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Nutrimillets as a Potential Source of Health Supplements: A Review

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ABSTRACT

Minor millets, often called "orphan crops" or "lost crops," are small-seeded grains that come from plants in the Poaceae family. Nutricereals are the food products of commercial importance prepared from these small-seeded millets. These nutricereals have a great potential to replace the staple food crops since they are an excellent source of starch, protein, energy, essential fatty acids, minerals, i.e., potassium, calcium, zinc, iron, magnesium and especially sulfur containing amino acids like methionine and cystine, B group vitamins, linoleic acid, tocopherols, phytochemicals and dietary fibers. Small-seeded millet-based fermented food shows high water absorption capacity, dispersibility, flowability and wettability, indicating good reconstitution properties. Nutraceuticals prepared from small-seeded millets have antioxidant properties, preventing health problems such as blood pressure, constipation, cholera, fever, cardiovascular and risk of heart diseases, thyroid, cancer and tumors.

Keywords Millets, Health, Antioxidants, Nutraceuticals, Micronutrients.

INTRODUCTION

Minor millets, also called Miracle grains, are an area group of small-seeded crops and while nutricereals are foodstuffs prepared from these small-seeded millets of the 30 species, five species of grasses from 20 genera are well known as minor millets. These crops are short-lived and resource-efficient because they use little water and fertilizer and emit little CO_2 during growth. Millets are locally grown health-food crops that have extra-health benefits due to being a good source of gluten-free protein, high fiber content, low glycemic index and rich in bioactive substances. The major and minor nutrients as well as dietary fiber of nutrimillets are good for celiac sufferers, and millets free from gluten can be used as a substitute for wheat or other gluten-containing grains

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(Singh *et al*. 2022). These millets are a better option than wheat and rice because these comprise nutrients with a high number of polysaccharides, low glycemic index, complete proteins, good-quality invisible fat, dietary fiber, and noticeably higher amounts of nutrients such as calcium, potassium, magnesium, iron, manganese, zinc, B-group vitamins and bioactive phytochemicals (Sanyal *et al.* 2021). Millets are rich in nutrients and antioxidants, thus, they are considered to be the best nutritive food.

Superiority of millets over wholegrains

The bioactive composition and Hypoglycemic profile make the millets as efficient ingredients for new food production (Sharma *et al.* 2021). The plant resources are being depleted at a faster rate, thus, there is a essential to discover new substitutes to human food. Many underutilized crops, with potential to replace main food crops, are consumed in villages and tribal areas. Small-seeded millets are a major underutilized crop with nutritional potential (Saini *et al.* 2021). They include vitamins and rare minerals, especially sulfur-containing amino acids and phytochemicals, hence, they have been used for the preparation of fortified nutricereals. Utilization of millet in combination with major food crops has developed an emerging zone in the food processing industries for food alternatives (Lalitha *et al.* 2018). Millets contain more nutrients than rice and wheat and they have huge potential to provide food, nutrition, fodder, fiber, health, livelihood, and ecology. In view of all these qualities, they are called as Miracle Grains (Uma and Shivakumar 2020). Many people use them as staple food in world, thus, millets are occasionally called as Orphan Crops or even Lost Crops (Shaikanth *et al.* 2022). The processing of antinutritional factors present in millets, namely tannins, phytic acid, trypsin inhibitors and protease inhibitors contribute many health benefits. They offer various health benefits, including helping to lower blood sugar levels, support healthy blood pressure, reduce the risk of cardiovascular diseases, and aid in managing thyroid function (Bakshi *et al.* 2025). Considering the nutritional value of millet, various millet-based food products, such as bread, snacks, baby foods, millet wine, porridge, fast foods and millet nutrition powder, can be prepared (Bhatt *et al.* 2023).

Classification of millets

Based on the grain size, millets have been classified as major millets and small grain millets. According to Ratnavathi and Tonapi (2022), sorghum, pearl millet, finger millet, foxtail millet, Kodo millet, little millet, Proso millet and barnyard millet were included in the millet group. The major millets include sorghum and pearl millet, whereas the small millets include finger millet, foxtail millet, barnyard millet, little millet Kodo millet, and Proso millet. Singh *et al.* (2020) reported that finger millet (Mandua), foxtail millet (Kangni), little millet (Kutki), Kodo millet, barnyard millet (Jhangora), and Proso millet (Cheena) are the most important cultivated small millet species.

Nutritional importance of minor millets

Millets are also referred to as Cereals of the Future owing to their sustainability and environmental impact (Sharma and Gujral 2019). They are high in macro- and micronutrients, and their mineral and essential amino acid profile overtake other important grains such as wheat and rice (Maitra *et al.* 2020).

Millets are also rich in magnesium, calcium, manganese, tryptophan, phosphorus, B complex vitamins and fiber. The antioxidant property of these micronutrients are essential for the human body (Singh *et al.* 2020). These millets are highly nutritious owing to the occurrence of starch, protein, dietary fiber, and vital minerals, i.e. as potassium, calcium, zinc, iron, magnesium, and B group vitamins (Anitha *et al.* 2021). The dietary fibers, minerals (calcium, potassium and magnesium), and phenolic substances present in millet make them superior to other cereals (Himanshu *et al.* 2021). They are highly nutritious, non-acid-forming, and gluten-free (Saini *et al.* 2021). The UN General Assembly designated 2023 as the International Year of Millets to emphasize the importance of these nutrient-dense crops (Poshadri *et al.* 2023). Millets, particularly finger millet or ragi, are an excellent source of calcium, containing around 364 mg per 100 grams nearly ten times the amount found in wheat or rice (Achinna *et al.* 2023).

Health benefits

The significance of millets in health is shown in Fig. 1. Millet flour can be incorporated into the diets of diabetic and celiac patients due to gluten-free nature (Bhatt *et al.* 2023). The consumption of millets prevents post-translational diseases such as cancer and celiac (Sanyal *et al.* 2021). Medical practitioners have noticed fewer cases of duodenal ulcers among regular millet consumers (Patroti *et al*. 2017). They provide sustenance for intestinal bacteria as a probiotic source (Mir *et al.* 2019). Traditional Chinese medicine regards millet as helpful in alleviating nausea and dysentery. Millet porridge is believed to support digestive health by harmonizing the stomach and intestines, boosting energy in cases of deficiency, and enhancing appetite. It assistances in treating indigestion, gastric and digestive ulcers (Lin *et al.* 2020). The high fiber profile of millet improves health and nutrition (Saini *et al.* 2021). The consumption of millets or whole grains with pulses is associated with a reduction in non-communicable diseases, as they possess dietary fiber, minerals, phenolics, and antioxidants (Mounika and Hymavathi 2021). The dietary fiber of millets can bulk up and absorb more water (Chaturvedi *et al.* 2022). Food prepared from millet moves through the intestines more slowly, thereby reducing inflammatory bowel disease (Saini *et al.* 2021).

Millets also help in controlling blood sugar, thyroid and blood pressure, in spite of these significant properties, the consumption of millets is still declining. The oil of millet is rich in tocopherols and linoleic acid with antioxidative properties (Sanyal *et al.* 2021). Numerous studies have reported that Polyphenols found in millets possess antioxidant, anti-cancer, anti-inflammatory, antiviral and neuroprotective properties. These compounds contribute to the prevention and management of various health conditions, including cancer, heart disease, diabetes, hypertension, high cholesterol, inflammatory disorders, metabolic syndrome and neurodegenerative diseases like Parkinson's (Anitha *et al.* 2022). The antioxidants of millets help flush out harmful free radicals from the body and maintain several health issues in the bay. Millets are also recognized as immunity boosters (Shaikanth *et al*. 2022).

Processing techniques like soaking, germination, fermentation and puffing improve the nutritional quality of millets. These methods enhance digestibility and lower the levels of antinutrients present in the grains (Handa *et al.* 2017). Multiple studies have shown that millet provides notable protective effects in relation to *Lacto bacillus* (Forgani *et al.* 2018).

Diabetes

Millets rich in fiber cause slow release of glucose into

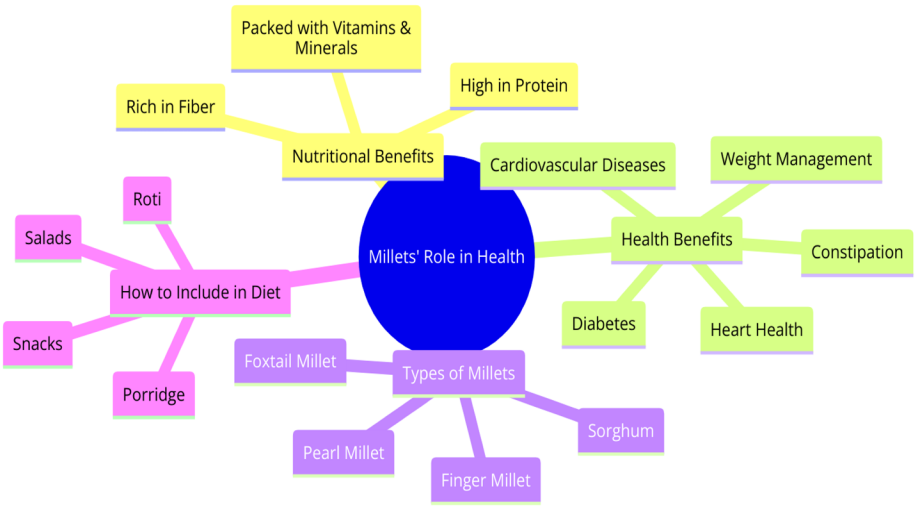

Fig. 1. Millet's role in health.

the bloodstream during digestion, hence, hyperglycemia (diabetes) has been reported among regular millet consumers (Patroti *et al*. 2017). Small millets have great potential for use in different food schemes due to their nutritional quality and economic importance and are considered to have therapeutic value against illnesses such as diabetes (Karuppasamy *et al.* 2020). Millets have a low glycemic index (GI) and gluten-free property which is best suited for patients (Kumar *et al.* 2021). The consumption of millet helps to prevent post-translational diseases such as diabetes (Sanyal *et al.* 2021). The consumption of millet rich in fiber decreases the susceptibility of diabetes and slows down the absorption and digestion processes (Singh *et al.* 2022).

Constipation

Epidemiological studies reported 14% global constipation (Camilleri *et al.* 2017). This rate increases modestly with age. It is almost double as high (17.4 vs. 9.2%) in females than in males (Le-Leiko *et al.* 2020). The recent studies have confirmed that the intestinal microbiota plays an important role in health and affects many physical activities including gastrointestinal activity (Barbara *et al.* 2016, Dimidi *et al.* 2017). Diet plays a crucial role in shaping the composition of the microbiota (Jia *et al.* 2020). Gut activity is influenced by gastrointestinal microbiota, nervous and immune systems, fermentation products and mucus secretion. Chronic constipation is a characteristic indication of gut motility disorders (Scott *et al.* 2021). Millet grains contain approximately 65% carbohydrates, in the form of dietary fiber and non-starchy polysaccharides, which help in the prevention of constipation (Patroti *et al*. 2017). Constipation extremely affects life and work productivity and poses a substantial medical and economic burden, more so than irritable bowel syndrome and type 2 diabetes (Tomita *et al.* 2021).

Dietary fiber promotes health by the improving intestinal bacterial flora (Gill *et al.* 2021). Millet porridge contains 23.86% amylose, which serves as a key component in the formation of resistant starch and increases *Butyrivibrio*, *Desulfovibrio* and *Clostridium cellulolyticum* bacteria, which can degrade hemicellulose and cellulose. It also enhances the levels of short-chain fatty acids like acetate and butyrate in the colon (Palevich *et al.* 2019). Millet porridge helps in increasing water content of feces and prevents constipation, shortening the period of the initial melena excretion, promoting gastric emptying, refining the rate of gastrointestinal impulsion, increasing the levels of Bifidobacterium and *Lacto bacillus* and decreasing the levels of *Bacteroides, Enterococcus* and *Escherichia coli* in the intestine. These results illustrate that millet porridge can modify the content of intestinal flora and quicken intestinal motility (Chen *et al.* 2022).

Cardiovascular health

Millets are rich in potassium and magnesium, which help lower blood pressure and decrease the risk of heart attacks, particularly in cases of atherosclerosis, by functioning as natural vasodilators. Millets also favor the development of cell structures due to phosphorus richness. Reducing blood pressure and optimizing the circulatory system are the best ways to protect cardiovascular health (Kimeera and Sucharitha 2019). Millets containing a high proportion of non-starchy polysaccharides and dietary fiber help lower blood cholesterol, thus lowering the frequency of cardiovascular disease (Patroti *et al.* 2017). Niacin from millet can help decrease cholesterol in the blood stream ; thus, regular consumption of whole grains rich in fiber decreases cardiovascular disease (Singh *et al*. 2022).

Sorghum (sorghum bicolor)

Sorghum is considered a promising food security crop and a remarkably rich source of bioactive components, including phenolic acids, flavonoids and tannins (Sleem *et al.* 2024). Sorghum is an excellent source of fat-soluble vitamins such as D, E and K, as well as B-complex vitamins including thiamine, riboflavin and pyridoxine, though it does not contain vitamin B12 (De Morais-Cardoso *et al*. 2017). Various anthocyanins have been identified by Zhu (2018) in sorghum including 5-methoxyluteolinidin (0 to 154 mg/g), luteolinidin (ranging from 0 to 282 mg/g), apigeninidin (0 to 166 mg/g) and 7-methoxy-apigeninidin (0 to 137 mg/g). Sorghum's potential health benefits are largely attributed to its abundance

of phytochemicals, including tannins, phenolic acids, anthocyanins, phytosterols, and polycosanols. These compounds are rich in bioactive phenolics such as ferulic acid, gallic acid, vanillic acid, luteolin, apigenin, and 3-deoxyanthocyanidins (Xu *et al.* 2021).

Sorghum provides slow-digesting starch, which may benefit satiety and attenuate glycemic response. Sorghum also contains a unique array of polyphenols, which are associated with protection against chronic diseases linked to oxidative stress and inflammation (Awika 2016). Sorghum possesses stronger antioxidant properties compared to many other cereals, which is linked to a lower risk of developing certain cancers, cardiovascular conditions, diabetes and obesity (de Morais-Cardoso *et al.* 2017). Phenolics in sorghum exhibit numerous protective effects against multiple chronic diseases. Sorghum phenolics can maintain gastrointestinal homeostasis and enhance the microbial diversity and richness. Furthermore, sorghum phenolics exhibited GI anticancer effects. Sorghum intake reduces intestinal oxidative stress and inflammatory mediators in humans (Sleem *et al.* 2024).

Proso millet (*Panicum miliaceum* L.)

It is regarded as the most extensively grown millet crop in regions such as the Northwestern United States, Northern China, Eastern Asia, Mongolia, Manchuria, Japan, India and parts of Eastern and Central Russia (Zhang *et al.* 2016). This crop is known for its resilience to drought and its ability to thrive in high-temperature conditions (Habiyaremye *et al.* 2017) and Proso millet is a nutrient-dense grain, packed with minerals, dietary fiber, polyphenols, proteins, and essential vitamins. Being naturally gluten-free, it is well-suited for individuals with gluten intolerance. It contains a significant amount of lecithin, which contributes to maintaining a healthy nervous system. Additionally, it is a rich source of vitamins such as niacin, B-complex vitamins and folic acid, along with key minerals like phosphorus, calcium, zinc and iron and essential amino acids including methionine and cysteine. It possesses a low glycemic index and reduces the danger of type-2 diabetes (Das *et al.* 2019). Proso millet in regular diets can lower cholesterol, TNFα, phytate, and increase HDL and adiponectin levels, which can reduce the risks of hormone-dependent cancers, CVD, and breast cancer (Habiyaremye *et al.* 2017). Proso millet contains beta-carotene, which is converted into vitamin A in the body. This contributes to health, immune function and cell growth (Ahamed *et al.* 2019).

Pearl millet (*Pennisetum glaucum* (L.)

It is called as *Bajra*, and is mainly cultivated in Gujarat, Rajasthan, Maharashtra, Haryana and Uttar Pradesh. The iron content in pearl millet (6.42 mg/100 g) was higher than that in other staple cereals. It comprises crude fiber, dietary fiber, minerals, and vitamins (Poshadri *et al.* 2019). Pearl millet has been labeled as a nutricereal due to antioxidant properties and high fatty acid, protein, fiber, and mineral contents (Kumar *et al.* 2018). Pearl millet is also nutritionally superior and rich in micronutrients, and can mitigate malnutrition and hidden hunger (Satyavathi *et al.* 2021). Vitamin E and B-complexes are also present along with folate, magnesium, iron, copper and zinc. It has more energy than any other millet and contains a huge quantity of calcium and unsaturated fats (Saini *et al.* 2021). Insoluble fiber helps in the reduction of excessive bile juice in the human digestive tract because excessive bile juice in the tract leads to gallstones (Shweta 2015).

Foxtail or Italian millet (*Setaria italica*)

Foxtail millet (*Setaria italica* L.) has been cultivated in China for over 8,000 years and is primarily found in Northern regions of China and India (Sachdev *et al.* 2021). It is also commonly known around the world as Italian millet or German millet (Senevirathne *et al.* 2021), and is extensively cultivated in the semi-arid and arid areas of Asia and Africa, as well as in some other economically developed countries of the world where it is more commonly used as feed for birds (Sharma and Niranjan 2017). The yellow-seeded cultivars of foxtail are medicinally used as astringent, digestive, emollient and stomachic agents, while the white-seeded cultivars of foxtail millet act as refrigerants and is utilized in managing conditions like cholera and fever and its green seeds are known for their diuretic properties. It is also used to treat dyspepsia and poor digestion. Foxtail millet, with a

sweet nutty flavor delivering a plethora of nutrients, is easy to digest and is allergy-free. Its protein content is twice as high as that of rice. Minerals such as iron and copper are also present in it (LaLonde and Jadeja 2018). Foxtail millet has many health benefits, including antihypertensive (Chen *et al.* 2017). It is considered as healthy food as encourages gastrointestinal health in China. Millets provide gastric mucosal protection (Lin *et al.* 2020).

Finger millet (*Eleusine coracana*)

Finger millet is commonly referred to as small millet (Ragi). This salt-tolerant plant is regarded as a major cereal crop following maize and is extensively cultivated in regions such as Eastern and Central Africa, India and Uganda (Satish *et al*. 2016). It is unique among cereal crops, namely barley, rye and oats, with higher nutritional content and has outstanding properties as a subsistence food crop, which is rich in protein (6–13%), minerals 2.5–3.5%, calcium (0.34%), dietary fibers (18%), phenolics (0.3–3%), and phytates (0.48%) (Chandra *et al.* 2016). Finger millet flour is used as a vehicle for zinc fortification to derive an additional amount of bio-accessible zinc with good storage stability and zinc deficiency combating power. They are tasty, with a nut-like flavor, and are high in B-complex vitamins, including niacin, thiamine, and riboflavin (Patroti *et al.* 2017). Finger millet is popular because of its nutritional benefits. Its flakes are mostly used in baby food items because of presence of minerals, i.e., calcium, iron, and zinc (Kumar *et al.* 2020) and have high antioxidant activity; however, they contain less protein (6-8%) and fat (1.5-2%). Its grains have excellent malting properties and are widely known for their used as weaning food (Ambre *et al*. 2020).

Barnyard millet

Echinochloa esculenta is cultivated in the marginal lands of Andhra Pradesh and Uttarakhand, and is the richest source of calcium, which is about 10 times that of rice or wheat. The iron content in barnyard millet is also higher (5.0 mg/100 g) than that in other staple cereals. It comprises minerals, vitamins, crude fiber, and dietary fiber (Poshadri *et al.* 2019), thus, its intake reduces blood glucose and serum cholesterol levels. Barnyard millet contains approximately 15.6 to 18.6 mg of iron per 100 grams of grain and the grain has a relatively low phytate content, ranging from 3.30 to 3.70 mg per 100 grams (Renganathan *et al.* 2017, Panwar *et al.* 2016).

Little millet (*Panicum sumatrense*)

Little millet is tetraploid species (2n = 4x = 36) of minor millets and is cultivated for its grain (Das *et al.* 2020). The crop is loaded with nutrients, such as dietary fiber, protein and minerals like iron 32.20 ppm and zinc 32.40 ppm (Vetriventhan *et al.* 2021). Little millet is a nutrient-dense gluten-free grain. It contains fiber, minerals, and antioxidants, offers a range of health benefits, making it suitable for individuals with gluten sensitivity or celiac disease. Its consumption reduces diabetes, cardiovascular disease and cancer, aiding digestion and blood sugar regulation (Singh and Chaudhary 2023).

Buckwheat millet (*Fagopyrum esculentum* Moench)

Buckwheat is most popular millets and is called as Kuttu. It is diabetic-friendly and frequently consumed during the fasting period of Navratra. It is beneficial for cardiovascular health, for those who wish to lose weight, and for those suffering from blood pressure, gallstones, asthma, and breast cancer. Buckwheat is a storehouse of gluten-free nutrients, with profuse health benefits because of the presence of various bioactive compounds such as fatty acids, polyphenols, flavonoids, proteins, polysaccharides, saponins, and trace elements present in it (Choton *et al.* 2021). Buckwheat is a gluten-free crop known to contain carbohydrates, dietary fiber, proteins, omega 3, omega-6, important amino acids, phenolics and vitamins. Moreover, it also comprises essential elements, such as zinc, copper, iron, phosphorus, manganese and magnesium, as well as a good quantity of antioxidants and tannins (Ahmad *et al.* 2018). The proteins in buckwheat have high biological value because of a well-balanced amino acid with a good quality of lysine (Mahata 2018). Buckwheat and millets are underutilized food crops that have received widespread attention, particularly with regard to the development of nutrient-rich health foods, owing to their numer-

ous nutritional, medicinal and antioxidant properties (Kumari *et al*. 2020).

Amaranth (*Amaranthus caudatus* L. & *Amaranthus cruentus* L.)

Amaranth has regained attention as a valuable food crop due to its resilience to drought, heat, pests and diseases, along with its impressive nutritional profile found in both its seeds and leaves. The grain is rich in dietary fiber and contains minimal saturated fats. Its oil is particularly notable for including beneficial fatty acids such as oleic, linoleic and linolenic acids. Additionally, the lipid portion of amaranth is rich in antioxidants like tocopherols, flavonoids, anthocyanins and other phenolic compounds, which help neutralize lipid peroxyl radicals. Its seeds are high in protein content and contain essential amino acids that are beneficial for human health. It possesses high levels of lysine and cysteine (Joshi and Verma 2020). The protein content in its grains has been claimed to be very close to the levels recommended by the FAO/WHO because of the balance in the amino acid profile. The protein content in its leaves varies from 17.2 to 32.6% based on the dry weight for various species (Murya and Pratibha 2018). Amaranth grains have been found to provide alternative ingredients for the development of food products other than wheat and other cereals for celiac patients (Martínez-Villaluenga *et al.* 2020).

REFERENCES

Achinna, P., Deshpande, H. W., & Kshirsagar, R. B. (2023). The international year of millets 2023, millets as nutri-cereals of 21st centenary for health and wellness. *Agriculture Association of Textile Chemical and Critical Reviews Journal,* 7—12. doi.org/10.58321/AATCCReview.2023.11.01.02

Ahmad, M., Ahmad, F., Dar, E. A., Bhat, R. A., Mushtaq, T., & Shah, F. (2018). Buckwheat (*Fagopyrum esculentum*)- A neglected crop of high altitude cold arid region of Ladakh: Biology and nutritive value. *International Journal of Pure and Applied Bioscience*, 6, 395—408.

Ahamed, N., Varghese, S., & Nagarajan, R. (2019). Millets: Nutritional composition, health benefits and potential applications. *Critical Reviews in Food Science and Nutrition*, 59, 3469—3489. https://pubmed.ncbi.nlm.nih.gov/36219789/ doi:http://dx.doi.org/10.18782/2320-7051.6001

Ambre, P. K., Sawant, A. A., & Sawant, P. S. (2020). Processing and value addition: A finger millet. *Journal of Pharmacognosy and Phytochemistry*, 9, 375—380.

Anitha, R., Bhavani, G., & Malini, C. H. (2022). Nutricereals a magic food-know how ! Just Agriculture Multidisc. E-Newsletter, 2, 2582—8223. (e-ISSN: 2582-8223).

Anitha, S., Kane-Potaka, J., Botha, R., Givens, D. I., Sulaiman, N. L. B., Upadhyay, S., Vetriventhan, M., Tsusaka, T. W., Parasannanavar, D. J., Longvah, T., Rajendran, A., Subramaniam, K., & Bhandari, R. K. (2021). Millets can have a major impact on improving iron status, hemoglobin level, and in reducing iron deficiency anemia-a systematic review and meta-analysis. *Frontiers Nutrition,* 14 (8), 725529. https://doi.org/10.3389/fnut.2021.725529.

Awika, J. M. (2016). Sorghum: Its Unique Nutritional and Health-Promoting Attributes. *Gluten-Free Ancient Grains*, pp, 21—54. https://doi.org/10.1016/B978-0-08-100866-9.00003-0

Bakshi, S., Mishra, A., & Kaushik, R. (2025). Antinutritional factors in millets: Health benefits and adverse effects in human health. *Plant Archieves*, 25 (1), 809—815. DOI URL: https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-1.107

Barbara, G., Feinle-Bisset, C., Ghoshal, U. C., Quigley, E. M., Santos, J., Vanner, S., Vergnolle, N., & Zoetendal, E. G. (2016). The intestinal microenvironment and functional gastrointestinal disorders. *Gastroenterology*, 150, 1305—1318. doi:10.1053/j.gastro.2016.02.028

Bhatt, D., Rasane, P., Singh, J., Kaur, S., Fairos, M., Kaur, J., Gunjal, M., Mahato, D. K., Mehta, C. M., Avinashe, H., & Sharma, N. (2023). Nutritional advantages of barnyard millet and opportunities for its processing as value-added foods. *Journal of Food Science and Technology*, 60, 2748—2760. doi:10.1007/s13197-022-05602-1

Camilleri, M., Ford, A. C., Mawe, G. M., Dinning, P. G., Rao, S. S., Chey, W. D., Simrén, M., Lembo, A., Young-Fadok, T. M., & Chang, L. (2017). Chronic constipation. *Nature Reviews Disease Primers*, 3, 17095. doi:10.1038/nrdp.2017.95

Chandra, D., Chandra, S., Pallavi., & Sharma, A. K. (2016). Review of Finger millet (*Eleusine coracana* (L.) Gaertn): A power house of health benefiting nutrients. *Food Science and Human Wellness*, 5, 149—155. https://doi.org/10.1016/j.fshw.2016.05.004

Chaturvedi, P., Shukla, N., Shukla, R., & Dhumketi, K. (2022). Development and assessment of healthy multigrain biscuits of wheat flour with pearl millet, maize and buck wheat composite flours. *Journal of Pharmaceutical Innovation*, 11, 1702—1707.

Chen, J., Duan, W., Ren, X., Wang, C., Pan, Z., Diao, X., & Shen, Q. (2017). Effect of foxtail millet protein hydrolysates on lowering blood pressure in spontaneously hypertensive rats. *European Journal of Nutrition*, 56, 2129—2138. doi:10.1007/s00394-016-1252-7

Chen, Y., Zhang, R., Xu, J., & Ren, Q. (2022). Alteration of intestinal microflora by the intake of millet porridge improves gastrointestinal motility. *Frontiers in Nutrition,* 9,

965687.
https://doi.org/10.3389/fnut.2022.965687

Choton, S., Bandral, J. D., & Sood, M. (2021). Buckwheat, its health benefits and uses. *Just Agriculture*, 2, 023 In press.

Das, R. R., Pradhan, S., & Parida, A. (2020). De-novo transcriptome analysis unveils differentially expressed genes regulating drought and salt stress response in *Panicum Sumatrense*. *Science Reporter,* 10, 1—14. doi:10.1038/s41598-020-78118-3

Das, S., Khound, R., Santra, M., & Santra, D. K. (2019). Beyond Bird Feed: Proso Millet for Human Health and Environment. *Agriculture*, 9, 64 In press. https://doi.org/10.3390/agriculture9030064

De Morais-Cardoso, L., Pinheiro, S. S., Martino, H. S. D., Pinheiro-Sant'Ana H. M. (2017). Sorghum (*Sorghum bicolor* L.): Nutrients, bioactive compounds and potential impact on human health. *Critical Reviews in Food Science and Nutrition*, 57, 372—390. doi:10.1080/10408398.2014.887057

Dimidi, E., Christodoulides, S., Scott, S. M., & Whelan, K. (2017). Mechanisms of action of probiotics and the gastroin testinal microbiota on gut motility and constipation. *Advances in Nutrition*, 8, 484—494. DOI:10.3945/an.116.014407

Forgani, S., Peighambardoust, S. H., Hesari, J., & Rezai-Mokarram, R. (2018). Effect of adding millet milk on viability of lactobacillus acidophilus la-5, starter bacteria and some physicochemical characteristics of the probiotic yogurt. *Iranian Journal of Food Science and Technology*, 15, 207—219.

Gill, S. K., Rossi, M., Bajka, B., & Whelan, K. (2021). Dietary fiber in gastrointestinal health and disease. *Nature Reviews Gastroenterology & Hepatology*, 18, 101—106. doi10.1038/s41575-020-00375-4

Habiyaremye, C., Matanguihan, J. B., D'Alpoim-Guedes, J., Ganjyal, G. M., Whiteman, M. R., Kidwell, K. K., Murphy, K. M. (2017). Proso millet (*Panicum miliaceum* L.) and its potential for cultivation in the pacific Northwest, U.S.: A review. *Frontiers in Plant Science,* 7, 1—17. https://doi.org/10.3389/fpls.2016.01961

Handa, V., Kumar, V., Panghal, A., Suri, S., & Kaur, J. (2017). Effect of soaking and germination on physico-chemical and functional attributes of horse gram flour. *Journal of Food Science and Technology*, 54 (13), 4229—4239. doi:10.1007/s13197-017-2892-1

Himanshu Chauhan, M., Sonawane, S. K., & Arya, S. S. (2021). Nutritional and nutraceutical properties of millets: A review. *The American Journal of Clinical Nutrition*, 1, 1—10.

Jia, W., Zhen, J., Liu, A., Yuan, J., Wu, X., Zhao, P., Zhao, L., Li, X., Liu, Q., Huang, G., & Xu, A. (2020). Long-term vegan meditation improved human gut microbiota. *Evidence-Based Complementary and Alternative Medicine* 2020, 9517897. doi:10.1155/2020/9517897

Joshi, N., Verma, K. C. (2020). A review on nutrition value of Amaranth (*Amaranthus caudatus* L.): The crop of future. *Journal of Pharmacognosy and Phytochemistry*, 9, 1111—1113.

Karuppasamy, P., Malathi, D., & Karthikeyan, M. (2020). Nutritional and functional variability of nutricereals. *International Journal of Chemical Studies*, 8, 125—129. https://doi.org/10.22271/chemi.2020.v8.i5c.10457

Kimeera, A., & Sucharitha, K.V. (2019). Millets- Review on nutritional profiles and health benefits. *International Journal of Recent Scientific Research*, 10, 33943—33948. http://dx.doi.org/10.24327/ijrsr.2019.1007.3786

Kumar, A., Kaur, A., Tomer, V., Rasane, P., & Gupta, K. (2020). Development of nutricereals and milk-based beverage. *Journal of Food Process Engineering,* 43: 13025. https://doi.org/10.1111/jfpe.13025

Kumar, A., Tomer, V., Kaur, A., Kumar, V., & Gupta, K. (2018). Millets: A solution to agrarian and nutritional challenges. *Agriculture and Food Security*, 7, 1—15. https://doi.org/10.1186/s40066-018-0183-3

Kumar, P., Magadum, S., Kumar, A., & Paliwal, A. (2021). Nutricereals: The wonder crops. *Vigyan Varta*, 2, 32—35.

Kumari, S., Bhinder, S., Singh, B., Kaur, A., & Singh, N. (2020). Effect of buckwheat incorporation on batter fermentation, rheology, phenolic, amino acid composition and textural properties of idli. LWT122: 109042. https://doi.org/10.1016/j.lwt.2020.109042

Lalitha, R.V.M.S., Hymavathi, T. V., Devi, K. U., & Robert, T. P. (2018). *In-vitro* digestibility of protein, starch and *in-vitro* availability of minerals (iron and zinc) in whole and dehulled nutricereal based multigrain extruded snacks. *Journal of Pharmacognosy and Phytochemistry*, 7, 186—188.

LaLonde, T., & Jadeja, R. (2018). Cooking for individuals with food allergies and intolerances. *Madridge Journal of Food Technology*, 3, 115—121. doi:10.18689/mjft-1000117

LeLeiko, N. S., Mayer-Brown, S., Cerezo, C., & Plante, W. (2020). Constipation. *Pediatrics Review*, 41, 379—92. DOI:10.1542/pir.2018-0334

Lin, H. C., Sheu, S. Y., Sheen, L. Y., Sheu, P. W., Chiang, W., & Kuo, T. F. (2020). The gastroprotective effect of the foxtail millet and adlay processing product against stress-induced gastric mucosal lesions in rats. *Journal of Traditional and Complementary Medicine*, 10, 336—344. DOI:10.1016/j.jtcme.2020.01.003

Mahata, D. (2018). Importance of buckwheat (*Fagopyrum esculentum* Moench). *International Journal of Chemical Studies*, 6, 2121—2125.

Maitra, S., Pine, S., Shankar, T., Pal, A., & Pramanick, B. (2020). Agronomic management of foxtail millet (*Setaria italica* L.) in India for production sustainability: A review. *International Journal of Bioresource Science*, 7, 11—16. doi:10.30954/2347-9655.01.2020.3

Martínez-Villaluenga, C., Peñas, B., & Hernández-Ledesma. (2020). Pseudocereal grains: Nutritional value, health benefits and current applications for the development of gluten-free foods. *Food and Chemical Toxicology*, 137, 111—178. DOI:10.1016/j.fct.2020.111178

Mir, N. A., Yousuf, B., Gul, K., Riar, C. S., & Singh, S. (2019). Cereals and pseudocereals: Genera introduction, classification and nutritional properties. *Apple Academic Press*, pp, 281—322. eBook ISBN9780429242793

Mounika, M., & Hymavathi, T. V. (2021). Nutrient and phytonutrient quality of nutricereals incorporated flour mix suitable for diabetics. *Annals of Phytomedicine*, 10, 132—140. http://dx.doi.org/10.21276/ap.2021.10.1.14

Murya, N. K., & Pratibha, A. (2018). Amaranthus grain nutritional benefits: A review. *Journal of Pharmacognosy and Phytochemistry,* 7, 2258—2262.

Palevich, N., Kelly, W. J., Leahy, S. C., Denman, S., Altermann, E., Rakonjac, J., & Attwood, G. T. (2019). Comparative genomics of rumen *Butyrivibrio* spp. uncovers a continuum of polysaccharide-degrading capabilities. *Applied and Environmental Microbiology*, 86, 01993-19. DOI:10.1128/AEM.01993-19

Panwar, P., Dubey, A., & Verma, A. K. (2016). Evaluation of nutraceutical and antinutritional properties in barnyard and finger millet varieties grown in Himalayan region. *Journal of Food Science and Technology*, 53, 2779—2787. doi:10.1007/s13197-016-2250-8

Patroti, P., Sharma, K. K., & Tonapi, V. A. (2017). Nutricereals for widening food base and nutritional security. In: *Souvenir-cum-Abstracts of International Seminar on Agriculture and Food for Inclusive Growth and Development*, CSIR-NBRI, Lucknow, Uttar Pradesh, India, pp, 125—126. http://krishi.icar.gov.in/jspui/handle/123456789/11591

Poshadri, A., Deshpande, H. W., & Kshirsagar, R. B. (2023). The international year of millets-2023, millets as nutricereals of 21st centenary for health and wellness. *Agriculture Association of Textile Chemical and Critical Reviews Journal*, 2023, 07—12. DOI:10.58321/AATCCReview.2023.11.01.02

Poshadri, A. Y., Kumar, P., Charan, G. S., Raghuveer Kumar, M. S., & Devi, A. R. (2019). Energy rich composite millet and soybean based malted weaning mix: A complementary food in tribal areas of Adilabad district, India. *International Journal of Current Microbiology and Applied Sciences* 8, 2058—2064. https://doi.org/10.20546/ijcmas.2019.802.238

Ratnavathi, C. V., & Tonapi, V. A. (2022). Nutritional Properties of Millets: Nutricereals with Health Benefits to Reduce Lifestyle Diseases and Malnutrition. *Springer Link*. https://doi.org/10.1007/978-981-16-7224-8_7 129-149.

Renganathan, V. G., Vanniarajan, C., Nirmalakumari, A., Raveendran, M., & Thiyageshwari, S. (2017). Cluster analyses for qualitative and quantitative traits in barn yard millet *Echinochloa frumentacea* germplasm. *Bioscan*, 12, 1927—1931. https://www.researchgate.net/publication/343670812

Sachdev, N., Goomer, S., & Singh, L. R. (2021). Foxtail millet: A potential crop to meet future demand scenario for alternative sustainable protein. *Journal of Agricultural Science*, 101, 831—842. DOI:10.1002/jsfa.10716

Saini, S., Saxena, S., Samtiya, M., Puniya, M., & Dhewa, T. (2021). Potential of underutilized millets as nutricereal. *Journal of Food Science and Technology*, 58, 4465—4477. DOI:10.1007/s13197-021-04985-x

Sanyal, R., Jawed, D., Kumar, N., & Bishi, S. K. (2021). Small millets (nutricereals): Food for the future. *Biotica Research Today*, 3, 793—796.

Satish, L., Rathinapriya, P., Rency, S. A., Ceasar, S. A., Prathibha, M., Pandian, S., Ramakrishnan, R., & Ramesh, M. (2016). Effect of salinity stress on fin-ger millet (*Eleusine coracana* (L.) Gaertn): Histochemical and morphological analysis of coleoptile and coleorhizae. *Flora-Morphology, Distribution, Functional Ecology of Plants*, 222, 111—120. doi:10.1016/j.flora.2016.04.006

Satyavathi, C. T., Ambawat, S., Khandelwal, V., & Srivastava, R. K. (2021). Pearl Millet: A climate-resilient nutricereals for mitigating hidden hunger and provide nutritional security. *Frontiers in Plant Science*, 12, 659938. https://doi.org/10.3389/fpls.2021.659938.

Scott, S. M., Simren, M., Farmer, A. D., Dinning, P. G., Carrington, E. V., Benninga, M. A., Burgell, R. E., Dimidi, E., Fikree, A., Ford, A. C., Fox, M., Hoad, C. L., Knowles, C. H., Krogh, K., Nugent., K., Remes-Troche, J. M., Whelan, K., & Corsetti, M. (2021). Chronic constipation in adults: Contemporary perspectives and clinical challenges. 1: epidemiology, diagnosis, clinical associations, pathophysiology and investigation. *Neurogastroenterol. Motil*, 33, e14050. doi:10.1111/nmo.14050

Senevirathne, I., Abeysekera, W., Jayanath, N. Y., Galbada-Arachchige, S. P., & Wijewardana, D. (2021). Antiamylase, antiglucosidase and antiglycation properties of millets and sorghum from Sri Lanka. *Evidence-Based Complementary and Alternative Medicine,* 2021, 5834915. https://doi.org/10.1155/2021/5834915

Shaikanth, D. R. K., Chandana, T. S., Adhikari, B., & Sabrinathan, C. (2022). Innovation of Multidisciplinary Research in Present and Future Time, 1, 76—81.

Sharma, B., & Gujral, H. S. (2019). Influence of nutritional and antinutritional components on dough rheology and *in vitro* protein and starch digestibility of minor millets. *Food Chemistry*, 299, 125115. doi:10.1016/j.foodchem.2019.125115

Sharma, N., & Niranjan, K. (2017). Foxtail millet: Properties, processing, health benefits and uses. *Food Reviews International*, 34, 329—363. https://doi.org/10.1080/87559129.2017.1290103

Sharma, R., Sharma, S., Dar, B. N., & Singh, B. (2021). Millets as potential nutricereals. *Institute of Food Science and Technology*, 56, 3703—3718. https://doi.org/10.1111/ijfs.15044

Shweta, Malik. (2015). Pearl millet-nutritional value and medicinal uses. *Food Nut*, 1 (3), 414—418.

Singh, A., Kumar, M., & Shamin, Md. (2020). Importance of minor millets (Nutricereals) for nutrition purpose in present scenario. *International Journal of Chemical Studies*, 8, 3109—3113. doi:10.22271/chemi.2020.v8.i1au.9226

Singh, A., Yadav, S., & Mor, R. (2022). Millets (nutricereals) and its value-addition: A review of the health benefits and future- prospects. *Journal of Food Science and Nutrition Research*, 2, 1—8. doi:10.48165/jfdr.2022.2.1.1

Singh, N., & Chaudhary, A. (2023). Little millets– Review on nutritional profile and health benefits. *Journal of Engineering and Technology Research*, 10, 688—690.

Sleem, I., Smolensky, D., & Dia, V. (2024). Gastrointestinal Health Benefits of Sorghum Phenolics. *Plant Foods for Human Nutrition*, 79, 730—743. DOI:10.1007/s11130-024-01230-6

Tomita, T., Kazumori, K. , Baba, K., Zhao, X., Chen, Y., & Miwa, H. (2021). Impact of chronic constipation on health-related quality of life and work productivity in Japan. *Journal of*

Gastroenterology and Hepatology, 36, 1529—1537. doi:10.1111/jgh.15295

Uma, G. M., & Shivakumar, K. M. (2020). Millet scenario in India. *Eco*. *Affa*., 65, 363—370. doi:10.46852/0424-2513.3.2020.7

Vetriventhan, M., Upadhyaya, H. D., Azevedo, V. C., Allan, V., & Anitha, S. (2021). Variability and trait-specific accessions for grain yield and nutritional traits in germplasm of little millet (*Panicum sumatrense* Roth. Ex. Roem. & Schult.). *Crop Science*, 61, 2658—2679. DOI:10.1002/csc2.20527

Xu, J., Wang, W., & Zhao, Y. (2021). Phenolic compounds in whole grain sorghum and their health benefits. *Foods*, 10 (8), 1921. https://doi.org/10.3390/foods10081921

Zhang, Y. Y., Lu, Y., Zhang, B., He, L., Liu, L. L., Wang, X. C., & Han, Y. H. (2016). The relationship between the gene SiLCYB related to carotenoid synthesis and the colored formation of foxtail millet. *Molecular Plant Breeding*, 14, 1341—1351. doi:10.3724/SP.J.1006.2018.00686

Zhu, F. (2018). Anthocyanins in cereals: Composition and health effects. *Food Research International*, 109, 232—249. DOI:10.1016/j.foodres.2018.04.015