 54 |
| **Pearl Millet** | 10.6 | 1.3 | 2.3 | 16.9 | 38 |
| **Finger Millet** | 7.3 | 3.6 | 2.7 | 3.9 | 344 |

**Nutritional value of Minor Millets (for 100g of each Millet)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Minor Millet** | **Protein**  **(g)** | **Fiber**  **(g)** | **Minerals**  **(g)** | **Iron**  **(mg)** | **Calcium**  **(mg)** |
| **Foxtail Millet** | 12.3 | 8 | 3.3 | 2.8 | 31 |
| **Proso Millet** | 12.5 | 2.2 | 1.9 | 0.8 | 14 |
| **Kodo Millet** | 8.3 | 9 | 2.6 | 0.5 | 27 |
| **Little Millet** | 7.7 | 7.6 | 1.5 | 9.3 | 17 |
| **Barnyard Millet** | 11.2 | 10.1 | 4.4 | 15.2 | 11 |
| **Teff** | 13 | 8 | 0.85 | 7.6 | 180 |
| **Fonio** | 11 | 11.3 | 5.31 | 84.8 | 18 |
| **Brown top Millet** | 11.5 | 12.5 | 4.2 | 0.65 | 0.01 |

**Millets nutritional value per 100 g**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Nutrients per 100 g** | | | | | |
| **Millets** | **Energy (Kcal)** | **Protein**  **(g)** | **CHO**  **(g)** | **Crude Fibre**  **(g)** | **Calcium**  **(mg)** | **Iron**  **(mg)** |
| **Pearl** | 361 | 11.6 | 65.5 | 1.2 | 42 | 8 |
| **Finger** | 328 | 7.3 | 72 | 2.6 | 344 | 8.9 |
| **Foxtail** | 331 | 12.30 | 60.9 | 14 | 31 | 3.6 |
| **Barnyard** | 341 | 7.7 | 67.0 | 7.6 | 17 | 9.3 |
| **Kodo** | 302 | 8.03 | 69.9 | 8.5 | 22 | 9.9 |
| **Proso** | 309 | 8.30 | 65.90 | 9.00 | 27.0 | 0.50 |
| **Little Millet** | 314 | 10.13 | 65.55 | 7.72 | 32 | 1.30 |

*Source: Nutritive value of Indian food, NIN, ICMR 2018*

**BENEFITS OF MILLETS ON HEALTH AND ENVIRONMENT**

|  |  |
| --- | --- |
| **Effects on Human Health** | **Effects on Farmer/ Environment** |
| 1. Millets are health promoting nutritious crop. Compared to other cereals millets have superior micronutrient content and contains bioactive flavonoids. 2. Millets have a low Glycaemic Index (GI) so good for prevention and management of diabetes especially type II. 3. They are rich source of minerals especially iron, zinc, and calcium. 4. Millets are non- acidic in nature hence good for prevention of different types of cancer. 5. Millets are gluten-free and can be prescribed to the patient having celiac disease and gluten enteropathy. 6. Millet has a beneficial impact on the management and prevention of cardiac disease so helps in reduction of high cholesterol level in blood. 7. Millets are found to be helpful with the reduction of excess weight, maintenance of BMI, prevents obesity and controls hypertension. 8. In India, millet is generally consumed with legumes, which provides mutual supplementation of amino acids, increases the protein content, and improves the overall digestibility of protein. 9. Millet based value-added products in ready to cook, ready to eat category foods are easily available and convenient to the urban population. | 1. Millets are highly adaptive to a wide range of ecological conditions and thrive well in rain-fed; arid climate and they need minimum amount of water, fertilizers, and pesticides to grow. 2. Millets are grown for dual purposes as food for human as well as fodder, which make it more farming efficient. 3. Millet cultivation helps to reduce the carbon footprint. |

**HEALTH BENEFITS OF MILLETS**

Millets have potential health benefits and epidemiological studies have showed that consumption of millets reduces risk of heart disease, prevention from diabetes, improves digestive health, reduces the risk of cancer, detoxifies the body, improves immune system, enhances respiratory health, increases energy levels, improves muscular, neural systems, and provides protective actions against several degenerative diseases such as metabolic syndrome and Parkinson’s disease. The millets contain important nutrients which includes resistant starch, oligosaccharides, lipids, antioxidants such as phenolic acids, avenanthramides, flavonoids, lignans and phytosterols which are believed to provides for many health benefits. Some of the disease protections are given below.

Cardiovascular Diseases

As magnesium content is high in millets, they help in reducing blood pressure and reduces the risk of cardiac strokes especially in atherosclerosis. Also, the potassium present in millets helps in keeping blood pressure low by acting as a vasodilator and help to reduce cardiovascular related risk. Also, the plant lignans present in millets can convert into animal lignans in presence of microbiome in digestive system and protect against certain types of cancers and heart related disease. The high fibre content in millets plays a major role in reducing cholesterol level, eliminating LDL from the system, and increasing the effects of HDL.

A study was done on effect of cholesterol absorption and plasma non-HDL cholesterol concentration in hamsters fed with grain sorghum lipid extract. In this study, hamsters were fed with grain sorghum lipid extract (GSL) comprising different proportions of the diet and compare with control. GSL extract consist plant sterols that reduce cholesterol absorption efficiency significantly and policosanol is that inhibit endogenous cholesterol synthesis. Liver cholesterol ester concentration was also significantly reduced in hamsters fed with GSL. It was found that GSL diet lowers non-HDL cholesterol, at least in part, by inhibiting cholesterol absorption; Research findings further indicate that sorghum grains contain components that could be used as food ingredients or dietary supplements to manage cholesterol levels in humans. The lignin and phytonutrients in millet are powerful antioxidants thus provides protection against heart related diseases. For this reason, millet is known for food of heart health. The finger millets and proso millets can lower significantly the concentrations of serum triglycerides than white rice and sorghum fed rats. It was noted that finger millet and proso millet may prevent cardiovascular diseases by reducing serum triglycerides level in hyperlipidaemic rats. It was seen that when rats fed a diet of treated starch from barnyard millet had shown to lower blood glucose, serum cholesterol and triglycerides level compared with rice and other minor millets.It was observed that there areimproved plasma levels of adiponectin, high density lipoprotein (HDL) cholesterol in genetically obese type -2 diabetic mice under high fat conditions on feeding of Proso millet.

Detoxification (Anti-oxidant Properties)

Many types of the antioxidants present in millet which have a beneficial effect on neutralizing the free radicals (cause cancer) and detoxify other toxins from body such as those in kidney and liver. Quercetin, curcumin, ellagic acid and various other beneficial catechins can help to clean the system on any foreign agents and toxins by promoting proper elimination and neutralizing enzymatic activity in those organs. Therefore, tremendous attention has been given to polyphenol due to their beneficial roles in human health.

In India, Kodo millet, finger millet, little millet, foxtail millet, barnyard millet, and sorghum bicolor are grown and their white varieties were screened for free radical quenching of 1,1, diphenyl-2-picrylhydrazyl (DPPH) by electron spin resonance. Furthermore, finger millet extracts were found to have a potent free radical-scavenging activity that is higher than those of wheat, rice, and other species of millet. In addition, defatted variety of foxtail millet protein hydrolysates also exhibited antioxidant potency, thus, millets may serve as a natural source of antioxidants in food applications and as a nutraceuticals and functional food ingredient in disease risk reduction and in health promotion. The antioxidant, metal chelating and reducing properties are shown by the soluble and insoluble bound phenolic extracts of several varieties of millet (kodo, finger, foxtail, proso, pearl and little millets), (Foxtail millet contains 47mg polyphenolics/100 g and 3.34 mg tocopherol/100 g (wet basis); however, proso millet contains 29 mg polyphenolics/100 g and 2.22 mg tocopherol/100 g (wet basis). Over 50 phenolic compounds belonging to several classes, namely, phenolic acids and their derivatives, dehydrodiferulates and dehydrotriferulates, flavan-3-ol monomers and dimers, flavanols, flavones, and flavanonols in 4 phenolics fractions of several whole millet grains such as kodo, finger, foxtail, proso, little, and pearl millets were positively identified using HPLC and HPLC-tandem mass spectrometry (MS), Therefore, millet grains can be used as functional food ingredients as well as sources of natural antioxidants.

Diabetes Mellitus

Diabetes mellitus is considered as the most common endocrine disorder and results in deficient insulin production (type 1) or combined resistance to insulin action and the insulin-secretory response (type II). Diabetes mellitus is a chronic metabolic disorder characterized by hyper-glycemia with alterations in carbohydrate, protein, and lipid metabolism. The efficiency of insulin and glucose receptors in the body is increased by the significant amount of magnesium present in millets that helps in prevention of diabetes. Due to high fibre content in finger millet-based diets have shown lower glycemic response and alpha amylase inhibition properties which are known to reduce starch digestibility and absorption. The slow digestible starch is favourable for dietary management and for metabolic disorders such as diabetes and hyperlipidaemia. Sorghum contains slow digestible starch (SDS) in good amounts, which has functional property, prolongs digestion and absorption of carbohydrates in intestine. Sorghum is rich in dietary fibre and has low glycemic index, which could help in prevention and control of type II diabetes in Indians. The fibre, magnesium, vitamin -E, phenolic compounds and tannins present in millets slower the sudden increase of blood glucose and insulin levels and reduces the risk of diabetes. National Institute of Nutrition (ICMR) in 2010 assessed Glycemic Index (GI) of sorghum-based foods in collaboration with the Indian Institute of Millets Research, Hyderabad under National Agricultural Innovation Project (NAIP). The results revealed that sorghum-based foods have low GI and reduces the postprandial blood sugar level and glycosylated haemoglobin (Hba1c). A study shown that blood glucose level of non-obese patients with non-insulin-dependent diabetes mellitus, who consumed sorghum bran papadi, showed considerable reduction of blood glucose level. Studies performed on processing and cooking of white and yellow jowar varieties showed that boiled yellow jowar flour (coarse) had lower glycemic index compared to flour prepared from the same. Similarly, chapatti prepared from white jowar flour showed low glycemic index over yellow jowar flour. These changes in glycemic index due to processing and cooking play an important role in diets followed in dietary management of diabetes.

Pearl millets can increase insulin sensitivity and lower the level of serum triglycerides. Pearl millet is very effective for controlling the risk of diabetes, because of its high dietary fibre content, millet digests slowly and releases glucose into the blood at a slower rate as compared to other foods. Millets are effectively helps in maintaining the blood sugar level constant in diabetics patients for a long period of time. Finger millet-based diets have shown lower glycemic response due to high fibre content and alpha amylase inhibition properties which are known to reduce starch digestibility and absorption. Finger millet has shown significant results in dermal wound healing process. As shown in few studies done on rats which also found that it improves the antioxidant level and maintains blood sugar levels. The polyphenols of finger millets in a study were found as major anti-diabetic and anti-oxidant components, when evaluated for aldose reductase (AR) - inhibiting activity the reason being the phenolic with an OH group present at the 4th position which are responsible for this inhibitory activity. The gallic, protocatechuic, p-hydroxy benzoic, coumaric, vanillic, syringic, ferulic, trans-cinnamic acids, quercetin inhibited cataract eye lens effectively. Therefore, these studies show strong evidence for finger millets protein in inhibiting the cataract genesis in humans being.

Finger millet has shown significant results in dermal wound healing process. As shown in few studies done on rats which also showed that it improves antioxidant status and controlled blood glucose levels. Barnyard millet has been reported to be beneficial for type II diabetics especially the dehulled varieties, as the glycemic index for dehulled millet (50.0) and heat treated was 41.7. The rapidly digestible carbohydrate and slowly digestible carbohydrates were reduced significantly in the invitro studies performed in the extruded products made from amaranth, buckwheat, and millet combination food products. The strong inhibition on α-glucosidase and pancreatic amylase were found by few other phenolic compounds from the millet seed coat. The aqueous extracts of foxtail millets have excellent anti-hyperglycaemic activity. Proso millet had shown to improve the glycemic responses and insulin in genetically obese type II diabetics mice under high fat feeding conditions. Therefore, millet grains have the potentials to be useful in preventing, controlling, and treating diabetes mellitus.

Gastrointestinal Disorders

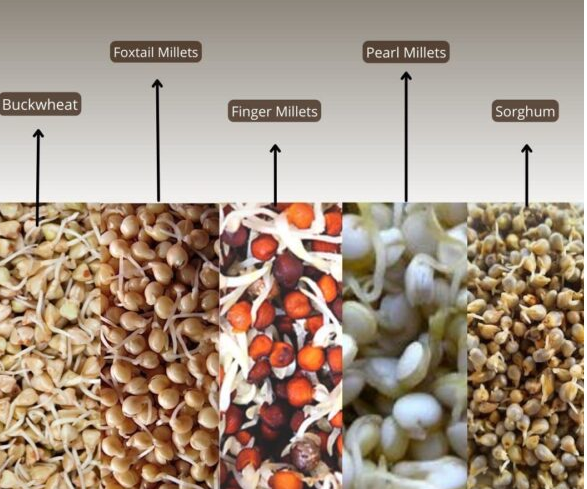
Dietary fibre of millets helps in eliminating gastro disorders such as constipation, flatulence, bloating and abdominal cramps. Regulating digestive process by consuming dietary fibre can increases nutrient retention and reduces the chances of more serious gastrointestinal conditions like gastric ulcers or colon cancer. Millets are gluten free and it is suitable for celiac disease patients. Millets have considerable potential in foods and beverages and can meet the growing demand for gluten free foods and will be suitable for individuals suffering from celiac disease and gluten sensitivity. An immune mediated enteropathy disease called celiac disease which is usually triggered by the ingestion of gluten in susceptible individual. A gluten free diet primarily plays a major role in affecting food consumption in the grain food group. Replacing cereals like wheat, barley, rye-based foods which are rich in gluten and product made from gluten free grains, including rice, corn, sorghum, millet, amaranth, buck wheat, quinoa, wild rice may help people adhering to gluten free diet.

Cancer

Recent research has revealed that fibre is one of the best and easiest ways to prevent the onset of breast cancer in women and chances of breast cancer can be reduce by more than 50% by eating more than 30 gm of fibre per day. The anti-carcinogenic properties of millets especially sorghum have been well documented. Millet grains are known to be rich in compound like phenolic acids, tannins, and phytate. These nutrients have capacity to reduce the risk for colon and breast cancer in animals. The fibre of sorghum and in other millets and the phenolic have been attributed for lower incidence of oesophageal cancer than those who consume wheat or maize. In Vivo and In Vitro studies have shown consumption of sorghum (jawar) has positive health impacts on cancer. The polyphenols and tannins present in sorghum have anti-mutagenic and anti-carcinogenic properties and can act against human melanoma cells, as well as positive melanogenic activity reported that in rat liver procyanidin extracts may induce cytochrome P-450, a protein that can convert certain pro-mutagens to mutagenic derivatives. The epidemiological studies showed that incidence of oesophageal cancer was low with sorghum consumption. In each country, the authors studied twenty-one communities over a period of six years and found consumption of sorghum showed lower mortality rate from oesophageal cancer than wheat and corn. This concludes that millets are anti carcinogenic properties and they are effective in prevention of cancers.

**PROCESSING OF MILLETS**

Millets are usually processed before consumption to remove the antinutritional factors, inedible portions, to increase their shelf life, and improve nutritional and sensory quality, are used to formulate millet-based value-added processed food products.

The processing techniques are mainly done with the aim of to improve the digestibility and bioavailability of micro and macro nutrients. The significant amount of nutrients is lost when millets are processed. Primary processing techniques such as dehulling, soaking, germination (sprouting), roasting, drying, polishing, and milling (reduction of size) are followed to make millets suitable for consumption. At the same time, modern or secondary processing techniques such as fermenting, parboiling, cooking, puffing, popping, malting, baking, flaking, extrusion is also used to processed the millets before consumption.

**ANTI NUTRITIONAL FACTORS IN MILLETS**

Anti-nutritional components are constituted of organic molecules which are found in food that prevent minerals, dietary proteins, and carbohydrates from being digested, utilized, and available in the body. They can be found in plant and animal diets as natural elements, artificial components added while processing, or ecological pollutants. Some of these components include tannins, trypsin, or protease inhibitors, saponins and haemagglutinin, phytates or phytic acid, oxalates or oxalic, glucosinolates, and gossypol. Many antinutrients, such as oxalate or cyanogenic acid, may be hazardous above a certain level in addition to their primary effects on nutrient absorption. As a result, it is critical to eliminate these factors. There are several anti-nutrients are also present in millets, they are phytates, phenols, tannins, trypsin inhibitory factors, and dietary fibre, which chelates with metals and impedes enzymes. Phytates and tannins are the antinutrient components found specifically in kodo and little millet.

Some anti nutrients factors such as phenols, phytates, and tannins have become known to perform an antioxidant activity, which play a significant role in improving health, reduces ageing, and controls metabolic diseases.

**HOW TO IMPROVE MILLETS NUTRITIONAL VALUE**

Food processing techniques are generally used to enhance nutritional quality of the millets, improve its digestibility and bioavailability of micro nutrients with reducing anti-nutritional components. Some of the common food techniques are decortications, milling, soaking, cooking, germination, fermentation, malting, and popping etc.

The most popular and household food processing technique is soaking of grains. It is used for reducing the content of anti-nutritional compounds like phytic acid and phytase activity to improve bioavailability of minerals. It is seen that combination of different processing like dehulling, soaking and cooking decreased in significant amount of anti-nutrients like polyphenols, phytate and improve the protein digestibility in vitro and increases the bioavailability of minerals especially iron and zinc.

Another technique is germination, Germination led to the reduction of anti-nutrients compound like phytic acid, tannins, and polyphenols, which form complexes with protein. Germination of millets (Pennisetum typhoides) decreases the levels of tannins (1.6% to 0.83%). Germination improved the in vitro protein (14% to 26%) and starch (86% to 112%) digestibility in pearl millet. The in vitro extractability and bio-accessibility of minerals mainly calcium, iron and zinc were increased and anti-nutritional factor such as phytic acid were decreased in pearl millet and finger millets by germination. Pearl millet has higher beta-amylase activity and higher free alpha-amino nitrogen in comparison to sorghum after malting. It was observed that germination and probiotic fermentation significantly improved the contents of thiamine, niacin, total lysine, protein fractions, sugars, soluble dietary fibre in millets.

Fermentation is widely used in food preservation, provides many varieties of food products with different Flavors and texture, and improves the nutritional properties of raw food significantly. Fermentation a processing technique which decreases the levels of antinutrients and improves the protein availability, digestibility in vitro and appreciable change in chemical composition of food substance. Fermentation of pearl millet improve nutrient value such as moisture, ash, fibre, protein, and fat and significantly reduced the mineral contents like sodium, potassium, iron, zinc etc. and enhanced flavonoids content after 16 hours of fermentation.

Popping or Puffing Popping is used as ready-to-eat food at commercial scale thus promoting utilization of millet grains. It is one of the processing techniques which uses sand as heat transfer media with HTST (high-temperature short time) method resulting in starch gelatinization and the endosperm bursts open giving highly desirable flavour and aroma.

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