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Millets: Properties, Processing, Nutritional Value

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Abstract
A few modifications might seriously affect agriculture. A danger to food security is imminent due to factors such as population growth, climate change, hydrological cycle changes, and social and economic problems. This might ultimately result in higher food costs and lower food output. We may search for more efficient, cost-effective, and healthful options, like millets, to address these problems. Due to its tolerance to drought, millet is an inexpensive and readily accessible crop. They are a significant source of minerals, micronutrients, proteins, and carbs. In the upcoming years, millets have a great chance of providing health and nutritional advantages in addition to ensuring food security. Thus, food scientists, technologists, nutritionists, etc. are becoming more and more interested in millet grain. This work's objective was to

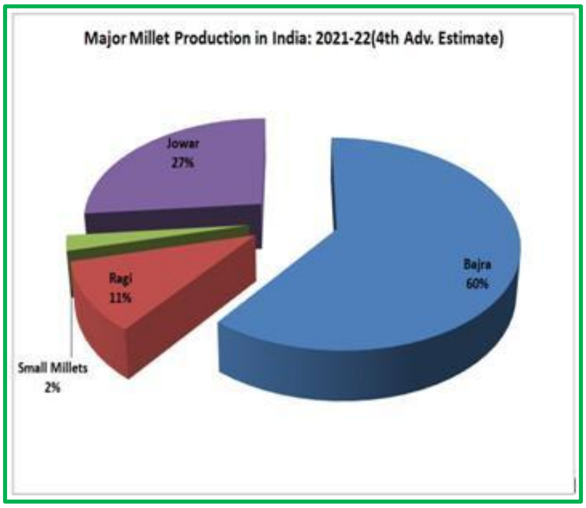
Keywords: Millets, Processing, Health benefits

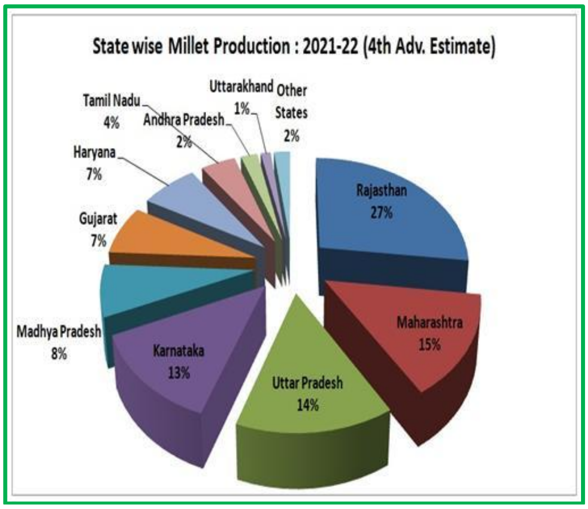
Introduction
A handful of millet can contain up to a thousand grains, as the name millet is derived from the French word "mille," which means "thousand" (Dayakar Rao *et al*., 2022). Once known as "poor man's food," millets are small-seeded grass species of the Poaceae family. Although millets are native to many regions of the world, it is thought that tropical western Africa is where they first evolved because there are the most wild and cultivated varieties of the grain there. Among the most significant drought-tolerant crops, millet ranks sixth in terms of global agricultural production among cereal crops. Although they may be grown on low-fertility soils as well, most millets are produced on reclaimed soils. They can flourish even in the absence of fertilisers since they do not require chemical fertilisers. In addition, compared to other main grains, millet has short growing seasons, drought tolerance, and disease and insect resistance (Devi *et al*., 2011). For millions of people, millet is a vital source of protein and energy. Significant levels of major and minor nutrients may be found in millet. Because they are so nutritious, they provide nutritional security. Millets are typically non-glutinous and high in fibre, minerals (such as calcium, iron, zinc, phosphorus, and others), and B-complex vitamins (such as folic acid and niacin) (Dayakar Rao B *et al*., 2017). Based on the grown area and grain size, the millets are divided into two types: major millets and minor millets. The major millets include sorghum (*Sorghum bicolour*), pearl millet (*Pennisetum glaucum*), and finger millet (*Eleusine coracana*). The minor millets include foxtail millet (Setaria *italica*), little millet (*Panicum sumatrense*), kodo millet (*Paspalum scorbiculatum*), proso millet (*Panicum miliaceum*), barnyard millet (*Echinochloa Frumentacea*) and browntop millet (*Brachiaria ramosa*). There are other three types of millets namely fonio (*Digitaria*

exilis), tef (*Eragrostis tef*), and job's tear millet (*Coix laeryma),* which are of minor importance in India because they are grown mostly in Africa (Prashanthi and Reddy, 2023). Due its nutritional benefits and its ability to grown in harsh condition there is a need for promoting millets

Economics of Millets

FAOSTAT (2021) reports that 84.17 million metric tonnes of millet were produced worldwide in 2019–20 from an area of 70.75 million hectares, with 20.50% of the production coming from India.An estimated 50.90 million tonnes of Nutri/course cereals were produced in 2021–2022, an increase of 4.32 million tonnes above the average output of 46.57 million tonnes over the previous five years. This amounts to 20% of worldwide production and 80% of Asia's production. India produces 1238 kg/ha of millet on average, whereas the world produces 1229 kg/ha on average. The 10 states that account for almost 98% (Fig. 2) of India's millets output between 2020 and 21 are Rajasthan, Karnataka, Maharashtra, Uttar Pradesh, Haryana, Gujarat, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, and Uttarakhand. More than 83% of the world's millet is produced in Rajasthan, Karnataka, Maharashtra, Uttar Pradesh, Haryana, and Gujarat. Of all the millet produced in India, Rajasthan produces 27% (Fig 1). Multiple varieties of millets are produced in India such as Pearl Millets, Sorghum, Finer Millet, Foxtail, Kodo, Barnyard, Porso, Little Millet and Pseudo Millets like Buckwheat and Amaranth. Pearl millet (Bajra), Sorghum (Jowar) and Finger Millet (Ragi) constitutes the largest share in India's total production of millets. In India production Bajra accounts for 60 per cent followed by Jowar, ragi and small millets ie., 27 per cent, 11 per cent and 2 per cent respectively. (Fig 1) (APEDA, 2022)





Source: APEDA, 2022

Nutritional value of Millet grains

Millets are a wholesome grain that has a lot of nutritional fibre. They have a composition of 65–75% carbs, 7–12% proteins, 1.5–5% fat, 2–7% crude fibre, 15-20% dietary fibre, and are a great source of minerals, vitamins (particularly vitamin B), and antioxidants. They include phytochemicals and phenolic compounds with culinary uses (Amadou, 2013). Millets, such as finger millet, pearl millet, and barnyard millet, are utilised in food fortification because they are rich in micronutrients including iron, zinc, calcium, and vitamins (Bhumika and Kalpana, 2010). Resistant starch, oligosaccharides, lipids, and antioxidants such phenolic acids, avenanthramides, flavonoids, lignans, and phytosterols are among the vital components found in millets and are thought to provide several health advantages (Miller, 2001; Edge *et al*., 2005).

Table no. 1. Proximate Nutritional composition of different millet (all values except protein are expressed on a dry weight basis).

Commodity	Protein (g)	Carbohydrate (g)	Fat (g)	Crude Fibre (g)	Ash (g)	Energy (Kcal)	Thiamin (mg)	Niacin (mg)	Riboflavin (mg)
Sorghum	10.4	70.7	3.1	2.0	1.6	329	0.38	4.3	0.15
Pearl millet	11.8	67.0	4.8	2.3	2.2	363	0.38	2.8	0.21
Finger millet	7.7	72.6	1.5	3.6	2.6	336	0.42	1.1	0.19
Foxtail	11.2	63.2	4.0	6.7	3.3	351	0.59	3.2	0.11
Common millet	12.5	63.8	3.5	5.2	3.1	364	0.41	4.5	0.28
Little millet	9.7	60.9	5.2	7.6	5.4	329	0.30	3.2	0.09
Barnyard millet	11.0	55.0	3.9	13.6	4.5	300	0.33	4.2	0.10
Kodo millet	9.8	66.6	3.6	5.2	3.3	353	0.15	2.0	0.09
Rice (brown)	7.9	76.0	2.7	1.0	1.3	362	0.41	4.3	0.04
Wheat	11.6	71.0	2.0	2.8	1.6	348	0.41	5.1	0.10
Maize	9.2	73.0	4.6	2.0	1.2	358	0.38	3.6	0.20

Sources: Hulse *et al.* (1980); United States National Research Council/National Academy of Sciences (1982); USDA/HNIS (1995); FAO (1995).

Table no. 2. Mineral composition of millets (mg/100 g edible portion, dry weight basis).

Mineral composition of millets									
K	Na	Mg	Ca	P	Mn	Zn		Cu	Fe
Pearl Millet	440–442	10.0–12.0	130–137	10–46	350–379	1.15–1.8	2.95–3.1	0.62–1.06	7.49–8.0
Finger Millet	408–570	7.0–11.0	110–137	240–410	240–320	5–5.5	2–2.23	0.4–4	3.9–7.5
Foxtail Millet	250–400	4.6–10	100–130	10–30	270–310	2.19–26	2.14–9	1–3.0	3.26–19
Little Millet	129–370	6–8.1	120–133	12–30	251–260	1.0–20.0	3.5–11	1.0–4.0	13–20
Proso Millet	250–320	8.2–10	117–153	20–23	230–281	0–1.81	1.4–2.4	0.83–5.8	4.0–5.2
Kodo Millet	144–170	4.6–10	130–166	10–31	215–310	1.10–2.9	0.7–1.5	1.6–5.8	0.7–3.6

Source: Singh *et al*., 2022

Millets cleaned up

Before being ingested, people often need to process the entire grains that have been collected. Refinement is the process of removing impurities and poorly digested chemicals from grain by the removal of bran and germ, nutritional content, and milling of the grain. Many arguments indicate the need of processing grains to increase grain consumption, even though processing is frequently seen as a negative trait in nutrition and some kinds of processing lower nutritional content.

There are two categories for processing millets: main and secondary. Dehulling (pearling) and milling the grain to produce flour and semolina (fine and medium semolina) are the main processing steps. Utilising the main processed raw material to process ready-to-cook and ready-to-eat items for processing such puffing, baking, flaking, fermenting, frying, and extrusion is known as secondary post-harvest activities (adding value to millets). (Hotz and Gibson, 2007). These consist of roasting, flaking, grinding, germination/malting, fermentation, and toasting. The goals of these processes are to either decrease the amount of antinutrients like phytates or increase the amount of compounds that boost bioavailability in order to increase the physicochemical accessibility of micronutrients.

Mechanical Processing Technologies: Decortications, Milling and sieving

Traditional and Bioprocess Technology: Germination or malting, Fermentation, Popping or puffing, Soaking and cooking

De-cortication: De-cortication is partial removal of outer layer of the millet grain. It is accomplished by hand pounding and using rice de-hulling or other abrasive de-hullers. (Chapke *et al*., 2020). Traditionally dry, moistened or wet grain is pounded with the help of a wooden pestle in a stone or wooden mortar. It not only removes fibrous bran but also separates germ and endosperm. Parboiling also increases the de-hulling efficiency of kodo millet and eliminates the stickiness in cooked finger millet porridge.

Milling and Sieving: Milling involves separating bran i.e., the pericarp, the seed coat, the nucellar epidermis and the aleurone layer and germ from the starchy endosperm so that the endosperm can be ground into flour and rawa using different types of sieves in a hammer mill (Chapke *et al*., 2020). Millet grains are usually milled by a non motorized grain mill that cranks by hand or another nonelectric method, especially in rural areas for household uses. (Saleh *et al*., 2013). Hand operated pestle or denki method of dehusking and debranning still continues. Sieving after crushing yields fairly white flour and separates most of the bran (Kurien *et al*., 1962; Birania *et al*., 2020. Milling can be done though playe mill, hammer millor roller mill. Milling and heat treatment during chapatti (unleavened bread) making, lowered polyphenols and phytic acid and improved the protein digestibility and starch digestibility to a significant extent (Chowdhury and Punia 1997; Saleh *et al*., 2013).

Germination or Malting: Malting is a traditional process of brewing raw materials employing a controlled germination of grain in moist air. It involves the mobilization of amylases, proteases and other enzymes which hydroloyze and modify the grain components and its structure. Seeds are generally cleaned and steeped for 24 h, they are then allowed to germinated under controlled condition on moist cloth at room temperature up to 24 h. Germinated seeds are dried at 50°C in an air oven for 12 h and vegetative growth portion is removed by gentle brushing (manually) which is then ground for malting. The soured beer is made from malted millet or sorghum or both, and several different starch materials, e.g. corn grits are used as adjuncts (Kajuna Silas). Malted ragi flour, or extract derived from it, is extensively used in preparation of weaning and infant foods, beverages or other pharmaceutical preparations (Nirmala *et al*., 2000). It has been found that germination of proso millet grains increased the free amino acids and total sugars and decreased the dry weight and starch content. Increases in lysine, tryptophan, and non protein nitrogen were also noticed (Parameswaran and Sadasivam, 1994). Swami *et al*. (2013) prepared Finger millet malt at various germination times 8, 12, 16, 20 and 24 h. As germination time increases, the protein content also increases. The protein content was in the range of 14% -17.5%. It has been shown that a well designed malting/ germination process can significantly reduce anti nutrients (such as tannin and oxalate, phytic acid) and consequently enhance the nutrient availability in finger millet. (Najdi Hejari and Orsat, 2016; Najdi Hejari *et al*., 2016). It has been found to increase trace elements like Ca, Fe, Cu, Zn and Mn (Rateesh *et al*., 2012). Therefore, malting generally improves the nutrient content and digestibility of foods and it could be an appropriate food-based strategy to derive iron and other minerals maximally from food grains (Patel *et al*., 2010).

Fermentation: In Europe, Asia, and Africa, fermentation is a common process. A variety of procedures, including natural, water-based, and dried millet-based fermentation methods, are employed to ferment millet products. One procedure that lowers the antinutrient levels in food grains and raises their nutritional value, in vitro protein digestibility (IVPD), and protein availability is fermentation. Hassan et al. (2006) have shown that there was a noteworthy decrease in anti-nutritional factors and a considerable increase in the IVPD following the fermentation of processed pearl millet grains. In India, a variety of pancakes are made using fermented millet flour. There are classic fermented breads such galettes, kisra, dosa, massa, and jera.

Popping or Puffing: One of the old-fashioned techniques for turning food into ready-to-eat items is popping or puffing. According to reports, foxtail millet can be successfully processed using both traditional (popping and flaking) and modern (roller-drying and extrusion-cooking) methods to produce ready-to-eat products, which will increase the millet's use as a food (Usha kumari *et al.*, 2004). Popped grains are crisp, porous, and cooked ahead of time. Finger millet has a really pleasant flavour when bursting. Expanded millets are created by maintaining a 19% grain moisture content and a popping temperature of around 250°C, as described by Malleshi and Desikachar in 1986.

Effect of Millets on Health

Because they are gluten-free and anti-acid, millets are good for eating by all age groups. They don't generate acids, are simple to digest, and don't cause allergies (Saleh et al., 2013). In addition to their established roles in avoiding illnesses caused by dietary deficiencies, many nutrients, such as vitamins, minerals, and essential fatty acids, can have positive health effects in preventing degenerative diseases. According to Scalbert et al. (2005) and Chandrasekara and Shahidi (2012), eating millet lowers the risk of heart disease, diabetes, improves the digestive system, lowers the risk of cancer, detoxifies the body, boosts immunity in respiratory health, increases energy levels, and enhances the muscular and neural systems. It also protects against several degenerative diseases, including metabolic syndrome and Parkinson's disease.

Cardiovascular Diseases: Millets are abundant in phytochemicals that are good for your health, such as phytosterols, phyto-oestrogens, lignans, polyphenols, and phytocyanins. These prevent age-related degenerative illnesses such cancer, diabetes, and cardiovascular disease (CVD) by acting as antioxidants, immunological modulators, detoxifying agents, and other mechanisms (Rao et al., 2011). Millets include potassium, which works as a vasodilator to lower blood pressure and lower the risk of cardiovascular disease. Because the plant lignans in millets can change into animal lignans when they come into contact with bacteria in the digestive system, they can help protect some malignancies and heart diseases.

Diabetes Mellitus: Diabetes mellitus is a long-term metabolic disease marked by changes in the metabolism of fat, protein, and carbohydrates as well as hyperglycemia. The high magnesium content of millets contributes to the body's enhanced effectiveness of insulin and glucose receptors, which helps to avoid diabetes. Due to their high fibre content and alpha amylase inhibitory qualities, which are known to decrease starch absorption and digestion, finger millet-based diets have been demonstrated to lessen glycemic response (Kumari and Sumathi, 2002).

Gastrointestinal Disorders: Fiber content in millets helps in eliminating disorders like constipation, excess gas, bloating and cramping. An immune mediated enteropathic disease called celiac disease which is usually triggered by the ingestion of gluten in susceptible individuals (Catassi and Fasano, 2008). Millets being a gluten free diet plays role in replacing cereals which are rich in gluten content. As millets are gluten free, they have considerable potential in foods and beverages and can meet the growing demand for gluten free foods and will be suitable for individuals suffering from celiac disease. (Chandrasekara and Shahidi, 2011a and 2011b)

Cancer: It is well known that millet grains are high in phytate, tannins, and phenolic acids. According to Graf and Eaton (1990), these nutrients lower an animal's chance of developing breast and colon cancer. Compared to those who consume wheat or maize, individuals who consume sorghum and millet have been linked to a decreased incidence of esophageal cancer due to the fibre and phenolic compounds included in these grains (Van Rensburg, 1981). By using electron spin resonance, their white variants were examined for the ability of free radicals to quench 1,1, diphenyl-2-picrylhydrazyl (DPPH) (Hegde and Chandra, 2005).

Conclusion

Among the most significant drought-resistant crops, millet has more nutritional value than other cereals and the potential to become a staple food grain. Because of their relatively high dietary fibre content as compared to rice, they are crucial for maintaining food security. Because appropriate processing, technology, and equipment are readily available, their commercial consumption of a variety of value-added millets is steadily rising. Nonetheless, in order to raise the quality of millets and increase their bioavailability, it is necessary to develop innovative processing techniques and appropriate preparation techniques. Furthermore, it is imperative to create significantly enhanced millet products without sacrificing their health advantages.

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