

Nutritional effects, Processing and Value addition of small millets: A review

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Abstract

There is an ever-increasing global population that requires adequate and healthy food in the face of climate emergencies and depleting natural resources. Millets can contribute to meet this demand. These grains can withstand harsh climate conditions, providing solutions to food security. Because millets are often the only crops that can be harvested during dry seasons, they can be a vital food source for populations at risk of food insecurity. For thousands of years, people have benefited from millets' nutritional properties. Millet is an abundant source of essential macro- and micronutrients, carbohydrates, protein, dietary fiber, lipids, and phytochemicals. The processing techniques have a significant impact on the nutrient content and digestibility of millets. This review focuses on the nutritional properties and processing of Indian millets. It also considers the impact of traditional and modern processing techniques on the nutritional properties of millet. An extensive literature review was carried out using research and review articles on millet processing techniques such as fermentation, germination, dehusking, extrusion, puffing, popping, milling, and so on. Germination and fermentation improved the overall nutritional characteristics of millets, whereas excessive dehusking, polishing, and milling reduced dietary fiber and micronutrients. Understanding the changes in millet's nutrient value caused by processing can assist the food industry, researchers, and consumers in selecting a suitable processing technique to optimise nutrient value, increase nutrient bioavailability, and help combat food and nutrition security.

Key words

Millets, nutrition, processing, bioavailability, food security

Introduction

Millets, which resemble tiny grains, are actually seeds from the family Poaceae. This little round whole grain is farmed mostly

in India and Nigeria, as well as other parts of Asia and Africa. They are called grains because they resemble grains in appearance. Small millets are our traditional crops. They are extremely nutrient-dense. Some of these are far more beneficial than others. They are Foxtail millet (*Setaria italica* L.), Barnyard millet (*Echinochloa esculenta* A. Braun), Kodo millet (*Paspalum scrobiculatum* L.), Browntop millet (*Urochloa ramosa* L.) and little millet (*Panicum sumatrense* Roth.). Various millets have been mentioned in some of the yajurveda texts, identifying foxtail millet (priyangu), barnyard millet (anu), and finger millet (syamaka), indicating that millet cultivation was happening around 1200 BCE in India. Millets are referred to as "yesterday's coarse grains and today's nutri-cereals." Millets are referred to as "future crops" because they require low maintenance, are drought resistant, and adapt well to the harsh environment of Asia and Africa's dry and semi-arid regions. They are also resistant to the majority of pests and diseases¹. India dominates the global production of millets with a total share of about 40.62% and an estimated production of about 10.91 million metric tonnes during 2018–2019. The majority of millets are three to five times more nutritious than most cereals (rice, *Oryza sativa*; wheat, *Triticum aestivum*; maize, *Zea mays*) in terms of vitamins, dietary fiber, proteins, and minerals (calcium and iron), and are gluten-free; hence, they are known as "superfoods"². Millets are a highly nutritious crop and contain

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considerable amounts of vitamins and minerals. Millets are a good source of energy, dietary fiber, slowly digestible starch, and resistant starch, and thus provide sustained release of glucose and there by satiety^{3,4}. Compared to cereals, millets are a good source of protein and sulphur-containing amino acids (methionine and cysteine) and have a better fatty acid profile^{3,5}.

Millets' high nutrient content provides multiple benefits, such as reducing the incidence of cancer, obesity, diabetes, cardiovascular diseases, gastrointestinal problems, migraines, and asthma. Consumption of millets helps manage hyperglycemia due to their low-glycemic index and high dietary fiber content, thus making millets a perfect food for the diabetic populace^{6,7}. Millet is now the sixth most important cereal grain in the world.

Therefore, millets play an important role in the modern diet as a potential source of essential nutrients, especially in underdeveloped and developing countries. Although millets have a diversified food value, their consumption, especially by the Indian populace, has not reached a significant level. Recently, these grains have been slowly fueling the start-up revolution to improve the availability of nutrient-rich food and create employment.

Millets are collected and processed prior to consumption to remove inedible portions, increase shelf life, and improve nutritional and sensory properties. To prepare millets for consumption, primary processing techniques such as dehulling, soaking, germination, roasting, drying, polishing, and milling (size reduction) are used. Simultaneously, millet-based value-added processed food are developed using modern or secondary processing methods such as fermenting, parboiling, cooking, puffing, popping, malting, baking, flaking, extrusion, and so on⁸. Despite the fact that these processing techniques aim to improve digestibility and nutrient bioavailability, a significant amount of nutrients are lost during subsequent processing⁹.

Types

Based on nutrient content¹⁰-

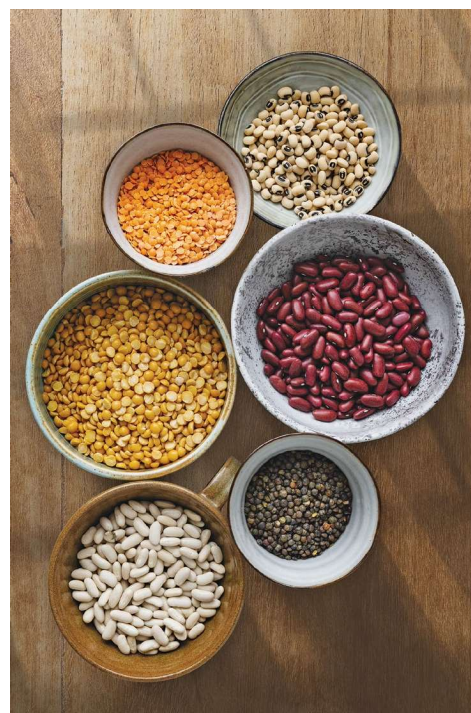
1. Positive grains: Foxtail millet, Barnyard millet, Kodo millet, Little millet, and Browntop millet
2. Neutral grains: Pearl millet, Finger millet, and Proso millet

Nutritional properties and health aspects of Small Millets¹⁰

Small millets like foxtail millet, brown top millet, little millet, barnyard millet, and kodo millet are a boon given to us by nature. These are the foods that have medicinal properties. They are, in fact, health capsules. By eating them regularly for 6 months to 2 years, everybody can get rid of their diseases. Small millets not only provide nutrients, but they remove disease-causing elements from our bodies and purify the body. Thus, they provide us with good health.

1) Foxtail millets (Kakum/Kagni)¹⁰

Foxtail millet has a sweet, bitter taste. It's a good food for diabetic patients. It reduces the cholesterol content in the body. It is rich in



antioxidants. There is a lot of fiber, protein, calcium, iron, manganese, magnesium, phosphorus, and vitamins, so they are good for children and pregnant women.

2) Barnyard millet (Sanwa)¹¹

Barnyard millets are sweet in taste. It is a good source of protein, carbohydrate, and fiber, and most notably, it contains more micronutrients (iron and zinc) than other major cereals. Highly digestible protein and is the least calorically dense. It is rich in iron and an excellent source of dietary fiber. So pregnant women and neonatal women are given food made of barnyard. This food maintains body temperature. It improves the resistance capacity of the body and is good for diabetes.

3) Kodo millet^{10,12}

Kodo millet is sweet, bitter, and acrid in taste. They are packed with the goodness of carbohydrates, proteins, and dietary fibers. It contains vitamins like niacin and riboflavin and minerals like calcium, iron, and phosphorus. It has high antioxidant activity due to the presence of phenolic compounds like vanillic acid, gallic acid, tannins, ferulic acid, et cetera. It keeps sugar and cholesterol levels in the blood in check. This is good for digestion. It prevents life-threatening diseases like cancer.

4) Little millet (Moraiyo)¹⁰

It is rich in fiber, minerals like magnesium, phosphorous, and iron, slow-digesting carbohydrates, and antioxidants. It is an ideal food for diabetics, as it prevents an abnormal spike in blood sugar levels. They help in curing diseases of the reproductive systems in both males and females. It also reduces PCOD in females. In males, sperm count can be increased by taking a little millet.

5) Browntop millet(Korle)¹³

It has rich proteins, healthy fats, carbohydrates, and dietary fiber content. They are also a treasure trove of essential nutrients, including calcium, iron, phosphorous, potassium, magnesium, manganese, copper, sodium, and zinc. Regular addition of this nutrient-rich grain lowers the risk of developing cardiovascular disease, diabetes, and digestive problems.

6) Pearl millet (Bajra)¹⁴

It contains most of the vitamin B and protein and is rich in other minerals such as iron, magnesium, calcium, phosphorus, manganese, potassium, calcium, and iron, among other cereal crops. It has the highest folic acid content among all the cereals, which makes it the diet of choice for pregnant women.

7) Finger millet (Ragi)¹³

It is an excellent source of vitamins A and B, minerals like phosphorus, calcium, iron, and potassium, dietary fiber, and antioxidants. It helps in conditions of anxiety, depression, and insomnia. It is also useful for migraines.

8) Proso millet (Chena/Barri)¹⁵

It is a rich source of essential phosphorous, iron, zinc, fiber, lecithin, vitamin B6, and antioxidants, which are essential for our day-to-day functioning. It is beneficial for the nervous system, for lowering cholesterol, for reducing the risk of diabetes, and for strengthening bones.

Antinutrient of millets

Anti nutrients are phyto chemical compounds that plants naturally produce to defend themselves. These anti nutritional factors interfere with nutrient absorption, resulting in decreased nutrient bioavailability and utilisation¹⁶. When consumed raw, anti nutrients and chemical compounds may be harmful or even cause health problems in humans, such as micronutrient malnutrition, nutritional deficiency, and bloating. Anti nutrients found in plant-based foods include tannins, phytates, oxalates, trypsin, and chymo trypsin inhibitors¹⁷. The need to eliminate anti nutrients is fulfilled by pretreatment or processing techniques for food grains, such as debranning, soaking, germination, fermentation, and autoclaving. These methods add value to food by enhancing the bioavailability of a few elements, such as Ca, Fe, and Zn, and also the protein absorption.

Small millet processing as a small-scale industry

As people become more health conscious, there has been an increase in interest in small millets, which are nutritious grains. As global food security is jeopardized, effective use of available millet crops to develop an affordable, palatable, and nutrient-rich product is critical. Millet grains must be processed in order to remove the inedible portions and transform them into a cooked and edible form. As a result, processing is an important task because it increases nutrient bioavailability and organoleptic properties while decreasing antinutrients¹.

However, not all small millets can be cooked directly. Furthermore, people of the current generation are unable to consume food items from previous generations. As a result, if small millets are processed and made suitable for making various types of food items, their use will increase. With this in mind, machines for de-husking, grinding, producing flakes, and popping and puffing millets are developed. Various methods are developed to produce various types of food items from processed millets¹⁰.

Processing may be of two types, namely, primary and secondary processing. Processes such as cleaning, washing (soaking/germination), dehulling, milling (into flour and semolina), and refining to remove the undesired seed coat and anti nutritional factors are termed primary processing, while secondary processing involves converting primary processed raw materials into “ready-to-cook” (RTC) or “ready-to-eat” (RTE) products by flaking, popping, and extrusion¹.

These processing techniques aim to convert grains into edible forms, with an extended shelf life, improved texture, specific flavor, taste, as well as improved nutritional quality and digestibility¹⁸.

1) Primary processing¹⁰

- a. Cleaning – It is to remove unwanted impurities and broken grains, using vibratory sieves, aspirators and specific gravity separators.
- b. Washing – It is a process done to prepare it for milling. Cleaned grains

are conditioned, with the addition of water, to soften the endosperm (the inner part of the seed). During washing, the surface of the grain is cleaned; heavy and light impurities, peels, and microorganisms are removed.

- c. Dehusking – Husk can be removed with the machinery of rice mills. The removed husk can be blown out with centrifugal shellers. After the husk is removed, bran can be removed in horizontal emery cones. It improves product appearance, texture, quality, palatability, and digestibility.
- d. Milling - Milling separates the grain into three components: the germ, endosperm and seed coat. It is the process of cleaning, tempering, and grinding cereal grains products.
- e. Fermentation – Millets are soaked in water for 72 hours to ferment, then strained and dried, resulting in decreased antinutrients, increased nutrients, and phytochemicals.
- f. Germination – Millets are sprouted at room temperature for 36 to 72 hours, resulting in decreased carbohydrates and fats and increased protein content, dietary fiber, phytochemicals, and minerals.

2) Secondary processing¹⁰

- a. Flaking: In this process, the grain has to be soaked and boiled, and then it has to be pressed hard. The advantage that flaked grain has over unprocessed grain is that it cooks at a much faster rate. Grain flakes are also known as rolled grains.
- b. Puffing or parching is a simultaneous starch gelatinization and expansion process during which grains are exposed to high temperatures for a short time. To make parched corn, grains should be dried till the moisture content comes to 16% and exposed to 230°C for a few seconds in a minute.
- c. Extrusion: It is a thermo-mechanical refinement process in which the raw material to be extruded, such as grain or proteins, is pressed through a previously-defined opening, using pressure and temperature.

The Effect of Millet Processing on Nutritional Properties

1) Proteins

Millets are a good source of protein and are popular among vegans. When compared to animal proteins, they are regarded as excellent plant proteins with negligible amounts of saturated fat. Antinutrients inhibit protein digestibility; therefore, lowering antinutrient levels is critical. Simple techniques such as dehulling, milling, soaking, and heating reduce antinutrient levels while increasing *in vitro* protein digestibility¹⁹.

Decortication removes about 12% to 30% of the outer husk, bran, and germ portion of grains, limiting the significant loss of proteins and amino acids such as histidine, lysine, and arginine²⁰.

2) Carbohydrates

Carbohydrates in the millets range from 60–75%, with foxtail millet containing the least carbohydrate and little millet containing the most. Starch, like other cereals, is the main carbohydrate in millets. The amount of available carbohydrates in food grains is affected by various domestic processing and cooking methods such as soaking, sprouting, pressure cooking, autoclaving, and so on. The germination and fermentation processes improve the carbohydrate digestibility by breaking down the complex starch into simple soluble sugars. This shows the importance of germination and fermentation in the development of energy-dense, easily digestible food products. Parboiling can significantly reduce starch digestibility and therefore be utilised to formulate products for metabolic diseases such as diabetes and obesity¹.

3) Dietary fibers

The millet bran fraction is a major and abundant source of dietary fiber, which is characterised as complex polysaccharides. Therefore, removal of the bran fraction during decortication or dehulling results in a substantial reduction in the fiber component. It was reported that dehulling by about 12% to 30% to remove the kernel is suitable for millet grains as it does not result in significant loss of fiber. However, dehulling of grains beyond 30% results in a substantial loss of dietary fiber. For a healthy millet diet, it is important to discourage millers from polishing millets and to advise consumers to prefer whole millets (unpolished) and their by-products¹⁸.

4) Vitamins

Millets, when polished or debranched contain a lower nutritional value since the bran and germ components of refined millet flour are eliminated, resulting in a loss of vitamins. Millets are considered superior to wheat, sorghum, and maize in terms of vitamin content and other nutrients that include fats, proteins, and minerals. Vitamins and minerals

are naturally accumulated in the aleurone, germ, and pericarp. The availability of important vitamins can be improved by germinating the millets and developing by-products from germinated millets²¹.

5) Minerals

Millets are an abundant source of minerals such as K, Mg, Fe, Ca, and Zn, along with vitamins that are mainly accumulated in the aleurone, germ, and pericarp. Soaking millet grains prior to cooking helps to reduce antinutrients while also improving mineral bioavailability¹.

6) Fats

Fats are necessary for calorie supply, brain development, and the absorption and transport of vitamins A, D, E, and K in the body. The germination time has an impact on fat content. Simple processing techniques such as soaking, germination, and malting could be the ideal option for manufacturers to develop low-fat food products from millets. The high temperature processing would damage the fat quality and might reduce the taste and flavour of the processed foods²².

Conclusion

Millets have a similar energy content to cereals. Furthermore, because of their high content of fiber, minerals, vitamins, macro- and micronutrients, and phytochemicals, they provide more

significant health benefits and can aid in the treatment of chronic diseases. Making millets a regular part of the diet can provide an inexpensive, complete, and healthy meal. It was discovered that the dietary fiber, mineral, and vitamin content of most millets improved during germination and fermentation. Simple processing techniques like soaking, germination, malting, and fermentation can help combat protein-energy malnutrition by increasing protein digestibility and mineral bioavailability. On the other hand, decortication, dehulling, milling, and extrusion resulted in a decrease in total proteins, total dietary fiber, and micronutrients. Thus, caution should be exercised during millet decortication, as excessive dehulling can result in lower fiber content and micronutrient loss due to the loss of nutrient-rich bran and germ portions. Looking at the variability of the impact of processing on the nutritional characteristics of millets, there is still a need to focus on optimising minor millet processing techniques to make them more acceptable without compromising the health benefits.

References:

- Rao, D.B.; Malleshi, N.G.; Annor, G.A.; Patil, J.V. Nutritional and health benefits of millets. In *Millets Value Chain for Nutritional Security: A Replicable Success Model from India*; Indian Institute of Millets Research (IIMR): Hyderabad, India, 2017; p. 112.
- Ashoka, P.; Gangaiah, B.; Sunitha, N. Millets-foods of twenty first century. *Int. J. Curr. Microbiol. Appl. Sci.* 2020, 9, 2404–2410.
- Nithyanantham, S.; Kalaiselvi, P.; Mahomoodally, M.F.; Zengin, G.; Abirami, A.; Srinivasan, G. Nutritional and functional roles of millets—A review. *J. Food Biochem.* 2019, 43, 1–10.
- Annor, G.A.; Tyl, C.; Marcone, M.; Ragaee, S.; Marti, A. Why do millets have slower starch and protein digestibility than other cereals? *Trends Food Sci. Technol.* 2017, 66, 73–83.
- Anitha, S.; Govindaraj, M.; Kane-Potaka, J. Balanced amino acid and higher micronutrients in millets complements legumes for improved human dietary nutrition. *Cereal Chem.* 2020, 97, 74–84.
- Nainwal, K. Conservation of minor millets for sustaining agricultural biodiversity and nutritional security. *J. Pharmacogn. Phytochem.* 2018, SP1, 1576–1580.
- Gowda, N.N.; Taj, F.; Subramanya, S.; Ranganna, B. Development a table top centrifugal dehuller for small millets. *AMA Agric. Mech. Asia Africa Latin Am.* 2020, 51, 72–78.
- Birania, S.; Rohilla, P.; Kumar, R.; Kumar, N. Post harvest processing of millets: A review on value added products. *Int. J. Chem. Stud.* 2020, 8, 1824–1829.
- Nazni, S.; Devi, S. Effect of processing on the characteristics changes in barnyard and foxtail millet. *J. Food Process. Technol.* 2016, 7, 1–9.
- Dr. khadar vali; siridhanyalu wholesome health with small millets; Rythu Nestham Publications; first edition, June, 2019
- <https://www.medindia.net>
- <https://pharameasy.in>
- <https://m.netmeds.com>
- <https://www.medindia.net>
- <https://www.zizira.com>
- Bora, P.; Ragaee, S.; Marcone, M. Characterisation of several types of millets as functional food ingredients. *Int. J. Food Sci. Nutr.* 2019, 70, 714–724.
- Popova, A.; Mihaylova, D. Antinutrients in plant-based foods: A Review. *Open Biotechnol. J.* 2019, 13, 68–76.
- Yousaf, L.; Hou, D.; Liaqat, H.; Shen, Q. Millet: A review of its nutritional and functional changes during processing. *Food Res. Int.* 2021, 142, 110197.
- Sharma, N.; Niranjani, K. Foxtail millet: Properties, processing, health benefits, and uses. *Food Rev. Int.* 2018, 34, 329–363.
- Rani, S.; Singh, R.; Sehrawat, R.; Kaur, B.P.; Upadhyay, A. Pearl millet processing: A Review. *Nutr. Food. Sci.* 2018, 30–44.
- Konapur, A.; Gavaravarapur, S.R.M.; Gupta, S.; Nair, K.M. Millets in meeting nutrition security: Issues and way forward for India. *Indian J. Nutr. Diet.* 2014, 51, 306–321.
- Rani, S.; Singh, R.; Sehrawat, R.; Kaur, B.P.; Upadhyay, A. Pearl millet processing: A Review. *Nutr. Food. Sci.* 2018, 30–44.