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NUTRIENT-RICH MILLETS: IMPLICATIONS FOR COMBATING MALNUTRITION AND ENSURING NUTRITIONAL SECURITY

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Abstract :

Malnutrition remains a pressing global health concern, affecting millions of people, particularly in low-income and developing countries. In this context, millets, a group of small-seeded, drought-tolerant grains, have emerged as promising solutions to combat malnutrition and enhance food security. Millets are inherently nutrient-rich, offering a rich source of protein, dietary fiber, vitamins, and minerals. They are also gluten-free, making them suitable for individuals with celiac disease or gluten sensitivities. This review paper explores the nutritional composition of millets and their potential implications for addressing malnutrition and ensuring food security. Millets are a valuable source of essential macronutrients, including protein and complex carbohydrates, as well as micronutrients such as iron, zinc, calcium, and various B vitamins. Their high fiber content contributes to improved digestion and reduced risk factors for non-communicable diseases. In conclusion, millets represent a valuable resource in the fight against malnutrition and the quest for food security. Their nutritional richness, adaptability, and sustainability make them a compelling choice for a more resilient and nutritious food future.

Keywords- *Millets, Malnutrition, Nutritional security, Climate resilience, Sustainable agriculture*

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1. Introduction :

The current global population of 7.8 billion is projected to reach approximately 10 billion by the end of the year 2050. With this continuously expanding population size, nutritional deprivation is also prevailed in many parts of the world, especially in third-world countries. A properly balanced dietary supplement is mandatory for the health of a child to grow and develop properly. However, a disturbing number of 155 million children are reported to suffer from stunting, and 55 million are wasted globally due to malnutrition (UNICEF 2018).

The global food system is facing immense challenges in the 21st century with climate change, population growth, malnutrition, and the increasing prevalence of non-communicable diseases (NCDs). Millets, a group of ancient, climate-resilient grains, are now recognized as a potential solution to these complex problems. Millets have been an integral part of the diets from the ancient periods. Unfortunately, with time the production and consumption of millets have reduced drastically and limited to the selected regions of the globe. The green revolution has selectively emphasized the cultivation of crops like wheat and rice created an enormous drift in the farming practices of millets and other essential ancient food plants. Millets are highly nutritious being rich source of proteins, vitamins, and minerals. About 80% of millet grains are used for food, while the rest is used as animal fodder and in brewing industry for alcoholic products (Saleh et al., 2013; Shivran, 2016). Millets are commonly referred as "small seeded grasses" which include pearl millet [Pennisetum glaucum (L.) R.Br.], finger millet [Eleusine coracana (L.) Gaertn], foxtail millet [Setaria italica (L.) Beauv], proso millet (Panicum miliaceum L.), barnyard millet (Echinochloa spp.), kodo millet (Paspalum scrobiculatum), and little millet (Panicum sumatrense).

Image 1. Millets: The Nutri-Cereal

Millets are highly nutritious crops feeding poor populations in Asia and Africa. Scientific research to utilize the highly nutritious millet crops to combat micronutrient malnutrition is still meager. Beyond their nutritional richness, millets exhibit exceptional adaptability to diverse agroecological conditions, making them resilient crops in the face of climate change and water scarcity. They require considerably fewer resources and inputs in comparison to many other staple crops, making them an environmentally sustainable choice for resource-constrained regions.

The promotion of millets in both agricultural practices and diets aligns cohesively with several Sustainable Development Goals (SDGs), including zero hunger (SDG 2), good health and well-being (SDG 3), and responsible consumption and production (SDG 12). Millets can play a pivotal role in achieving these goals by contributing to diversified and nutritious diets, enhancing income opportunities for smallholder farmers, and reducing the environmental footprint of food production.

The purpose of this review paper is to delve into the nutritional composition of millets

and examine their potential implications for combating malnutrition and ensuring food security. Millets are distinguished by their unique nutritional profile, which includes a well-balanced ratio of macronutrients - comprising proteins and complex carbohydrates - along with an array of essential micronutrients such as iron, zinc, calcium, and several B vitamins. Their high fiber content contributes to improved digestion, aids in satiety, and holds the potential to reduce risk factors for non-communicable diseases.

1.1 Millet production in India :

At present, with millets being grown in about 21 states, India is its largest producer in the world. With 173 lakh tonnes of millets production, India accounts for 80 percent of Asia's millets production and 20 percent of the global production. In India, the cultivated area of millets is 12.45 million hectares which produces 15.53 million tonnes with a yield of around 1247 kg/ha. It is interesting to note that India is the topmost producer of barnyard millet (99.9 percent), finger millet (53.3 percent), kodo millet (100 percent), little millet (100 percent), and pearl millet (44.5 percent), producing about 12.46 million metric tonnes from an area of 8.87 million ha. Pearl millet (bajra) and finger millet (ragi) are the two most widely cultivated types. Millets have been an essential part of traditional Indian diets.

Among the states in India, Rajasthan has the maximum area under cultivation (6.15 million hectares) for millets and is the largest producer (8.33 million tonnes) as well. Telangana has the highest yield (6563 kg/hectare) for millets. West Bengal has seen the highest increase in area under cultivation as well as production between 2014-15 and 2020-21 while Telangana has seen the greatest increase in yield. Maharashtra during the same period witnessed a 5.3% decline in area under millet cultivation but interestingly, the state's production has increased by 3.09%. A look at the state-wise production figures of nutri-cereals in 2020-21 shows that close to 70% of the production in the country is concentrated in the six states of Rajasthan, Karnataka, Maharashtra, Madhya Pradesh, Uttar Pradesh and Tamil Nadu (Agriculture Statistics at a Glance, 2021). Their production needs to be encouraged in other states and UTs as well especially in the states which have a very high incidence of anaemia such as Gujarat, Punjab and Haryana.

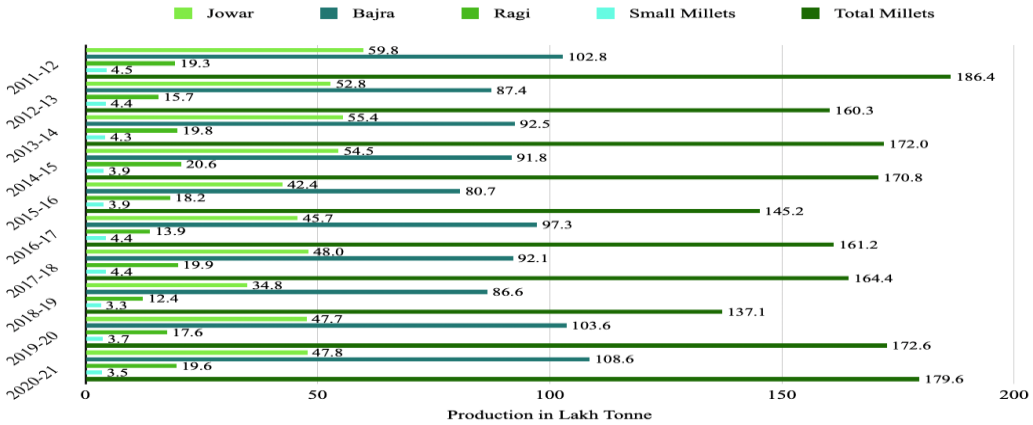

Fig 1: Millet production in India (2011-12 onwards) Source: Author's calculation based

on data from Directorate of Economics and Statistics, Ministry of Agriculture

Millets provide essential vitamins and micronutrients that can bolster nutrition for populations in dry land areas. They are rich sources of nutrients, such as carbohydrates, protein, fibre, and good-quality fats, and contain significantly higher amounts of minerals, such as calcium, potassium, magnesium, iron, manganese, zinc, and B-complex vitamins. Millets are an excellent source of slow digestive starch and fibre. The presence of 1.5–5 percent fat, 65 percent carbohydrates, and 6–12.5 percent protein makes them energy-dense and an excellent choice for fortification against malnutrition. Millets also have other dietary qualities that can help stave off anaemia, celiac disease, and diabetes.

1.2 Millet production and consumption in the world :

India, Nigeria and China are the largest producers of millets in the world, accounting for more than 55% of the global production. For many years, India was a major producer of millets. However, in recent years, millet production has increased dramatically in Africa. It is grown in about 131 countries and is the traditional food for around 60 crore people in Asia & Africa. India is the largest producer of millet in the world. It accounts for 20 % of global production and 80% of Asia's production.

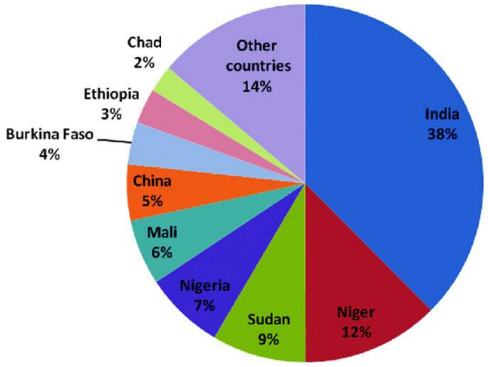

Fig 2. Millet Production (%) in key countries

The top importers of millets along with their share in world import are Indonesia (8%), Belgium (7.36%), Germany (4.65), Mexico (4.1%), Italy (4.02%), United States of America (3.35%), United Kingdom (3.25%) Brazil (3.24%) and Netherlands (3.14%) in 2020. The per capita consumption of millets is the highest in the countries of Western Africa. In the Sahel region countries of Gambia, Burkina Faso, and Chad, 35% of the total cereal consumption contained millet. In Niger and Namibia, 60% of the cereal consumption involves millets while the cereal accounts for 40% of the cereal intake in Mali and Senegal.

1.3 Comparison of Millets with Other Major Cereal Crops :

When compared to other major cereals like rice, wheat, and maize, millets often have superior nutritional profiles. The protein content in millets is similar to wheat and higher than rice, with better essential amino acid profiles. Millets are nutritionally superior to rice and

wheat as they contain a high amount of proteins, dietary fibers, iron, zinc, calcium, phosphorus, potassium, vitamin B, and essential amino acids (Hegde et al., 2005; Saleh et al., 2013). Millets also have higher fiber content, promoting satiety, and improving digestive health compared to rice and wheat. Millets are an excellent source of several essential minerals, like iron and zinc. The iron content in millets, particularly in finger and pearl millets, is significantly higher than in rice and wheat. The same goes for zinc content, especially in pearl millet. Millets contain more calcium than any other cereal. The calcium content in finger millet is about 10 times that in rice or wheat. Thus, millets can contribute significantly to overcoming the common global challenge of micronutrient malnutrition, often referred to as "hidden hunger" Srivastava et al. (2023).

Grain/ nutrient	Bajra	Jowar	Ragi	Fox tail millet	Proso millet	Barnyard millet	Kodo millet	Rice-milled	Maize	Wheat-flour
Energy	361	349	328	331	341	397	309	345	342	346
Protein (g)	11.6	10.4	7.3	12.3	7.7	6.2	8.3	6.8	11.1	12.1
Fat (g)	5.0	1.9	1.3	4.3	4.7	2.2	1.4	0.4	3.6	1.7
Calcium (mg)	42.0	25.0	344	31.0	17.0	20.0	27.0	10.0	10.0	48.0
Iron (mg)	8.0	4.1	3.9	2.8	9.3	5.0	0.5	3.2	2.3	4.9
Zinc (mg)	3.1	1.6	2.3	2.4	3.7	3.0	0.7	1.4	2.8	2.2
Thiamine (Vit. B1) (mg)	0.33	0.37	0.42	0.59	0.21`	0.33	0.33	0.06	0.42	0.49
Riboflavin Vit. B2 (mg)	0.25	0.13	0.19	0.11	0.01	0.10	0.09	0.06	0.10	0.17
Folic acid mg	45.5	20	18.3	15.0	9.0	-	23.1	8.0	20	36.6
Fibre g	1.2	1.6	3.6	8.0	7.6	9.8	9.0	0.2	2.7	1.2

Table No. 1 Nutrient content of cereals and millets per 100 g (Gopalan et al., 1989)

1.4 Health Benefits Associated with Millet Consumption :

The health benefits of millets are mainly attributed to their rich nutritional profile. They have high dietary fiber content, which aids digestion and promotes a feeling of satiety, aiding in weight management. Millets are rich in phytochemicals, including phenolic compounds and phytosterols, which have antioxidant and anti-inflammatory properties, reducing the risk of chronic diseases such as diabetes and heart disease. The high magnesium content in millets also contributes to their cardio-protective properties by playing a vital role in regulating blood pressure and reducing the risk of stroke.

Millets, being gluten-free, are suitable for individuals with celiac disease or gluten sensitivity. Also, millets have a low glycemic index, helping to control blood sugar levels, which is beneficial for people with diabetes. The high content of iron and zinc in millets can help combat anemia and boost immune function, respectively. The high calcium content, especially in finger millet, is beneficial for bone health. Millets, a group of small-seeded, cereal grains, have emerged as a promising solution at the intersection of these challenges.

Historically a staple food in many regions, millets offers a wide array of nutritional benefits, including a rich source of protein, dietary fiber, vitamins, and minerals. Additionally, they hold a distinct advantage in being naturally gluten-free, rendering them suitable for individuals with celiac disease or gluten sensitivities.

Realizing the health benefits of millets viz gluten free, low fat and low carbohydrates, the efforts have been made to increase production, productivity and income of millet growers under various schemes of the Central and State Governments. To encourage production and consumption of millets, Government of India notified millets as Nutri-Cereals in April 2018 which includes Sorghum (Jowar), Pearl Millet (Bajra), Finger Millet (Ragi/Mandua), Minor Millets i.e., Foxtail Millet (Kangani/Kakun), Proso Millet (Cheena), Kodo Millet (Kodo), Barnyard Millet (Sawa/Sanwa/ Jhangora), Little Millet (Kutki) and two Pseudo Millets Buckwheat (Kuttu) and Amaranthus (Chaulai).

2. Nutritional composition of millets :

In recent years, the health-benefiting nutritional values of millets have been noted, and it is considered a storehouse of nutrition. Millets contain 7-12% protein, 2-5% fat, 65-75% carbohydrates and 15-20% dietary fibre and are also a natural source of iron, zinc, calcium and other nutrients that are essential for tackling the problem of malnutrition and anaemia in India. Millets can also help in several lifestyle diseases like obesity, diabetes, cardiovascular diseases and cancer due to the presence of slow digestible starch (SDS) which prolongs digestion and absorption of carbohydrates.

Apart from carbohydrates and proteins, they are also rich in antioxidants, dietary fiber, phytochemicals, vitamins, and minerals. Millets are a good source of protein, and the grains of proso-, foxtail-, and pearl millet have a significantly higher protein profile than rice, wheat, and maize. Further, millet proteins are reasonably abundant in essential amino acids and sulfur-containing amino acids, including cysteine and methionine. Generally, cereal proteins are limited in tryptophan and lysine contents, but this could vary within varieties. Thus, with the virtuous essential amino acid contents, the biological value of protein digested from millets is also more than other major cereals.

Millets are also rich in dietary fibers and low glycaemic index (GI) polysaccharides. Lipids are nonpolar biomolecules that include biomolecules like sterols, fatty acids, waxes, monoglycerides, diglycerides, triglycerides, phospholipids. Millets are a good source of essential fatty acids like linoleic acid, linolenic acid, and arachidonic acid. The fat content in millets is found to be between 1-5%.

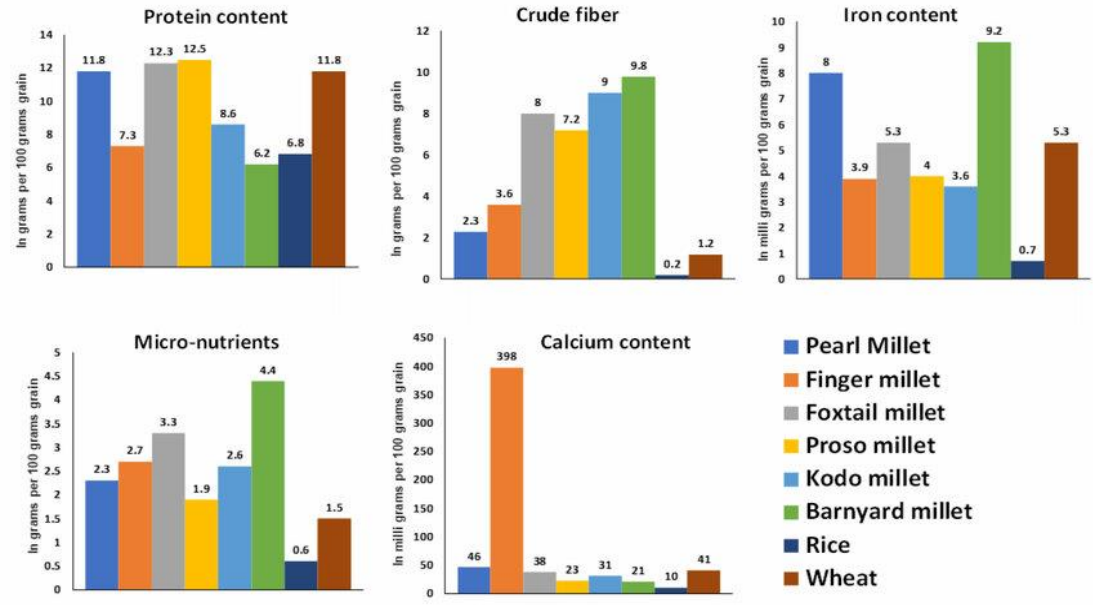

Fig.3 Comparative illustration of the nutritional content of millet of millet seeds (per 100 g) with rice and wheat [Source- Annvi Dhaka, *et al*., Genetics and Genomics Interventions for Promoting Millets as Functional Foods. Current Genomics, 2021, 22, 154-163]

3. Millets as contributors of nutritional security :

Nutritional security is the key to improve the health status of the world's population as mankind is primarily dependent on plant-based diets. Millets are important sources of nutrients and can play a significant role in improving nutritional security and preventing diseases caused by imbalanced nutrition. They are gluten-free and contain as much protein as wheat does. In terms of macronutrients, millets are either similar or superior to major cereals (Kumar *et al.*, 2018). They also contain several micronutrients, vitamins, insoluble dietary fiber, and phenolic compounds, which are essential for health benefits. They are thought to have several health benefits including the ability to address diabetes, aging, cancer, celiac disease, and cardio-vascular disease (Bhat et al., 2018). Millets are a group of diverse small-grain cereal crops grown in marginal soil and under stressed conditions. They comprise about a dozen crop species originated in Asia and Africa, primarily in the third world countries (Gupta et al., 2017).

Small millets are used as an ingredient in multigrain and gluten-free cereal products and serves as a major food component for various traditional foods and beverages, such as bread, porridges, and snack foods, and while grains are feed to animals, including pigs, fowls, and cage birds. All these crops have superior nutritional properties including high micronutrients, dietary fibre content and low glycemic index (GI) with potential health prospective (Chandel *et al.*, 2014; Dwivedi *et al.*, 2012; Saleh *et al.*, 2013). Millets are recommended for well- being of infants, lactating mothers, elderly, and convalescents. The grains release sugar slowly into the blood stream and thus considered "gluten-free" (Taylor and Emmambux, 2008). With high fiber and protein content, millets are preferred as dietary foods for people with diabetes and cardiovascular diseases (Muthamilarasan et al., 2016). Indeed, in recent years, many countries

have started focusing on the Neglected and Underutilized Species (NUS) for sustainable livelihood of people living in the developing countries for secure food and nutrition supply.

4. The potential of millets for combating malnutrition and ensuring global food security :

Nutritional security and food security are interconnected concepts that are vital for the well-being of individuals, communities, and nations. The concept of Food Security evolved over time from 'freedom from hunger' in the early 1940s into broad concept encompassing four dimensions i.e. Availability of foods, Access to food, utilization and stability. The 1995 World Food Summit declared, “Food security at the individual, household, regional, national and global levels exist when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO, 1996). The declaration further recognizes that “poverty eradication is essential to improve access to food”.

Ensuring food and nutrition security for a huge and diverse population in India, at the macro and micro-level, is a challenge and efforts have been made in many different fronts. Nutritional security is the key to improve the health status of the world’s population as mankind is primarily dependent on plant-based diets. Plants are the major source of nutrients essential for normal growth and development. However, half of the global population, especially people from Asia and Africa suffer from nutrition deficiency as they rely on cereal crops for food (White and Broadley, 2005; Hirschi, 2009; Zhao and McGrath, 2009).

Millets are nutritionally superior to rice and wheat as they contain a high amount of proteins, dietary fibers, iron, zinc, calcium, phosphorus, potassium, vitamin B, and essential amino acids (Hegde et al., 2005; Saleh et al., 2013). India is the leading producer of millets accounting for about 80% of the global millet production (Food and Agricultural Organization [FAO], 2015)

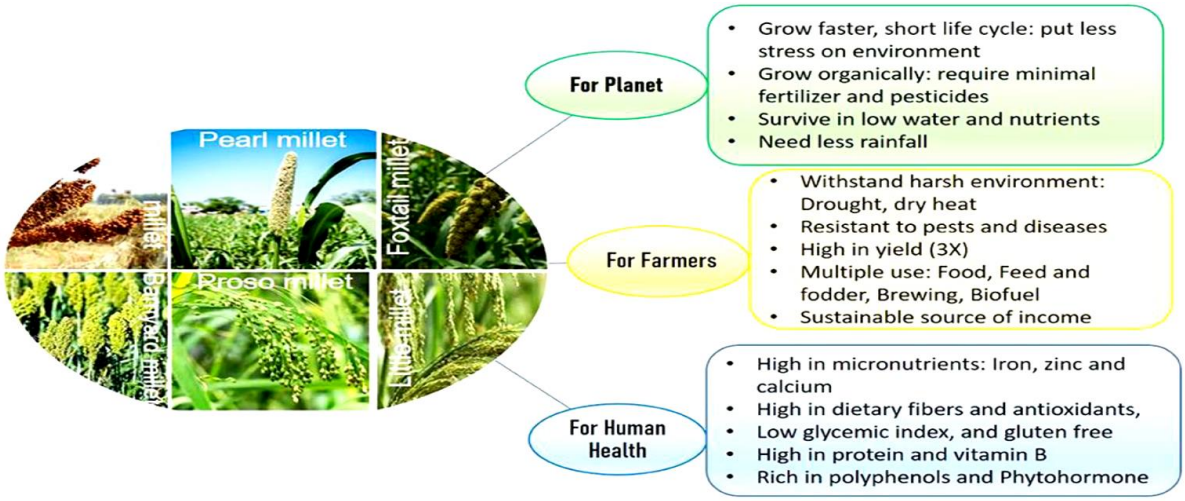

Fig. 4. Unique properties of millets for climate smart agriculture, ensuring human health, food and nutritional security. (Kumar et al, 2022*)*

Conclusion :

It was realized that millets have substantial potential to contribute toward food and nutritional security in India. Millets represent a valuable and multifaceted resource in the ongoing effort to combat malnutrition and enhance global food security. Their inherent nutritional richness, coupled with adaptability and sustainability, renders them a compelling choice for a more resilient and nutritious food future. Millets can contribute significantly to overcoming the common global challenge of micronutrient malnutrition, often referred to as "hidden hunger". However, unlocking the full potential of millets necessitates concerted efforts at global, national, and local levels to promote their adoption and maximize their benefits for communities worldwide.

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