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Millets- Nutritional Facts & Health Benefits: International Year of Millets (Iyom)-2023

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Introduction:

Millet is not just one grain, but the name given to a group of several different small-seeded grains from several different genera of the grass family Poaceae. Millets are commonly referred as "small seeded grasses" which include pearl millet [*Pennisetumglaucum* (L.) R. Br.], finger millet [*Eleusinecoracana* (L.) Gaertn], foxtail millet [*Setariaitalica* (L.) Beauv], proso millet (*Panicum miliaceum* L.), barnyard millet (*Echinochloa* spp.), kodo millet (*Paspalumscrobiculatum*), and little millet (*Panicum sumatrense*). Moreover, millets are drought tolerant crops, resistant to pests and diseases offering good insurance against crop failure in developing countries. Millets are highly nutritious being rich source of proteins, vitamins, and minerals. About 80% of millet grains are used for food, while the rest is used as animal fodder and in brewing industry for alcoholic products. Millet grains are ground into flour and consumed as cakes or porridges. In Asian countries, street food vendors serve less expensive, ready-to-eat millet-based foods for poor consumers. Millets are naturally gluten freethat's high in antioxidant activity and also especially high in magnesium, a mineral that helps maintain normal muscle and nerve function. For many years, little research was done on the health benefits of millets, but recently they have been "rediscovered" by researchers, who have found millets helpful in controlling diabetes and inflammation.

Four different millets are mostly commonly cultivated worldwide, listed here starting with the most widely produced:

- Pearl millet [*Pennisetumglaucum*],
- Foxtail millet [*Setariaitalica*],

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- Proso millet, also called hog, common or broom corn millet [*Panicum miliaceum*],
- Finger millet, also called ragi in India [*Eleusinecoracana*]&
- Fonio [*Digitariaexilis*]

AACC International recognizes seven genera of millets:

Brachiaria spp.; *Pennisetum* spp.; *Panicum* spp.; *Setaria* spp.; *Paspalum* spp.; *Eleusine* spp.; *Echinochloa* spp. Te *Eragrostiste f*], Fonio [*Digitariaexilis*] and Job's Tears [*Coixlacrima-jobi*] are also sometimes classified as millets, including by the USDA.Among the millets, pearl millet occupies 95% of the production. Foxtail millet [*Setariaitalica* (L.) P. Beauv] is the second largest crop among the millets, cultivated for food in semi-arid tropics of Asia and as forage in Europe, North America, Australia, and North Africa. Finger millet is the sixth largest crop under cultivation serving as the primary food for rural populations of East and Central Africa and southern India. Proso millet is a short-season crop cultivated in drier regions of Asia, Africa, Europe, Australia, and North America. Barnyard millet is the fastest growing among the millets with a harvesting period of 6 weeks. It is predominantly cultivated in India, China, Japan, and Korea for food as well as fodder. Kodo millet is native to the tropical and sub-tropical regions of South America and domesticated in India 3,000 years ago. Little millet was domesticated in the Eastern Ghats of India occupying a major portion of diet amongst the tribal people and spread to Sri Lanka, Nepal, and

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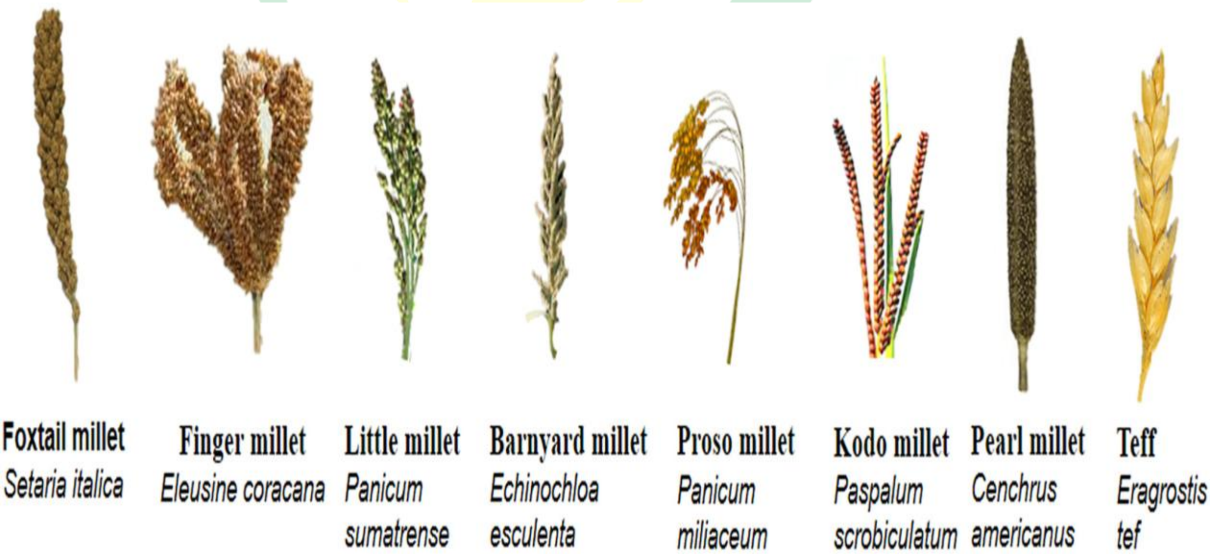
Myanmar.Millets are nutritionally superior to rice and wheat as they contain a high amount of proteins, dietary fibres, iron, zinc, calcium, phosphorus, potassium, vitamin B, and essential amino acids. But the presence of antinutrients like phytates, polyphenols, and tannins reduce the mineral bioavailability by chelating multivalent cations like Fe^{2+}, Zn^{2+}, Ca^{2+}, Mg^{2+}, and K^{+}. In addition, high amounts of protease and amylase inhibitors affect the digestibility of millet grains. The predominance of the antinutritional factors has thus rendered the orphan status to millets in terms of global economic importance. Today, millet is the world's sixth most important grain. India is the world's largest producer of millet, with eight African countries and China making up the rest of the top ten producers. Depending on variety, millets can grow anywhere from one to 15 feet tall, and usually have an undigestible hull (ranging from papery-thin to hard) that must be removed before the grain can be eaten. Most millets do best in dry, warm climates. Millets exhibit vast genetic variability for key mineral elements like, iron, zinc, and calcium when compared to other cereal crops. In spite of the superior quality of millets, only pearl millet has been prioritized as crop of choice for iron biofortification in India. In India, ragi (finger millet) is used to make roti, a staple flat bread. And in much of Africa, millet is commonly eaten as a porridge, and is also used for brewing millet beer. In the United States, millet is probably most familiar as the primary component of birdseed.



Millet nutrition facts: In a 100 gram serving, raw millet provides 378 calories and is a rich source (20% or more of the Daily Value, DV) of protein, dietary fibre, several B vitamins and

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numerous dietary minerals, especially manganese at 76% DVRaw millet is 9% water, 73% carbohydrates, 4% fat and 11% protein (Table-1).

Table-1: Millet (raw) nutrition facts.

Nutrient	Unit	Value per 100 g
Approximates		
Water	g	8.67
Energy	kcal	378
Energy	kJ	1582
Protein	g	11.02
Total lipid (fat)	g	4.22
Ash	g	3.25
Carbohydrate, by difference	g	72.85
Fiber, total dietary	g	8.5
Minerals		
Calcium, Ca	mg	8
Iron, Fe	mg	3.01
Magnesium, Mg	mg	114
Phosphorus, P	mg	285
Potassium, K	mg	195
Sodium, Na	mg	5
Zinc, Zn	mg	1.68
Copper, Cu	mg	0.75
Manganese, Mn	mg	1.632
Selenium, Se	µg	2.7
Vitamins		
Vitamin C, total ascorbic acid	mg	0
Thiamin	mg	0.421
Riboflavin	mg	0.29
Niacin	mg	4.72
Pantothenic acid	mg	0.848
Vitamin B-6	mg	0.384
Folate, total	µg	85
Folic acid	µg	0
Folate, food	µg	85
Folate, DFE	µg	85
Vitamin B-12	µg	0
Vitamin A, RAE	µg	0
Retinol	µg	0
Vitamin A, IU	IU	0
Vitamin E (alpha-tocopherol)	mg	0.05
Vitamin D (D2 + D3)	µg	0
Vitamin D	IU	0
Vitamin K (phylloquinone)	µg	0.9
Lipids		

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Fatty acids, total saturated	g	0.723
12:00:00	g	0.003
16:00:00	g	0.528
18:00:00	g	0.154
Fatty acids, total monounsaturated	g	0.773
16:1 undifferentiated	g	0.014
18:1 undifferentiated	g	0.739
20:01:00	g	0.02
Fatty acids, total polyunsaturated	g	2.134
18:2 undifferentiated	g	2.015
18:3 undifferentiated	g	0.118
Cholesterol	mg	0
Amino acids		
Tryptophan	g	0.119
Threonine	g	0.353
Isoleucine	g	0.465
Leucine	g	1.4
Lysine	g	0.212
Methionine	g	0.221
Cystine	g	0.212
Phenylalanine	g	0.58
Tyrosine	g	0.34
Valine	g	0.578
Arginine	g	0.382
Histidine	g	0.236
Alanine	g	0.986
Aspartic acid	g	0.726
Glutamic acid	g	2.396
Glycine	g	0.287
Proline	g	0.877
Serine	g	0.644
Proanthocyanin		
Proanthocyanin dimers	mg	0
Proanthocyanin trimers	mg	0
Proanthocyanin 4-6mers	mg	0
Proanthocyanin 7-10mers	mg	0
Proanthocyanin polymers (>10mers)	mg	0

Source: www.fao.in.

Table-2: Millet (cooked) nutrition facts.

Nutrient	**Unit**	**Value per 100 g**
Approximates		
Water	g	71.41
Energy	kcal	119
Protein	g	3.51

Total lipid (fat)	g	1
Carbohydrate, by difference	g	23.67
Fiber, total dietary	g	1.3
Sugars, total	g	0.13
Minerals		
Calcium, Ca	mg	3
Iron, Fe	mg	0.63
Magnesium, Mg	mg	44
Phosphorus, P	mg	100
Potassium, K	mg	62
Sodium, Na	mg	2
Zinc, Zn	mg	0.91
Vitamins		
Vitamin C, total ascorbic acid	mg	0
Thiamin	mg	0.106
Riboflavin	mg	0.082
Niacin	mg	1.33
Vitamin B-6	mg	0.108
Folate, DFE	µg	19
Vitamin B-12	µg	0
Vitamin A, RAE	µg	0
Vitamin A, IU	IU	3
Vitamin E (alpha-tocopherol)	mg	0.02
Vitamin D (D2 + D3)	µg	0
Vitamin D	IU	0
Vitamin K (phylloquinone)	µg	0.3
Lipids		
Fatty acids, total saturated	g	0.172
Fatty acids, total monounsaturated	g	0.184
Fatty acids, total polyunsaturated	g	0.508
Cholesterol	mg	0
Other		
Caffeine	mg	0

Source: www.fao.in.

Table-3: Millet flour nutrition facts.

Nutrient	**Unit**	**Value per 100 g**
Approximates		
Water	g	8.67
Energy	kcal	382
Protein	g	10.75
Total lipid (fat)	g	4.25
Carbohydrate, by difference	g	75.12
Fiber, total dietary	g	3.5
Sugars, total	g	1.66

Minerals		
Calcium, Ca	mg	14
Iron, Fe	mg	3.94
Magnesium, Mg	mg	119
Phosphorus, P	mg	285
Potassium, K	mg	224
Sodium, Na	mg	4
Zinc, Zn	mg	2.63
Vitamins		
Vitamin C, total ascorbic acid	mg	0
Thiamin	mg	0.413
Riboflavin	mg	0.073
Niacin	mg	6.02
Vitamin B-6	mg	0.372
Folate, DFE	µg	42
Vitamin E (alpha-tocopherol)	mg	0.11
Vitamin K (phylloquinone)	µg	0.8
Lipids		
Fatty acids, total saturated	g	0.536
Fatty acids, total monounsaturated	g	0.924
Fatty acids, total polyunsaturated	g	2.618
Fatty acids, total trans	g	0.002

Source: www.fao.in.

Table-4: Millet puffed nutrition facts.

Nutrient	Unit	Value per 100 g
Approximates		
Water	g	2.5
Energy	kcal	354
Protein	g	13
Total lipid (fat)	g	3.4
Carbohydrate, by difference	g	80
Fiber, total dietary	g	2.7
Sugars, total	g	0.55
Minerals		
Calcium, Ca	mg	8
Iron, Fe	mg	2.81
Magnesium, Mg	mg	106
Phosphorus, P	mg	266
Potassium, K	mg	40
Sodium, Na	mg	5
Zinc, Zn	mg	1.58
Vitamins		
Vitamin C, total ascorbic acid	mg	0
Thiamin	mg	0.39

Riboflavin	mg	0.27
Niacin	mg	4.42
Vitamin B-6	mg	0.36
Folate, DFE	µg	79
Vitamin B-12	µg	0
Vitamin A, RAE	µg	0
Vitamin A, IU	IU	0
Vitamin E (alpha-tocopherol)	mg	0.66
Vitamin D (D2 + D3)	µg	0
Vitamin D	IU	0
Vitamin K (phylloquinone)	µg	1.4
Lipids		
Fatty acids, total saturated	g	0.67
Fatty acids, total monounsaturated	g	0.717
Fatty acids, total polyunsaturated	g	1.98
Cholesterol	mg	0
Other		
Caffeine	mg	0

Source: www.fao.in.

Millet comparison with other major cereal grains:

Nutritional potential of millets in terms of protein, carbohydrate and energy values are comparable to the popular cereals like rice, wheat, barley or bajra (Tables-5 and 6). Finger millet contains about 5–8% protein, 1–2% ether extractives, 65–75% carbohydrates, 15–20% dietary fibre and 2.5–3.5% minerals. Finger Millet has the highest calcium content among all cereals (344 mg/100 g) (see Table-6). However, the millet also contains phytates (0.48%), polyphenols, tannins (0.61%), trypsin inhibitory factors, and dietary fibre, which were once considered as "anti-nutrients" due to their metal chelating and enzyme inhibition activities but nowadays they are termed as nutraceuticals. The seed coat of the millet is an edible component of the kernel and is a rich source of phytochemicals, such as dietary fibre and polyphenols (0.2–3.0%). It is now established that phytates, polyphenols and tannins can contribute to antioxidant activity of the millet foods, which is an important factor in health, aging and metabolic diseases.

Table-5: Nutrient composition of cereal grains.

Cereals	Protein (%)	Fat (%)	Crude fiber (%)	Ash (%)	Starch (%)	Total dietary fiber (%)	Total phenol (mg/100 g)
Wheat	14.4	2.3	2.9	1.9	64.0	12.1	20.5
Rice	7.5	2.4	10.2	4.7	77.2	3.7	2.51

Maize	12.1	4.6	2.3	1.8	62.3	12.8	2.91
Sorghum	11	3.2	2.7	1.8	73.8	11.8	43.1
Barley	11.5	2.2	5.6	2.9	58.5	15.4	16.4
Oats	17.1	6.4	11.3	3.2	52.8	12.5	1.2
Rye	13.4	1.8	2.1	2.0	68.3	16.1	13.2
Finger millet	7.3	1.3	3.6	3.0	59.0	19.1	102
Pearl millet	14.5	5.1	2.0	2.0	60.5	7.0	51.4
Proso millet	11	3.5	9.0	3.6	56.1	8.5	–
Foxtail millet	11.7	3.9	7.0	3.0	59.1	19.11	106
Kodo millet	8.3	1.4	9.0	3.6	72.0	37.8	368

Source: www.fao.in.

Table-6: Mineral and vitamin composition of cereal grains.

Cereals	Ca(%)	P (%)	K (%)	Na (%)	Mg (%)	Fe (%)	Mn (%)	Zn (%)	Thiamin (mg/ 100gm)	Riboflavin (mg/ 100gm)	Nicotinic acid (mg/ 100gm)
Wheat	0.04	0.35	0.36	0.04	0.14	40.1	40.0	30.9	0.57	0.12	7.40
Rice	0.02	0.12	0.10	0.00	0.03	19.0	12.0	10.0	0.07	0.03	1.60
Maize	0.03	0.29	0.37	0.03	0.14	30.0	5.0	20.0	0.38	0.14	2.80
Sorghum	0.04	0.35	0.38	0.05	0.19	50.0	16.3	15.4	0.46	0.15	4.84
Barley	0.04	0.56	0.50	0.02	0.14	36.7	18.9	23.6	0.44	0.15	7.20
Oats	0.11	0.38	0.47	0.02	0.13	62.0	45.0	37.0	0.77	0.14	0.97
Rye	0.05	0.36	0.47	0.01	0.11	38.0	58.4	32.2	0.69	0.26	1.52
Finger millet	0.33	0.24	0.43	0.02	0.11	46.0	7.5	15.0	0.48	0.12	0.30
Pearl millet	0.01	0.35	0.44	0.01	0.13	74.9	18.0	29.5	0.38	0.22	2.70
Proso millet	0.01	0.15	0.21	0.01	0.12	33.1	18.1	18.1	0.63	0.22	1.32
Foxtail millet	0.01	0.31	0.27	0.01	0.13	32.6	21.9	21.9	0.48	0.12	3.70
Kodo millet	0.01	0.32	0.17	0.01	0.13	7.0	–	–	0.32	0.05	0.70

Source: www.fao.in.

Millet health benefits:

Millets are recommended for well-being of infants, lactating mothers, elderly, and convalescents. The grains release sugar slowly into the blood stream and thus considered "gluten-free". With high fibre and protein content, millets are preferred as dietary foods for people with diabetes and cardiovascular diseases. In addition, they contain health promoting phenolic acids and flavonoids that play a vital role in combating free-radical mediated oxidative stress and in lowering blood glucose level. Pearl millet is rich in Fe (iron), Zn (zinc), and lysine (17–65 mg/g of protein) compared to other millets. Foxtail millet contains a high amount of protein (11%) and fat (4%). The protein fractions are represented by albumins and globulins (13%), prolamins (39.4%), and glutelins (9.9%). It is thus recommended as an ideal food for diabetics. It also contains significant amounts of potential antioxidants like phenols, phenolic acids, and carotenoids. Finger millet grains contain higher levels of minerals like Ca (calcium), Mg (magnesium), and K (potassium). Positive calcium content maintains healthy bones, while potassium prevents the onset of diabetes, renal and cardiovascular diseases. It also has high levels of amino acids like methionine, lysine and tryptophan, and polyphenols. Proso millet contains the highest amount of proteins (12.5%) while barnyard millet is the richest source of crude fibre (13.6%) and Fe (186 mg/kg dry matter). Barnyard millet grains possess other functional constituents' viz. γ-amino butyric acid (GABA) and β-glucan, used as antioxidants and in reducing blood lipid levels. With lowest carbohydrate content among the millets, barnyard millet is recommended as an ideal food for type II diabetics. Kodo millet is bestowed with high magnesium content (1.1 g/kg dry matter). Millets are therefore consumed as multi-grains to reap the collective health benefits of nutrients.

The dietary fibre and polyphenols in finger millet are known to offer several health benefits such as antidiabetic, antioxidant, hypocholesterolaemic, antimicrobial effects and protection from diet related chronic diseases. The millet polyphenols is a complex mixture of benzoic acid and cinnamic acid derivatives and exhibit enzyme inhibitory and anti-cataractogenic activities also. The non-starchy polysaccharides of the millet form bulk of its dietary fibre constituents and offer several health benefits including delayed nutrient absorption, increased faecal bulk and lowering of blood lipids. Regular consumption of finger millet as a food or even as snacks helps in managing diabetes and its complications by regulation of glucose homeostasis and prevention of dyslipideamia.

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Potential contribution of dietary fibre to the health effects of finger millets:

Finger millet like any other cereal is a source of dietary carbohydrates but the proportion of dietary fibre in finger millet is relatively higher than many other cereals. Finger millet carbohydrates (72%) comprises of starch as the main constituent and the non-starchy polysaccharides which amounts to 15–20% of the seed matter as an unavailable carbohydrate. Dietary fibre, principally the non-starchy polysaccharides and lignin of the plant origin, is not digested by endogenous enzymes within the human intestinal tract, but is an important component of our diet. Dietary fibre can be divided into two categories according to their water solubility. Each category provides different therapeutic effects. Water-soluble fibre consists of non-starchy polysaccharides, mainly β-glucan and arabinoxylan. Water-insoluble fibre contains lignin, cellulose, hemicelluloses, and non-starchy polysaccharides such as water-unextractable arabinoxylan. In millets, non-starchy polysaccharides form the quantitatively most important source of both soluble and insoluble dietary fibres. In cereal botanical components, the majority of dietary fibres generally occur in decreasing amounts from the outer pericarp to the endosperm, except arabinoxylan, which is also a major component of endosperm cell wall materials. The health benefits associated with high fibre foods are delayed nutrient absorption, increased faecal bulk, lowering of blood lipids, prevention of colon cancer, barrier to digestion, mobility of intestinal contents, increased faecal transit time and fermentability characteristics. Water-soluble fibre fractions are important in foods because they trap fatty substances in the gastro-intestinal tract and therefore, reduce cholesterol level in the blood and lower the risk of heart disease. Water-soluble fibre in general has a wide range of functionality due to its ability to absorb water and form gel like structure, and is almost fully fermented in the large intestine microflora, bringing about many desired metabolic effects of fibre. The ability of water-soluble fibre to retard absorption of glucose in the small intestine is also a desirable characteristic in the development of foods for diabetic individuals. The increase in the soluble fibre content of the product has special nutritional significance because of its physiological advantages in terms of hypoglycemic and hypocholesterolemic characteristics. Soluble fibre also decreases serum cholesterol, postprandial blood glucose, and insulin contents in the human body. Insoluble fibre has a major impact on gastrointestinal transit times, binds water, speeds up intestinal transit, faecal bulk and binds some carcinogens. It reduces contact time for faecal mutagens to interact with the intestinal epithelium and also modifies the activity of digestive microflora and leads to modification or reduction in the production of mutagens. Some fibres can adsorb mutagenic agents and are eliminated in the faeces.

Formation of the resistant starch also contributes towards dietary fibre content and complements the health benefits of the millet. This residual starch can be quantified in the soluble dietary fibre residue and is highly susceptible to fermentation in the large intestine. Resistant starch, a functional fibre fraction is also present in ragi, which escapes the enzymatic digestion imparts beneficial effects by preventing several intestinal disorders. Similar to oligosaccharides, especially fructooligosaccharides, it escapes digestion and provides fermentable carbohydrates for colonic bacteria. It has also been shown to provide benefits such as the production of desirable metabolites, including short-chain fatty acids in the colon, especially butyrate, which seems to stabilize colonic cell proliferation as a preventive mechanism for colon cancer. In addition to its therapeutic effects, resistant starch provides better appearance, texture, and mouth feel than conventional fibres.

Dietary fibre has gained importance during the last two decades due to its role in decreasing the risk diseases such as diabetes, cardiovascular diseases, colon cancer, constipation and diverticulosis. Physical attributes of the fibrecauses change in morphology of the intestine and these changes could be associated with functional changes in the gastrointestinal tract through different mechanisms. Consumption of dietary fibre that are viscous lowers blood glucose levels and helps to maintain it and also helps to treat cardiovascular and type II diabetes. Fibres are incompletely or slowly fermented by microflora in the colon promotes normal laxation which prevents constipation, diverticulosis and diverticulitis. Daily intake of fibre is 20–35 g/day for healthy individuals and age plus 5 g/day for children is recommended.

Dietary fibre has major effects on the rate of gastrointestinal absorption; sterol metabolism; cercal fermentation and stool weight. Rate of intestinal absorption in the upper gastrointestinal tract dietary fibre prolongs gastric emptying time and retards the absorption of nutrients. Both processes are dependent on the physical form of the fibre, and particularly on viscosity. The physiological effects of dietary fibre in relation to functions of intestines are given in Table-7. An important function of insoluble fibres is to increase luminal viscosity in the intestine. The inclusion of viscous polysaccharides in carbohydrate meals reduces the postprandial blood glucose level concentrations in humans. The direct effect of fibre on sterol metabolism may be through one of several mechanisms: altered lipid absorption; altered bile acid metabolism in the cecum; reduced bile acid absorption in the cecum; indirectly via short chain fatty acids, especially propionic acid, resulting from fibre fermentation. Fermentation in colon involves nutrient salvage so that dietary fibre, resistant starch, fat, and protein are utilized by bacteria and the end products are absorbed and used by the body. The functions of dietary fibre in the colon are susceptible to bacterial fermentation, ability to increase bacterial mass and saccharolytic enzyme activity and water holding capacity of the fibre residue after fermentation. The most important mechanism whereby dietary fibre increases stool weight is through the water-holding capacity of unfermented fibre. Potential negative effects of dietary fibre are reduced absorption of vitamins, minerals and proteins. Fermentation of dietary fibre by anaerobic bacteria in the large intestine produces gas such as hydrogen, methane and carbon dioxide, which causes flatulence problems.

Table-7: Physiological effects of dietary fibre in relation to intestinal functions.

Characteristics	Effects	Physiological implications
Dietary fiber and small intestinal functions		
Dispersibility in water	Increases volume, dilution of metabolites formed	Slower digestion, promotes nutrient absorption with reduction of plasma cholesterol
Bulk	Increases bulk, alters mixing of contents	Alters transit time
Viscosity	Slows gastric emptying	Alters mixing and diffusion
Adsorption-binding	Increases bile acid excretion	Reduction in plasma cholesterol
Dietary fiber and large intestinal functions		
Dispersibility in water	Provides an aqueous phase for penetration of microbes	Increased polysaccharide break down by microflora
Bulk	Increases bulk/volume	Aids laxation
Adsorption-binding	Increases bile acid concentration	Bile acid excretion increased
Fermentability	Growth of microflora, microbial adaptation to polysaccharide structures	Increased microbial mass and products of metabolism

Source: www.fao.in.

Foxtail Millet May Help Control Blood Sugar and Cholesterol:

Foxtail millet (*Setariaitalica*) is a common food in parts of India. Health benefits in diabetic rats, and concluded that the millet produced a "significant fall (70%) in blood glucose" while having no such effect in normal rats. Diabetic rats fed millet also showed significantly lower levels of triglycerides, and total/LDL/VLDLcholesterol, while exhibiting an increase in HDL cholesterol.

Sprouting (Malting) Millet Makes Some Minerals More Bioavailable:

In India and some other countries, sprouted (malted) grains are commonly used as weaning foods for infants and as easily-digested foods for the elderly and infirm. A study at the Central Food Technological Research Institute in Mysore, India, measured the changes caused by malting finger millet, wheat and barley. They found that malting millet increased the bio-accessibility of iron (> 300%) and manganese (17%), and calcium ("marginally"), while reducing bio-accessibility of zinc and making no difference in copper. The effects of malting on different minerals varied widely by grain.

All Millet Varieties Show High Antioxidant Activity:

At the Memorial University of Newfoundland in Canada, a team of biochemists analysed the antioxidant activity and phenolic content of several varieties of millet: kodo, finger, foxtail, proso, pearl, and little millets. Kodo millet showed the highest phenolic content, and proso millet the least. All varieties showed high antioxidant activity, in both soluble and bound fractions.

- **Naturally Gluten-Free Grains May Be Cross-Contaminated:** A Polish team from the InstytutZywnosci in Warsaw analysed 22 gluten-free products and 19 naturally gluten-free grains and flours, for gluten content. Gluten content in the products ranged from 5.19 to 57.16 mg/kg. In the inherently gluten-free grains and flours, no gluten was detected in rice and buckwheat samples, but was detected in rice flakes (7.05 mg/kg) in pearl millet (27.51 mg/kg) and in oats (>100 mg/kg).Meanwhile, in the U.S., Tricia Thompson, a nutrition consultant specializing in gluten-free diets, arranged for gluten-testing of 22 retail samples of inherently gluten-free grains, seeds, and flours. She found contamination of 20 to 2925 ppm in seven of 22 samples, putting them over the proposed FDA limit of 20 ppm, with lower levels in some others. Both articles point to the importance of gluten-free certification even on foods that are naturally gluten-free, such as millet.
- **Millet consumption decreases triglycerides and C-reactive protein:** Scientists in Seoul, South Korea, fed a high-fat diet to rats for 8 weeks to induce hyperlipidemia,

then randomly divided into four diet groups: white rice, sorghum, foxtail millet and proso millet for the next 4 weeks. At the end of the study, triglycerides were significantly lower in the two groups consuming foxtail or proso millet, and levels of C-reactive protein were lowest in the foxtail millet group. The researchers concluded that millet may be useful in preventing cardiovascular disease.

- **Indian Diabetics Turn to Ragi (Finger Millet) and other Millets:** Diabetes is rising rapidly in India, as it is in many nations. Researchers at Sri Devaraj Urs Medical College in Tamaka, Kola, India decided to study the prevalence and awareness of diabetes in rural areas, in order to inform health policy. While there was widespread lack of awareness of the longterm effects of diabetes and diabetic care, common perception favored consumption of ragi, millet and whole wheat chapatis instead of rice, sweets and fruit.
- **Finger Millet (Ragi) Tops in Antioxidant Activity Among Common Indian Foods:** The National Institute of Nutrition in Hyderabad, India, carried out a study of the total phenolic content and antioxidant activity of various pulses, legumes and cereals, including millets. Finger millet and Rajmah (a type of bean) were highest in antioxidant activity, while finger millet and black gram dhal (a type of lentil) had the highest total phenolic content.

Millets Macronutrients:

- **Starch:** Millets are the primary source of carbohydrates in tropics and semi-arid tropics of India and sub-Saharan Africa. Grain starch typically comprises of two polymers, amylose (15–30%) and amylopectin (70–85%). Based on the amylose content, millet are classified into two major phenotypes, waxy and non-waxy. Waxy grains containing 0% amylose and nearly 100% amylopectin are glutinous in nature, easily digestible and therefore recommended as food for infants under 6 years of age. Waxy mutants in staple crops have evolved during the domestication of landraces by human selection. They have been identified in cereals and millets including rice (*Oryza sativa*), barley (*Hordeum vulgare*), sorghum (*Sorghum bicolor*), maize (*Zea mays*), foxtail millet (*S. italica*), proso millet (*P. miliaceum*), and barnyard millet (*Echinochloa* sp.). Amylose synthesis in millets is controlled by a single dominant waxy allele (Wx), while the recessive loss-of-function allele (wx) leads to the waxy phenotype with near 0% amylose content. In polyploid crops, mutations in different alleles of Wx loci produce low amylose, non-waxy and waxy phenotypes. Low amylose lines contain <3% amylose content due to the residual activity of non-mutant alleles. Precise identification of mutations in low amylose and waxy mutants have led to the development of waxy starch foods. Traditional breeding in millets for waxy trait is a labor intensive and time consuming process. It took nearly 15 years to transform waxy trait into non-waxy elite foxtail millet cultivar Yugu1 through cross breeding. With recent advancements in genome editing, application of programmable site-specific nucleases is a straightforward approach to induce genetic mutations in non-waxy elite cultivars for transforming them into waxy phenotypes. Thus genomics approaches will speed up the genetic improvement in millets in a cost effective manner to produce biofortified varieties.

- **Proteins and Amino Acids:** High quality proteins are essential for physical and mental well-being of humans, especially children. Cereal proteins deficient in essential amino acids like methionine, lysine, and tryptophan lead to malnutrition in developing countries. Cereal proteins contain 1.5–2% lysine and 0.25–0.5% tryptophan while estimated average requirement is 5% and 1.1% for lysine and tryptophan. Finger millet on the other hand is high in essential amino acids than cereals.

Conclusion:

Millets are highly nutritious, providing a rich source of protein, fibre, vitamins, and minerals. Millets do not contain gluten, which makes them an excellent choice for individuals who have celiac disease or are gluten intolerant. Additionally, millets have a low glycemic index, which means they release glucose slowly into the bloodstream, making them a good choice for people with diabetes. Millets are a sustainable crop that requires less water, pesticides, and fertilizers compared to other major cereals like rice and wheat. They can grow in harsh conditions and are resistant to pests and diseases, making them an ideal crop for small-scale farmers. The cultivation of millets can improve soil health and biodiversity, as they attract beneficial insects and birds. Millets can be a profitable crop for small-scale farmers, as they require less investment and can be grown in marginal lands. The production and consumption of millet can also benefit local communities and promote food security.

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Millets have a long shelf life and can be stored for several months, making them a reliable food source during times of scarcity. Millets are ancient grains with significant nutritional, environmental, and economic benefits. They are a sustainable and nutritious alternative to other grains and can play an important role in promoting food security and sustainability. As we move towards a more sustainable future, it is important to understand the potential of millets as a valuable food crop. By promoting the production and consumption of millet, we can create a more resilient and sustainable food system.