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EDITORIAL

Millets as superfoods: Let thy cereal be thy medicine

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Millets are superfoods that can potentially provide a solution to rising gut-related diseases and metabolic disorders. Superfoods are food items that claim to confer health benefits resulting from their exceptional nutrient density. Common millets include pearl millet (bajra), proso millet (barri), sorghum (jawar), finger millet (ragi), barley (jo), oats (jaee) and foxtail millet (kangani). Once a common food item on Indian plates, millets hardly find any place as cereals in modern Indian diet now, as rice and wheat have taken over as staple food.

Millets, in contrast to rice and wheat, are not only a good source of energy and major nutrients, including protein, but are also a good source of micronutrients such as vitamins, including vitamins A, B, D, E, niacin, pyridoxine, antioxidants, iron and zinc. Millets have high protein content (10–12.3 g/100 g), fat (1% to 5%), iron (0.5–19.0 mg) and calcium (10–410 mg) compared to rice and wheat (Table 1) [1]. Millets contain a plenty of protective polyphenols such as hydroxycinnamic acid, catechin, quercetin, luteolin, orientin, apigenin and isoorientin. These polyphenols have an antioxidant activity with free radical scavenging action and anti-inflammatory activity. Finger millets have highest flavonoids, while foxtail millet, pearl millet and proso millet have highest phenolic acids. Ferulic acid is the most common type of hydroxycinnamic acid, which has potent antioxidant properties [2]. The seed coat of finger millets has been found to have antimicrobial and antifungal properties [1]. Millets not only provide comprehensive nutrition but also have an additional benefit of building immunity.

Green Revolution was introduced in India in 1965 to combat food security and reduce famine-related deaths, which were very common then [3]. High-yielding varieties of cereals were introduced. The focus shifted to growing rice and wheat. Pesticides and fertilizers were used to prevent crops from pest infestation and improve yield. This had major benefits in terms of reducing malnutrition and reducing the import of essential foodgrains, decreasing famine and increasing the availability of cereals in the form of rice and wheat all across India. The fallout was that millets and other ancient grain varieties of rice and wheat, which have lesser allergenic varieties of proteins, started vanishing as staple food and its production slowly started to decrease. Moreover, farmers used to get subsidies for rice and wheat production, but not for millets. All this resulted in a major shift in the Indian agriculture scenario to bringing wheat and rice as the commonest food on Indian plate.

With rice and wheat becoming the staple food over the world, millets almost disappeared from the scene. The United Nation, in order to bring the focus back on millets, declared 2023 as the International Year of Millets. The Indian government, too, has started the "Millet Mindfulness" awareness campaign to make it a people's movement. Millets belong to the family of Poaceae and are often labeled as "coarse cereals" and have been rechristened as "nutricereals". These have the additional advantage of being a friend to the gut and thus, these coarse grains have been given the status of "Shree Anna."

India produces around 80% of millets in Asia and is one of the largest producers in the world (41% of global production). It is poised to becoming a global hub for coarse cereals. The hay produced from millet farming is limited and can be utilized completely as animal fodder, thereby reducing the need to burn stubble, which is common with wheat. Millet farming is thus likely to result in lesser pollution.

Millets require lesser water for irrigation than that for wheat and rice, which require 26 times more water. They need 70% less water than rice and grow faster than wheat by 50%. Millets are also naturally pest-resistant, thereby reducing the need for pesticides.

Millets are easily cultivable, as these have climate and drought-tolerant properties and can survive extreme

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Table 1 Nutrient composition of common cereals in comparison to millets [1]

Composition	Rice	Wheat	Maize	Millets
Protein (%)	7.5	14.4	12.1	7.3–14.5
Carbohydrates (%)	77.2	64	62.3	56.1–72
Fat (%)	2.4	2.3	4.6	1.3–5.1
Dietary fibers (%)	3.7	12.1	12.8	7.0–37.8
Total phenols (mg/100 g)	2.51	20.5	2.91	51.4–368
Calcium (%)	0.02	0.04	0.03	0.01–0.33
Iron (%)	19	40.1	30	18–21.9
Zinc (%)	10	30.9	20	15–29.5
Sodium (%)	0.00	0.04	0.14	0.11
Thiamine (mg/100 g)	0.07	0.57	0.38	0.32–0.63
Riboflavin (mg/100 g)	0.03	0.12	0.14	0.05–0.22
Nicotinic acid (mg/100 g)	1.6	7.4	2.8	0.3–3.7

temperatures. These can be grown in both kharif or rabi seasons and have a good shelf life.

Nutritional sciences and therapies have been receiving increasing attention amid exponential rise in diseases such as diabetes, obesity and non-alcoholic fatty liver all around the globe. The phytochemicals in millets help in reducing cholesterol and phytates in the human body. As compared to wheat and rice, millets have high fiber content and low glycemic index and can be beneficial in the diet of patients of diabetes mellitus (DM). The mean glycemic index value of millets is 52.7 ± 10.3 [4]. This was lower than that of milled rice (71.7 ± 14.4) and refined wheat (74.2 ± 14.9). There was a significant reduction in fasting blood glucose by 12% and post-prandial blood glucose levels by 15% among those consuming millets [4].

In a randomized controlled trial, pearl millets caused lower glucose-dependent insulinotropic polypeptide concentration than oats porridge ($p = 0.001$) [5]. An analysis of 19 studies had revealed that millet consumption was associated with reduction in total cholesterol by 8%, very-low-density lipoprotein (VLDL) by 9%, triacylglycerol by 9.5% and low-density lipoprotein cholesterol (LDL-C) by 10% in over four months [6]. Interestingly, the study also found a reduction in body mass index by 7% and reduction in blood pressure by 5%. The consumption of finger millets is associated with reduction in markers of adipogenesis and inflammation such as nuclear factor kappa B (NF-κB), tumor necrosis factor α (TNFα), interleukin 6 (IL-6) and leptin [7]. Foxtail and proso variants of millets increase the serum adiponectin levels [8, 9]. Millets thus have anti-inflammatory, anti-diabetic, anti-obesity and anti-hypertensive properties [10].

Millets also inherently lack gluten and are an attractive option for patients with celiac disease and non-celiac gluten sensitivity [11]. These are least prone to causing allergic reactions and are more digestible. The alcohol-soluble protein fraction lacks immunogenicity in patients with celiac disease. Millets could thus enhance the nutritional quality of the diet of patients with celiac disease and improve their overall nutritional status. The unleavened bread (roti) made from millets gives a feeling of satiety similar to that of wheat as these have a slower gastric emptying [12]. Thus, for patients who are accustomed to consuming unleavened bread as daily meal, shifting to millet-based option is likely to have better patient acceptability than advocating a rice-based diet.

The fiber content of millets is around 2–9 g/100 g. The amount of fiber is higher when consumed as whole grain and thus could be beneficial in patients with chronic constipation. Millets are a part of permitted items in the low Fermentable Oligo, Di and Mono-saccharides and Polyols (FODMAP) diet [13, 14]. Low FODMAP diet helps in reducing abdominal pain, flatulence and bloating. Millets have been shown to promote probiotic such as *Bifidobacterium* and *Lactobacillus* in the colon, while reducing the growth of pathogenic bacteria such as *Escherichia coli*, *Enterococcus* and *Bacteroides* in mice models [15]. This implies that millets could also have a prebiotic effect on the gut. Fermented and germinated millets have been shown to be protective against dextran sulfate sodium–induced ulcerative colitis [16, 17]. Further evaluation in conditions such as inflammatory bowel disease and irritable bowel syndrome is required. Millets are thus gluten-free, low FODMAP, high fiber, anti-inflammatory and probiotic food option for a patient with gastrointestinal (GI) disorders.

Millets could be an appealing addition in the daily diet for children. In a meta-analysis on millets substituted in place of rice for a period up to 4.5 years, there was an improvement in mean height (+28.2%), weight (+26%), and mid-upper arm circumference (+39%) in undernourished children [18]. Iron and zinc fortified pearl millet could improve the hemoglobin levels and iron status in children [19, 20]. This could be an addition to the mid-day meal program in our country for schoolchildren. Fortification of food items such as bread, biscuits, pasta, bread, beverages and noodles with millets could increase the nutritive content of our meals. Millets are thus gut barrier friendly and promote a healthy gut microenvironment. There are obstacles in the pathway of millet revolution. The problems include the availability, improving the palatability, counselling for the better acceptability, adaptation to changed diet and making it affordable at consumer level. The limitation of studies on millets include lack of prospective trials with diseases such as diabetes mellitus, non-alcoholic fatty liver disease and irritable bowel syndrome in real world scenario. Pearls millets have been associated with risk of hypothyroid in some vitro studies [21]. Phytic acid in pearl

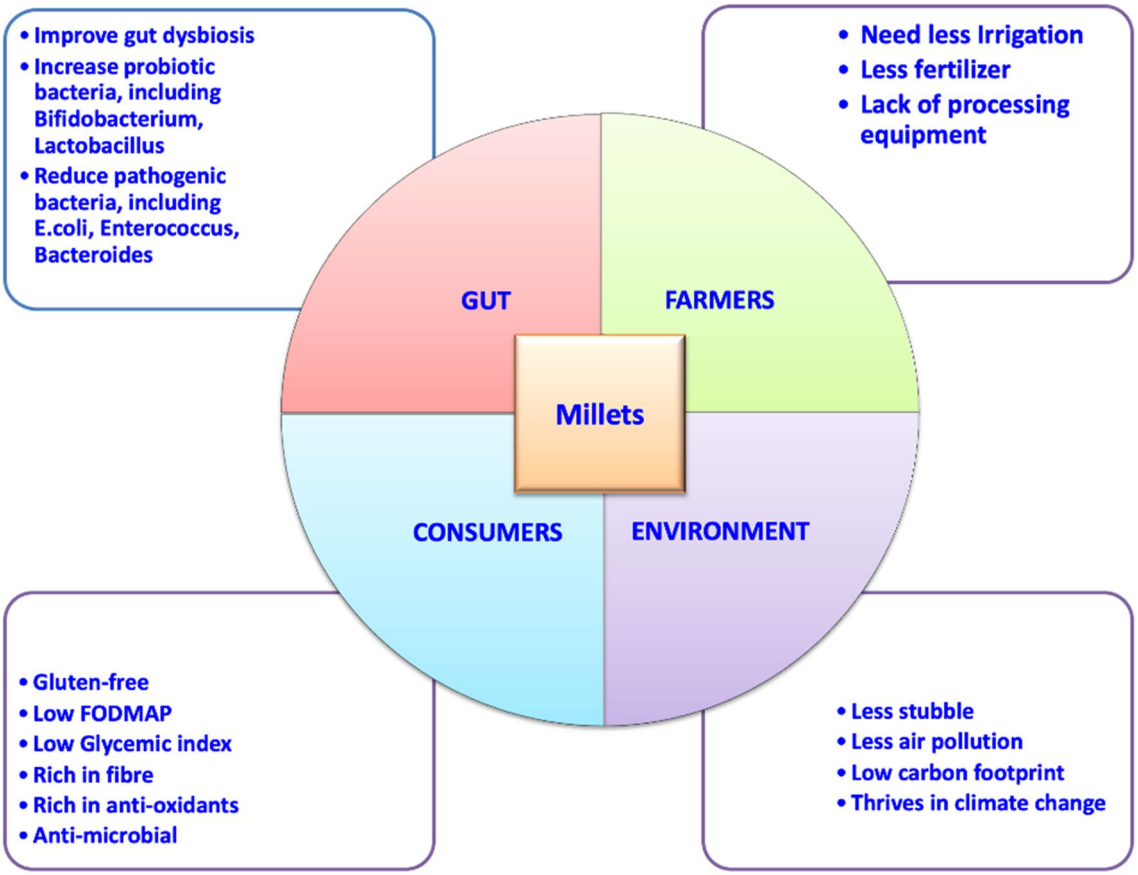

Fig. 1 Advantages of millets to gut, farmers, consumers and the environment

millet has been shown to form complexes with cations such as potassium, magnesium and calcium [22]. However these would require larger in vivo studies for confirmation.

Man has been eternally in search of food since nomadic times. However, when he learnt how to grow his own food, he focused on producing better varieties of crops to feed everybody. Due to food scarcity, there was a societal need to grow high-yielding crops to feed a larger population resulting in abundant food availability. In the present era, where the excess of food intake is resulting in obesity, diabetes and cancers, we have to now shift our focus to identifying an ideal food that promotes overall gut health, is economically viable and acceptable to farming community and is eco-friendly (Fig. 1). Millets fit all these requirements.

Hence, millets are an attractive option for ensuring food security on the one hand and improving the gut health on the other [23]. There is a need to recognize this superfood and the International Year of Millets is providing us with an opportunity to bring this wholesome superfood back to our plate!

Declarations

Conflict of interest AJ, AS and UD declare no competing interests.

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