

## MILLETS – A NEW GENERATION NUTRI-CEREAL

### Abstract

Millets are a coarse cereal and is full of fibre and micro-nutrients. There are two types of millets world-wide, viz. major and minor millets. Millets can easily grow in arid climate and require minimal inputs. It is the most neglected grain worldwide despite having high nutritional values and fibre content. Millets are non-acid forming and gluten free grains. Due to the high nutritional values, millets provide protection against many non-communicable diseases diabetes, cardio vascular disease, obesity, cancer etc. Since millets are gluten free, they are suitable for celiac disease or gluten enteropathy. It is important to note that millets are also high on anti-nutritional factors which prevent or interfere the absorption of its nutrients. In order to improve the bio-availability of its nutrients, the millets should be processed. Millets need to be boiled, soaked, fermented, germinated, roasted etc. before consumption to improve the absorption of the nutrients inside the human body. Millets should be included at least once in a daily diet.

**Keywords:** Millets neglected grain, non-acid forming

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## I. WHAT IS MILLET?

Millets (Nutri-Cereal) are a diverse group of small-seeded grasses that are widely cultivated over the globe as cereal grains for human consumption and for use as fodder. The majority of the species that are commonly referred to as millets are members of the Paniceae tribe, but some millets are also members of other taxa. They are a vital component of India's ecological and economic security and provide millions of resource-poor farmers with a significant supply of food and fodder. The terms "cereals of the poor" and "coarse cereals" are also used to describe these millets.

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 (*Digitaria exilis*).

Previously known as coarse grains, millets are now referred to as "Nutri-cereal" due to their excellent nutritional value, resistance to the majority of pest and diseases, and ability to thrive in the demanding conditions of the arid. They are a group of nutrient-dense and drought-resistant Indian grains.

Most millets are gluten-free and three to five times more nutrient-dense than other cereals, such as rice (*Oryza sativa*), wheat (*Triticum aestivum*), and maize (*Zea mays*). They are therefore referred to as "superfoods." The nutrient-dense millet can offer the nation with nutrition and food security while also helping to reduce the incidence of metabolic disorders, which are on the rise.

## II. SCENARIO OF MILLET PRODUCTION IN INDIA

Millets can be cultivated in dry, arid settings where other crops would not thrive because they are drought-tolerant. 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 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.

There are several regions in the world where millets are native. Sorghum and pearl millets are among the most frequently cultivated millets, and finger, proso, and foxtail millets are also significant crop species in India and some regions of Africa. The world's leading producer and exporter of cereal goods is India. In the fiscal years 2021–2022, India exported 12,872.64 USD million worth of grains. 75% (in value terms) of India's total cereal exports over the same period were made up primarily of rice (including Basmati and Non-Basmati). Other grains, including wheat, make up only 25% of the total amount of cereals exported from India during this time. For over 7,000 years and possibly longer, humans have consumed millets

- 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	<i>Pennisetum glaucum</i> L.
Sorghum	<i>Sorghum Bicolor</i>
Finger Millet	<i>Eleusine Coracana</i>
Foxtail Millet	<i>Setaria italica</i>
Minor Millet	Botanical Name
Barnyard Millet	<i>Echinochloa frumentacea</i>
Kodo Millet	<i>Paspalum scrobiculatum</i>
Proso Millet	<i>Panicum miliaceum</i> L.
Little Millet	<i>Panicum sumatrense</i>
Pseudo Millet	Botanical Name
Buck wheat (Kuttu)	<i>Fagopyrum esculentum</i>
Amaranthus (Chaulai)	<i>Amaranthus viridis</i>

### III. NUTRITIONAL VALUE OF DIFFERENT MILLETS

Indian millets are more nutrient-dense than wheat and rice and are higher in protein, vitamins, and minerals. Millets are also great for those with celiac disease, obesity, overweight people, and type II diabetics because they are non-acidic, non-allergic, gluten-free, and have a low glycemic index value.

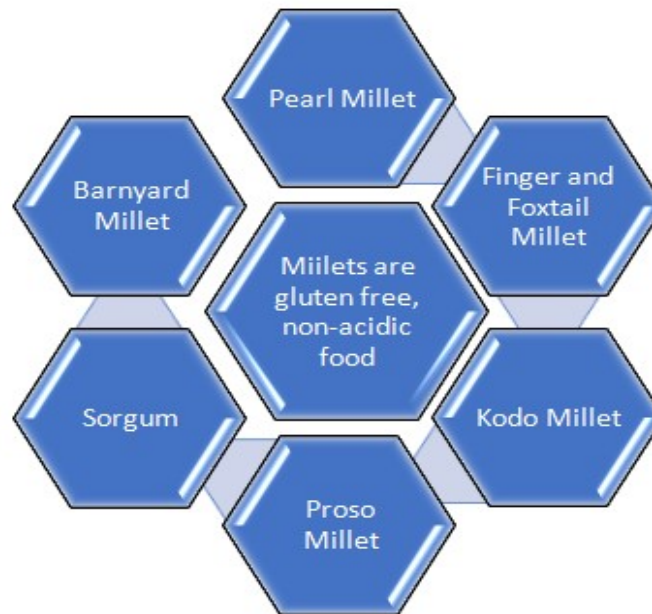
When compared to staple cereals like rice and wheat, millets contain 65 to 75 percent carbs and a higher amount of non-starchy polysaccharides and dietary fibre. Due to their high dietary fibre content, millets provide several health advantages, including bettering gastrointestinal health, blood lipid profiles, and blood glucose control. Because millets contain less gluten and have a low glycemic index, they are a good choice for those with gluten enteropathy and diabetes. Millets are also abundant in phytochemicals that promote health, including phytocyanins, lignins, phytosterols, and polyphenols.

#### MAJOR MILLETS

- Pearl Millet:** In India, one of the most widely grown crops is pearl millet (Bajra). It may be cultivated under both irrigated and short-duration rainfed environments. Pearl millets are a strong source of energy and are also high in dietary fibre, proteins, minerals, and vitamins. Less than the staple grains, pearl millet includes carbs. Its major ingredient is a high amylose starch content of 20-22%, and the insoluble dietary fibre component of pearl millet aids in displaying a lower glycaemic response. Pearl millet protein is excellent for patients with gluten sensitivity since it is free of gluten and has a greater prolamins content. Although pearl millet has an excellent score for amino acids, it has low levels of 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.

- 2. Finger Millet:** The finger millet, also known as ragi in India (India, Nepal), is a key staple crop in Eastern Africa and Asia. The top of the stem of the plant is covered in many spikes or "fingers." The grains are quite small (1-2 mm in diameter). The grains of finger millet are full of proteins, dietary fibre, polyphenols, and minerals like calcium, which is essential for developing children, pregnant women, and those with obesity, diabetes, and malnutrition. Ragi is high in potassium, which aids in kidney and brain health and promotes smooth muscle and brain function.



The selected millets' carbohydrate content is highest in finger millet. However, compared to most typical cereals like rice and wheat, carbohydrates have a lower glycemic index value since they are predominantly composed of slowly digesting starch, dietary fibre, and resistant starch. Finger millet has a lower protein level than other millets (about 7%), but it has a higher amino acid score and more lysine, threonine, and valine than other millets. Therefore, finger millets are rich in micronutrients such minerals like calcium, iron, magnesium, potassium, and zinc as well as B-complex vitamins, particularly niacin, B6, and folic acid.

- 3. Foxtail Millet:** For finger millet to grow, less than 12 hours of daylight must be available. One of the reliable crops that may thrive in harsh, arid climates and can withstand high temperatures is foxtail millet. Its high carbohydrate content aids in stabilising the blood sugar level. It is abundant in minerals, particularly iron. Additionally, foxtail millet may strengthen weak immunity and malnutrition. It has a lot of potassium, which is necessary for the kidneys to function properly, for the brain to operate normally and for controlling high blood pressure. Foxtail millet has a higher nutritional value than other grains due to its substantial amount of dietary fibre, 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.

4. **Proso Millet:** When compared to staple cereals, proso millet has a higher nutritional value since it has a higher concentration of minerals and dietary fibre. Iron, calcium, potassium, phosphorus, zinc, magnesium, the vitamin B-complex family of vitamins, niacin, and folic acid are among the vitamins and minerals abundant in proso millet. Minerals, dietary fibre, polyphenols, vitamins, and proteins are all present in proso millet. Because the crops are gluten-free, they are suitable for celiac disease patients as well as those who are gluten sensitive. High levels of lecithin in proso millet help the neurological health system. It contains significant amounts of important amino acids (methionine and cysteine), minerals (potassium, calcium, zinc, and folic acid), and vitamins (niacin, B-complex vitamins, and folic acid).

Apart from lysine, the limiting amino acid, proso millet provides essential amino acids in much larger amounts.

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:** Popular among millets, barnyard millet is also referred to as sanwa. It has a lot of dietary fibre, which helps with digestion, reduces constipation, and promotes weight loss. due to its high calcium and phosphorus content, which supports bone density.
2. **Kodo Millet:** It is a very old millet grain that was domesticated in India about three thousand years ago but originally came from tropical Africa. Kodo millet is also known as Indian Crown Grass, Native Paspalum, Ditch Millet, or Rice Grass. It also goes by the names Kodra and Varagu in India. Millets are grown in a number of nations, including West Africa, Vietnam, Pakistan, Thailand, the Philippines, and India. It is the primary food supply for Gujarat's Deccan Plateau in India. Kodo millet is mostly farmed in India's Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Bihar, Maharashtra, Gujarat, and Orissa. The most coarse and gastrointestinally pleasant millets are kodo varieties. A digestible form of millet called Kodo Millet is also called 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.

In addition to other vitamins and minerals, kodo millet contains the B complex group of vitamins, namely niacin, B6, and folic acid. Minerals such as zinc, calcium, iron, potassium, and magnesium are also present. Being a gluten-free millet, it is suitable for those who cannot consume gluten. Kodo millet is easily digested, making it advantageous

for baby and geriatric product formulation. When used frequently by postmenopausal women, it can treat cardiovascular conditions like hypertension and dyslipidemia.

Kodo millet offers a similar amount of energy as other millets and common grains like wheat and rice. Kodo millet, on the other hand, delivers gluten-free protein but has a lower protein content than other chosen millets, except for finger millet. Iron, zinc, calcium, magnesium, and potassium are among the vitamins and minerals that kodo millets are particularly high in, along with B-complex vitamins, B6, niacin, and folic acid. The abundance of polyphenols, flavonoids, and antioxidant chemicals in kodo millet has numerous health advantages. Its high phytate and phytochemical content makes it an anti-cancerous food that also aids in maintaining a healthy weight and reducing arthritic and knee discomfort.

- 3. Little Millet:** Little millet (*Panicum miliare*), a traditional crop of India, is planted all over the country. Other names for it are Moraiyo, Kutki, Shavan, and Sama. Although it is related to proso millet, little millet has significantly smaller seeds than proso millet. It is abundant in vital minerals like calcium, iron, zinc, and potassium as well as vitamin B complexes. Little millet is commonly used in the southern states of India, where it is utilised to produce a variety of traditional recipes. It is a better option than rice and will not make you gain weight.

Little millet has similar nutritional value to other cereal and millet crops; it includes 8.7% protein and a balanced number of amino acids, and it is a good source of lysine and other sulphur-containing amino acids, which are typically low in cereals. Due to the large amount of dietary fibre, resistant starch, and slowly digesting starch, it is typically thought to cause a reduced glycemic response. Micronutrients like niacin, potassium, and iron are also abundant in it. To capitalise on the health advantages of small millet, a lot of value-added products have recently been created using 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

<b>Teff</b>	13	8	0.85	7.6	180
<b>Fonio</b>	11	11.3	5.31	84.8	18
<b>Brown top Millet</b>	11.5	12.5	4.2	0.65	0.01

### Millets nutritional value per 100 g

Millets	Nutrients per 100 g					
	Energy (Kcal)	Protein (g)	CHO (g)	Crude Fibre (g)	Calcium (mg)	Iron (mg)
<b>Pearl</b>	361	11.6	65.5	1.2	42	8
<b>Finger</b>	328	7.3	72	2.6	344	8.9
<b>Foxtail</b>	331	12.30	60.9	14	31	3.6
<b>Barnyard</b>	341	7.7	67.0	7.6	17	9.3
<b>Kodo</b>	302	8.03	69.9	8.5	22	9.9
<b>Proso</b>	309	8.30	65.90	9.00	27.0	0.50
<b>Little Millet</b>	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
<p>1. A nutritious crop that promotes health is millets. Millets contain bioactive flavonoids and a higher level of micronutrients than other cereals.</p> <p>2. Millets, especially type II, have a low Glycaemic Index (GI), making them beneficial for managing and preventing diabetes.</p> <p>3. They are abundant in minerals, particularly calcium, iron, and zinc.</p> <p>4. Because millets are naturally non-acidic, they are beneficial for preventing many cancers.</p> <p>5. Millets are gluten-free and may be administered to patients with gluten enteropathy and celiac disease.</p> <p>6. Millet helps lower blood cholesterol levels by having a positive effect on the management and prevention of heart disease.</p> <p>7. Millets are found to be helpful with the reduction of excess weight, maintenance</p>	<p>1. Millets grow well in rain-fed, desert climates and are very adaptable to a variety of ecological circumstances. They require little water, fertiliser, or pesticides to grow.</p> <p>2. Millets are grown for both human food and fodder, which increases their farming efficiency.</p> <p>3. The planting of millet lowers carbon emissions</p>

<p>of BMI, prevents obesity and controls hypertension.</p> <p>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.</p> <p>9. For the urban population, millet-based value-added goods in the category of ready-to-cook, ready-to-eat foods are readily available and practical.</p>	
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#### IV. HEALTH BENEFITS OF MILLETS

Milletts may have health benefits, and epidemiological studies have shown that eating them lowers the risk of heart disease, lowers the risk of diabetes, improves digestive health, lowers the risk of cancer, detoxifies the body, strengthens the immune system, improves respiratory health, boosts energy, strengthens the muscular and neural systems, and protects against several degenerative diseases, including Parkinson's disease and metabolic syndrome. Important nutrients found in millets include resistant starch, oligosaccharides, lipids, antioxidants such phenolic acids, avenanthramides, flavonoids, lignans, and phytosterols, which are thought to have a variety of positive health effects. Below is a list of several disease defences.

1. **Cardiovascular Diseases:** Millets' high magnesium concentration aids in lowering blood pressure and lowers the risk of heart strokes, particularly in atherosclerosis. Additionally, the potassium included in millets acts as a vasodilator, lowering blood pressure and lowering the risk of cardiovascular disease. Additionally, the plant lignans found in millets have the ability to transform into animal lignans when the digestive tract has a healthy microbiota, protecting against some malignancies and heart diseases. Millets' high fibre content significantly lowers cholesterol levels, eliminates LDL from the body, and boosts the effects of HDL.

A study was conducted on the relationship between plasma non-HDL cholesterol levels and cholesterol absorption in hamsters given grain sorghum lipid extract. Hamsters were used as test subjects in this study, and they were fed grain sorghum lipid extract (GSL) in various diet compositions. Plant sterols found in GSL extract dramatically lower cholesterol absorption efficiency, and policosanol inhibits endogenous cholesterol synthesis. Hamsters given GSL also had considerably lower liver cholesterol ester concentrations. Research findings also suggest that sorghum grains include components that could be employed as food ingredients or dietary supplements to control cholesterol levels in people. It has been discovered that the GSL diet lowers non-HDL cholesterol, at least in part, by preventing cholesterol absorption.

Because millet contains potent antioxidants including lignin and phytonutrients, it offers defence against illnesses of the heart. Because of this, millet is regarded as a heart-healthy food. Compared to rats fed white rice and sorghum, finger and proso millets can considerably lower serum triglyceride levels. It was shown that finger millet and proso



millet can lower serum triglycerides in hyperlipidemic rats, which may help avoid cardiovascular illnesses. When compared to rice and other minor millets, rats fed a diet of treated starch from barnyard millet had reduced levels of triglycerides, serum cholesterol, and blood sugar. It was found that genetically obese type -2 diabetic mice have higher plasma levels of adiponectin and high density lipoprotein (HDL) cholesterol in genetically obese type -2 diabetic mice under high fat conditions on feeding of Proso millet.

- 2. Detoxification (Anti-oxidant Properties):** Many different antioxidants are found in millet, and they have a positive impact on scavenging free radicals (which cause cancer) and clearing other toxins from the body, like those found in the kidney and liver. By encouraging appropriate elimination and reducing enzymatic activity in those organs, quercetin, curcumin, ellagic acid, and other beneficial catechins can aid in clearing the body of any foreign agents and poisons. As a result of its positive effects on human health, polyphenol has received a lot of attention.

The white types of Kodo millet, finger millet, tiny millet, foxtail millet, barnyard millet, and sorghum bicolor were screened by electron spin resonance for their ability to quench free radicals that attack 1,1, diphenyl-2-picrylhydrazyl (DPPH), a chemical compound. Furthermore, it was discovered that finger millet extracts had stronger free radical-scavenging abilities than those of wheat, rice, and other millet species. Millets may operate as a natural source of antioxidants in food applications as well as a nutraceuticals and functional food element in disease risk reduction and in health promotion. In addition, defatted version of foxtail millet protein hydrolysates also demonstrated antioxidant potency.

The soluble and insoluble bound phenolic extracts of a number of millet varieties, including kodo, finger, foxtail, proso, pearl, and little millets, demonstrate their anti-oxidant, metal-chelating, and reducing properties. For example, foxtail millet contains 47 mg of polyphenolics per 100 g and 3.34 mg of tocopherol per 100 g (wet basis), while proso millet only has 29 mg and 2. Using HPLC and HPLC-tandem mass spectrometry (MS), more than 50 phenolic compounds from several classes, including phenolic acids and their derivatives, dehydrodiferulates and dehydrotriferulates, flavan-3-ol monomers and dimers, flavanols, flavones, and flavanols, were positively identified in four phenolic fractions of several whole millet grains, including kodo. Consequently, millet grains can serve as both useful food elements as well as sources of natural antioxidants.

- 3. Diabetes Mellitus:** Type I diabetes mellitus, which is thought to be the most prevalent endocrine condition, causes inadequate insulin production, whereas type II diabetes mellitus causes both combined insulin action and secretory response resistance. A chronic metabolic illness called diabetes mellitus causes hyperglycemia and changes in the way that proteins, carbohydrates, and lipids are processed. The substantial magnesium content of millets aids in the prevention of diabetes by improving the body's insulin and glucose receptors' efficiency. Diets based on finger millet have lower glycemic responses and alpha amylase inhibitory qualities, which are known to decrease starch digestion and absorption, as a result of the high fibre content.

The slow-digesting starch is advantageous for controlling diet and treating metabolic diseases including diabetes and hyperlipidemia. Sorghum has significant levels of slow digestible starch (SDS), which has the practical feature of delaying the breakdown and absorption of carbs in the intestine. Sorghum has a low glycemic index and is high in dietary fibre, both of which could aid in the prevention and management of type II diabetes in Indians. Millets' fibre, magnesium, vitamin E, phenolic compounds, and tannins decrease the abrupt rise in blood sugar and insulin levels, which lowers the risk of developing diabetes. In 2010, as part of the National Agricultural Innovation Project (NAIP), the National Institute of Nutrition (ICMR) and the Indian Institute of Millets Research, Hyderabad, evaluated the Glycemic Index (GI) of foods based on sorghum.

The findings showed that foods made from sorghum have a low GI, which lowers postprandial blood sugar levels and levels of glycosylated haemoglobin (Hb<sub>1c</sub>). According to a study, non-obese people with non-insulin-dependent diabetes mellitus whose blood glucose levels were significantly reduced by eating sorghum bran papadi. According to studies done on the processing and cooking of white and yellow jowar varieties, coarse yellow jowar flour that had been cooked had a lower glycemic index than flour made from the same. The glycemic index of chapatti made from white jowar flour was lower than that of yellow jowar flour. These modifications in glycemic index brought on by processing and heating have a significant impact on the diets used for diabetic dietary management.

Pearl millets have been shown to improve insulin sensitivity and reduce serum triglyceride levels. Due to its high dietary fibre content, pearl millet digests slowly and releases glucose into the blood at a slower rate than other foods, making it particularly beneficial for reducing the risk of developing diabetes. Millets are a good way to help diabetic individuals maintain a steady blood sugar level over an extended length of time. Due to the high fibre content and alpha amylase inhibitory capabilities of finger millet, which are known to lessen starch digestion and absorption, diets based on it have demonstrated decreased glycemic response. The healing of cutaneous wounds has been improved with the use of finger millet. According to a few research conducted on rats, it increases antioxidant levels and maintains blood sugar.

In a study, finger millets' polyphenols were discovered to have significant anti-diabetic and anti-oxidant properties. This inhibitory activity of the enzyme aldose reductase (AR) was attributed to the presence of phenolics with an OH group in the fourth position. Quercetin successfully reduced cataract eye lens growth along with gallic, protocatechuic, p-hydroxy benzoic, coumaric, vanillic, syringic, ferulic, and trans-cinnamic acids. As a result, these investigations provide compelling evidence that the protein from finger millets inhibits the development of cataracts in humans.

The healing of cutaneous wounds has been improved with the use of finger millet. According to a few research conducted on rats, it enhances antioxidant status and regulates blood glucose levels. Because dehulled types of barnyard millet have a lower glycemic index (41.7) and are heat-treated, they may be especially advantageous for type II diabetes. In the extruded products derived from amaranth, buckwheat, and millet combination food products studied in vitro, the fast and slowly digested carbs were

dramatically reduced. Few other phenolic compounds from the millet seed coat were identified to have the potent inhibition on -glucosidase and pancreatic amylase.

Foxtail millets' aqueous extracts have outstanding anti-hyperglycemic action. Under conditions of high fat feeding, proso millet has been demonstrated to enhance the glycemic responses and insulin in genetically obese type II diabetic mice. As a result, millet has the potential to be helpful in the prevention, management, and treatment of diabetes mellitus.

4. **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 increase nutrient retention and reduce 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 are excellent for people with celiac disease and gluten sensitivity, and they offer a lot of promise in foods and beverages. They can also meet the growing demand for gluten-free cuisine. Celiac disease is an immune-mediated enteropathy condition that, in susceptible individuals, is typically brought on by ingesting gluten. A gluten-free diet mainly influences how much of the grain food group is consumed. People who follow a gluten-free diet may benefit by substituting high-gluten cereals like wheat, barley and rye with products made from gluten-free grains such as rice, corn, sorghum, millet, amaranth, buckwheat, quinoa and wild rice.
5. **Cancer :** According to recent studies, consuming more than 30 grammes of fibre per day can cut the risk of breast cancer by more than 50%, making it one of the best and simplest approaches to avoid the disease in women. It is well known that millets, particularly sorghum, have anti-carcinogenic qualities. It is well known that millet grains are full of compounds such as phenolic acids, tannins, and phytate. In animals, these nutrients can lower the incidence of breast and colon cancer. Sorghum's and other millets' phenolic content, together with their high fibre content, have been linked to a decreased incidence of oesophageal cancer than people who eat wheat or maize. Studies conducted in vitro and in vivo have revealed that sorghum (jawar) has positive health impacts on cancer. In addition to having positive melanogenic activity, the polyphenols and tannins found in sorghum have anti-mutagenic and anti-carcinogenic properties and can act against human melanoma cells. It has also been reported that procyanidin extracts in rat liver may induce cytochrome P-450, a protein that can cause the conversion of some pro-mutagens into mutagenic derivatives. Oesophageal cancer incidence was low, according to epidemiological research, when sorghum was consumed. The scientists examined twenty-one villages in each nation over the course of six years, and they discovered that sorghum consumption was associated with a lower mortality rate from oesophageal cancer than wheat and maize. This means that millets have anti-carcinogenic effects and are useful for cancer prevention.

## V. PROCESSING OF MILLETS

Millet-based value-added processed food is made from millets that have been processed to eliminate antinutritional elements, inedible sections, extend their shelf life, and improve nutritional and sensory quality.



The primary goal of the processing processes is to increase the bioavailability and digestibility of micro and macronutrients. When millets are treated, a sizable proportion of nutrients are lost. To make millets fit for food, basic processing procedures like dehulling, soaking, germination (sprouting), roasting, drying, polishing, and milling (reduction of size) are used. Modern or secondary processing methods are also employed to process the millets before cooking, including as fermentation, parboiling, frying, puffing, popping, malting, baking, flaking, and extrusion before consumption.

## VI. ANTI NUTRITIONAL FACTORS IN MILLETS

Organic compounds that are present in food that inhibit the digestion, absorption, and availability of minerals, dietary proteins, and carbohydrates are known as anti-nutritional components. They can be present in the diets of plants and animals as natural ingredients, synthetic ingredients added during processing, or environmental contaminants. Tannins, trypsin or protease inhibitors, saponins and haemagglutinin, phytates or phytic acid, oxalates or oxalic acid, glucosinolates, and gossypol are a few of these ingredients. In addition to their primary impact on nutrient absorption, several antinutrients, such as oxalate or cyanogenic acid, may be dangerous above a certain threshold. Therefore, it is crucial to take these things out. Millets also include a few anti-nutrients, including phytates, phenols, tannins, trypsin inhibitory factors, and dietary fibre, which interferes with enzyme activity by chelating with metals. The antinutrient elements identified specifically in kodo and tiny millet are phytates and tannins. Antinutrient components like phenols, phytates, and tannins have been shown to perform an antioxidant activity that has been shown to significantly improve health, slow the ageing process, and regulate metabolic disorders.

## VII. HOW TO IMPROVE MILLETS NUTRITIONAL VALUE

Food processing methods are typically used to improve the nutritional value of millets, increase their digestibility and micronutrient bioavailability, and reduce their anti-nutritional components. Decortications, milling, soaking, heating, germination, fermentation, malting, and popping are a few of the popular food preparation methods.

The most widely used and common method of food preparation is the soaking of grains. To increase the bioavailability of minerals, it is used to reduce the amount of anti-nutritional substances such phytic acid and phytase activity. Dehulling, soaking, and heating together resulted in a considerable reduction in anti-nutrients such polyphenols and phytate, improved protein digestibility in vitro, and increased mineral bioavailability, particularly for iron and zinc.

The process of germination is another. Antinutrients such phytic acid, tannins, and polyphenols, which form compounds with protein, were reduced as a result of germination. Millets (*Pennisetum typhoides*) when germinated reduce the tannin content from 1.6% to 0.83%. The in vitro digestibility of starch (86% to 112%) and protein (14% to 26%) in pearl millet was enhanced by germination. In pearl millet and finger millets, germination boosted the in vitro extractability and bioaccessibility of minerals, primarily calcium, iron, and zinc, and lowered anti-nutritional factors like phytic acid. After malting, pearl millet has higher beta-amylase activity and free alpha-amino nitrogen than sorghum. Probiotic fermentation and germination were found to dramatically increase the amount of soluble dietary fibre, total lysine, thiamine, niacin, and sugars.

Fermentation is a popular method of food preservation that produces a wide range of food products with unique flavours and textures and considerably enhances the nutritional value of raw foods. By lowering the levels of antinutrients and increasing the availability of protein, in vitro digestibility, and noticeable change in chemical composition of food item, fermentation is a processing technique. After 16 hours of fermentation, pearl millet has a higher nutritional value in terms of moisture, ash, fibre, protein, and fat, and a much lower mineral content in terms of sodium, potassium, iron, and zinc. It also has a higher flavonoid content.

Puffed or popping Commercial use of popping as ready-to-eat food encourages the use of millet grains. Sand is used as a heat transfer medium in one of the processing methods, and the HTST (high-temperature, short-time) approach causes starch to gelatinize and the endosperm to break apart, producing a highly desirable flavour and aroma.

## REFERENCES

- [1] Millet. (2023, June 23). In *Wikipedia*. <https://en.wikipedia.org/wiki/Millet>
- [2] Gowda, N. A., Siliveru, K., Prasad, P. V., Bhatt, Y., Netravati, B. P., & Gurikar, C. (2022). Modern Processing of Indian Millets: A Perspective on Changes in Nutritional Properties. *Foods*, 11(4), 499. <https://doi.org/10.3390/foods11040499>
- [3] <https://nihkan.in/wp-content/uploads/2022/07/Ingredients-of-Nihkans-Super-Millet-Mix-Flour-600x600.jpg>,
- [4] Swaenima Dey, alok Saxena, Yogesh kumar Tanushree maity, Ayon Tarafdar, Understanding the antinutritional factors and bioactive compound of kodo millet and little millet, journal of food quality vol 2022, article id 1578448, 19 pages 2022. <http://doi.org/10.1155/2022/1578448>
- [5] ICAR- Indian institute of millets research (IIMR), Nutritional and health benefits of millets. Rajendra nagar, Hyderabad-500030, Telangana India. [www.millets.res.in](http://www.millets.res.in)
- [6] Lestienne I, Mouquet-Rivier C, Icard-Verniere C, Rochette I, Treche S. The effects of soaking of whole, dehulled and ground millet and soybean seeds on phytate degradation andPhy/Fe and Phy/Zn molar ratios. *Intl J Food Sci Technol*. 2005; 40: 391–9. 46.
- [7] Pawar VD, Machewad GM. Processing of foxtail millet for improved nutrient availability. *J Food Process Preserv*. 2006; 30: 269–79.

- [8] Hassan AB, Ahmed IAM, Osman NM, Eltayeb MM, Osman GA, Babiker EE. Effect of processing treatments followed by fermentation on protein content and digestibility of pearl millet (*Pennisetum typhoideum*) cultivars. *Pakistan J Nutr.* 2006; 5(1): 86–9.
- [9] Krishnan R, Dharmaraj U, Malleshi NG. Influence of decortication, popping and malting on bioaccessibility of calcium, iron, and zinc in finger millet. *LWT-Food Sci Technol.* 2012; 48: 169-74.
- [10] Arora S, Jood S & Khetarpaul N. Effect of germination and probiotic fermentation on nutrient profile of pearl millet-based food blends. *Br. Food J.* 2011; 113(4): 470-81.
- [11] Gotcheva V, Pandiella SS, Angelov A, Roshkova Z, Webb C. Monitoring the fermentation of the traditional Bulgarian beverage boza. *Intl J Food Sci Technol.* 2001; 36: 129–34.
- [12] Ahmed AI, Abdalla AA, El Tinay AH. Effect of traditional processing on chemical composition and mineral content of two cultivars of pearl millet (*Pennisetum glaucum*). *J Appl. Sci. Res.* 2009; 5(12): 2271–6.
- [13] Gupta V, Nagar R. Effect of cooking, fermentation, dehulling and utensils on antioxidants present in pearl millet rabadi—a traditional fermented food. *J Food Sci Technol.* 2010; 47(1): 73–6.
- [14] Shobana S, Krishnaswami K, Sudha V, Malleshi NG, Anjana RM, Palaniappan L & Mohan V. Finger Millet (*Ragi, Eleusine Coracana L.*): A Review Of Its Nutritional Properties, Processing, and Plausible Health Benefits. *Advance in Food and Nutrition Research.* 2013; 69: 1-3.