*Journal of Experimental Agriculture International*

***Volume 45, Issue 10, Page 44-50, 2023; Article no.JEAI.105021***
***ISSN: 2457-0591***
*(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)*

# Millets-A Powerhouse for Food Security and Combating Malnutrition

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/JEAI/2023/v45i102199

**Open Peer Review History:**
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/105021

***Review Article***

***Received: 14/06/2023***
***Accepted: 19/08/2023***
***Published: 31/08/2023***

## ABSTRACT

Malnutrition remains a global challenge, affecting millions of people and posing a significant threat to food security. It has become the emerging challenge in the contest of raising uncertainty of food supplies. Malnutrition factors like hidden hunger and micronutrient deficiency has become life threatening for children and women, as they become susceptible to common infections and life-threatening diseases. Millets are the ancient heritage grains valued for their nutritional properties as well as due to their high resistance to abiotic stress and low input requirement. These coarse grains are a rich source of carbohydrates, dietary fibres, fats, proteins, vitamins, essential minerals and trace elements, essential amino acids, and anti-oxidants, and hence can be regarded as miracle

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grains. Despite the ease of cultivation and various nutritional and therapeutic properties, very less importance is given for its promotion. These neglected crops can assure food security and sustainable production. In this review, a brief account on the role of millets to combat malnutrition and achieve nutritional security has been furnished.

*Keywords: Millets; malnutrition; hidden hunger; micronutrient deficiency; nutritional and therapeutic properties.*

## 1. INTRODUCTION

According to the World Food Program [1], “more than 345 million people face high levels of food insecurity and that is more than double the number in 2020”. “The climatic disaster, which obliterates lives, crops, and livelihoods while undermining people's capacity to feed themselves, is one of the main contributors to the sharp increase in world hunger. Global fertilizer crisis has climbed high which could turn the current food affordability crisis into food availability crisis, with production of food grains falling in 2022” [1]. In addition, changing climate conditions has caused a major threat to farmers. Climate resilient crops (millets) would address world hunger and improve the income of farmers. For attaining sustainable methods for nutritional security, the importance of millets cannot be understated (Chart 1). Millets have proven to be multipurpose crops, offering a range of benefits. For instance, they consume approximately 70 percent less water than rice, which is a significant advantage in regions facing water scarcity. Additionally, millets have a shorter growth cycle compared to wheat, taking half the time to mature. Moreover, the processing of millets requires about 40 percent less energy [2]. These attributes make millets a one-stop solution to tackle the challenges posed by climate change, water scarcity, and drought conditions. Furthermore, millets possess high nutritive value, contributing to sustainable food security.

## 2. MILLETS AND THEIR CHARACTERISTIC FEATURES

Millets are small seeded coarse cereals cultivated mostly by small holders and tribal farmers under rainfed conditions. They originated in Asia and Africa and were domesticated by the local populations and spread to other regions of the world [3] Millets are categorized into two main categories (1) major millets which include sorghum, pearl millet and finger millets and (2) minor millets which include little millet, proso millet, barnyard millet, foxtail millet and kodo millet [4]. In India, millets are utilized for food, fodder, feed and fuel. Table 1: provides a comprehensive list of millets and their characteristic uses. These were used as flour, partially broken, or as a whole grain in various local recipes.

## 3. ROLE OF MILLETS IN FOOD SECURITY AND COMBATING MALNUTRITION

Millets are nutritionally dense, containing high levels of protein, dietary fiber, vitamins, minerals and phytochemicals of diverse therapeutic uses. Table 2 shows the proximate composition of millets and other cereals. “Millets are better than other cereals since they have high fiber content, antioxidants, gluten-free proteins, low glycemic index, and filled with biologically active compounds. Millet protein has a good composition of essential amino acid like methionine and cysteine which contains sulphur” [5,6]. “It has huge potential to work as alternative grains for ensuring food and nutritional security in most parts of the world” [7,8]. The consumption of millets can contribute to balanced diets and improve the nutritional status of populations, particularly in regions where malnutrition is prevalent.

Apart from the macronutrients content, millets also harness a large quantity of micronutrients as mentioned in Table 3. “Micronutrient and trace elements are the nutrients required in minimal quantities but play a vital role in bone development, blood clotting, cell signaling, heartbeat control, cell energy metabolism, oxygen transport, protein and fat metabolism, and coenzyme roles in nerve conduction and bodily immunity. The micronutrients present in the millets are far higher than the other cereals” [11]. The nutritional and nutraceutical potential of millets is mentioned in Table 4.

**Chart 1. Millets: A strategy for sustainable agriculture and a healthy environment**

| Food security | Nutritional security | Safety from diseases | Economic security |
|---|---|---|---|
| ● Sustainably produced food to fight world hunger in light of climatic change.<br>● Resistant to climate stress, pests and diseases. | ● Rich in micronutrients like calcium, iron, zinc, iodine etc.<br>● Rich in bioactive compounds.<br>● Better amino acid profile. | ● Gluten free: a substitute for wheat in celiac diseases<br>● Low GI: a good food for diabetic persons<br>● Can help to combat cardiovascular diseases, anemia, calcium deficiency etc. | ● Climate resilient crop<br>● Sustainable income source for farmers<br>● Low investment needed for production<br>● Value addition can lead to economic gains |

***Source:*** *(Suri, [2])*

**Table 1. Millets and their characteristic uses**

| Millets | Scientific name | Common name | Major areas of production for grains | Uses |
|---|---|---|---|---|
| Sorghum | *Sorghum bicolor* | Great millet, jowar, cholam, jola, jonna, durra, Egyptian millet, feterita, Guinea corn, jwari, juwar, milo, shallu, gaoliang, kaoliang, kafir corn, dura, dari, mtama, solam. | USA, Nigeria, Sudan, Mexico, Ethiopia, India, Argentina, China, Niger, Australia | Grown for food grain in Asia and Africa, for fodder in Americas |
| Pearl millet | *Pennisetum glaucum* | Bajra, cattail, bulrush, candlestick, sanyo, munga, seno | India, Western & Central Africa, Eastern & Southern Africa | Grown for food grain in Asia and Africa, for fodder in Americas |
| Finger millet | *Eleusine coracana* | Ragi, African,bird's foot, rapoko, Hunsa, wimbi, bulo, telebun, koracan, kurakkan | India, Ethiopia, Nepal, Uganda, Malawi, Burundi, Sri Lanka, Rwanda | Grown for food grain and beer making in Asia and Africa |
| Foxtail millet | *Setaria italica* | Italian, German, Hungarian, Siberian, kangani, navane, thanahal | China, Myanmar, India, Eastern Europe | Grown for food grain and fodder |
| Proso millet | *Panicum milliaceum* | Common, hog, broom, samai, Russian, | Russia, USA, Ukraine, South | Grown for food grain and bird |

| Millets | Scientific name | Common name | Major areas of production for grains | Uses |
|---|---|---|---|---|
| | | panivarigu, panic, maha meneri | Korea, Kazakhstan, France, Poland, Belarus, India, Iran | seed |
| Little millet | *Paspalum sumatrense* | Blue panic, heen meneri | India | Grown for food grain |
| Kodo millet | *Paspalum scrobiculatum* | Varagu, bastard, ditch, naraka, water couch, Indian paspalum, creeping paspalum, amu | India | Grown for food grain |
| Barnyard millet | *Echinochola crusgalli* | Japanese, sanwa, sawan, Korean, kweichou | India, Japan, China, Malaysia | Grown for food grain |

***Source:*** *(Bhat, Rao, & Tonapi, [3])*

**Table 2. Proximate composition of millets and other cereals (per 100g)**

| Millet/Cereal | Calorific value (kcal) | Carbohydrate (g) | Protein (g) | Fat (g) | Crude fiber (g) | Minerals (g) |
|---|---|---|---|---|---|---|
| Sorghum | 349 | 72.6 | 10.4 | 1.9 | 1.6 | 1.6 |
| Pearl millet | 361 | 67.5 | 11.6 | 5.0 | 1.2 | 2.3 |
| Finger millet | 328 | 72.0 | 7.3 | 1.3 | 3.6 | 2.7 |
| Foxtail millet | 331 | 60.9 | 12.3 | 4.3 | 8.0 | 3.3 |
| Proso millet | 341 | 70.4 | 12.5 | 1.1 | 2.2 | 1.9 |
| Barnyard millet | 307 | 65.5 | 6.2 | 2.2 | 9.8 | 4.4 |
| Kodo millet | 309 | 65.9 | 8.3 | 1.4 | 9.0 | 2.6 |
| Little millet | 341 | 67.0 | 7.7 | 4.7 | 7.6 | 1.5 |
| Rice (raw milled) | 345 | 78.2 | 6.8 | 0.5 | 0.2 | 0.6 |
| Wheat flour (whole) | 341 | 69.4 | 12.1 | 1.7 | 1.9 | 2.7 |
| Maize (dry) | 342 | 66.2 | 11.1 | 3.6 | 2.7 | 1.5 |

***Source:*** *(Gopalan, Ramashastri, & Balasubramanium, [9,10])*

**Table 3. Micronutrient composition of millets and other cereals (mg/100 g)**

| Millet/Cereal | Iron | Calcium | Zinc | Phosphorous | Potassium | Magnesium |
|---|---|---|---|---|---|---|
| Sorghum | 4.1 | 25 | 1.6 | 222 | 131 | 171 |
| Pearl millet | 8.0 | 42 | 3.1 | 296 | 307 | 137 |
| Finger millet | 3.9 | 344 | 2.3 | 283 | 408 | 137 |
| Foxtail millet | 2.8 | 31 | 2.4 | 290 | 250 | 81 |
| Proso millet | 0.8 | 14 | 1.4 | 206 | 113 | 153 |
| Barnyard millet | 5.0 | 20 | 3.0 | 280 | - | 82 |
| Kodo millet | 0.5 | 27 | 0.7 | 188 | 144 | 147 |
| Little millet | 9.3 | 17 | 3.7 | 220 | 129 | 133 |
| Rice (raw milled) | 0.7 | 10 | 1.4 | 160 | - | 90 |
| Wheat flour (whole) | 4.9 | 48 | 2.2 | 3555 | 315 | 132 |
| Maize (dry) | 2.3 | 10 | 2.8 | 348 | 286 | 139 |

***Source**: (Gopalan, Ramashastri, & Balasubramanium, [9])*

**Table 4. Nutritional and nutraceutical potential of millets**

| S. No | Disease | Benefits | Positive factors |
|---|---|---|---|
| 1 | Diabetes | Treating diabetes | With low glycemic index |
| 2 | Anemia | Help in increasing hemoglobin | High iron and zinc concentration |
| 3 | Cancer | Anti-cancer property | Inhibit tumor growth |
| 4 | Stomach ulcer | Convert the stomach alkaline and prevent the formation of ulcers | Prevents formation of excess acidity |
| 5 | Constipation | Helps in reducing constipation | High fiber content |
| 6 | Heart health | Phytonutrients and lignin act as a strong antioxidant thus prevent heart disease. High content of magnesium useful in controlling blood pressure and heart stress. | As strong antioxidant |
| 7 | Prevent gall bladder stones | Reduces the risk in the gall bladder stone. Reduces the production of excessive bile Juice. | High fiber content |
| 8 | Respiratory problems for asthma patients | High amount of magnesium reduces respiratory problems (asthma patients). Reduce migraine attacks. | High amounts of magnesium |
| 9 | Bone growth, development and repair | High phosphorus is essential for bone growth Production of ATP, that is, energy currency in body | Due to presence of phosphorus |
| 10 | Anti-allergic properties | High digestible Low allergic response | Due to hypoallergic property |

***Source:** (Malik, [12])*

From the Tables 2, 3 and 4, it is clear that millets are rich in essential nutrients such as protein, dietary fiber, vitamins, and minerals like iron, calcium, and zinc. The high protein content of millets makes them an excellent source of plant-based protein, essential for growth and development. The dietary fiber in millets aids in digestion, promotes satiety, and helps prevent conditions such as obesity and diabetes [13]. The abundance of vitamins and minerals in millets supports overall health, including immune function, bone strength, and cognitive development. Therefore, consumption of millets can contribute to balanced diets and improve the nutritional status of populations, particularly in regions where malnutrition is prevalent.

## 4. SUSTAINABLE AND AGRARIAN IMPORTANCE OF MILLETS

Climate change poses significant challenges to agriculture, including rising temperatures, increased atmospheric $CO_2$ levels, and uncertain rainfall patterns. To address these challenges and ensure sustainable food production, the adoption of climate-smart agricultural practices is essential. One such practice involves cultivating crops that are resilient to climate change, and millets have emerged as a promising option.

Millets are a group of small-seeded cereal crops, including varieties such as finger millet, pearl millet, sorghum, and foxtail millet. They possess inherent characteristics that enable them to mitigate the adverse effects of climate change and adapt to a wider range of agro-climatic conditions. Studies, such as the research conducted by Kumar et al., [14], highlight the potential of millets as climate-smart crops.

Millets exhibit efficient morphological, physiological, molecular, and biochemical traits that contribute to their ability to withstand abiotic stresses induced by climate change [15]. One key characteristic is their drought tolerance, allowing them to thrive in regions with limited water availability. Millets have deep root systems that enable them to access moisture stored in deeper soil layers, improving their resilience to water scarcity. Additionally, millets exhibit water-use efficiency, ensuring optimal use of available water resources.

Furthermore, millets demonstrate heat tolerance, which is crucial in the face of rising temperatures [15]. They have mechanisms to dissipate excess heat, maintain cellular integrity, and protect against oxidative damage. These adaptive traits enable millets to tolerate high temperatures and maintain their productivity under heat stress conditions.

Millets also exhibit a remarkable capacity to adapt to elevated $CO_2$ levels, a prominent greenhouse gas. They can efficiently utilize atmospheric $CO_2$ for photosynthesis, which enhances their productivity under elevated $CO_2$ concentrations [16]. This feature is particularly relevant in a changing climate where $CO_2$ levels are expected to rise.

Additionally, millets have a short growing cycle, allowing for quicker maturation and harvest [3]. This shorter duration helps them avoid prolonged exposure to adverse climatic conditions, reducing the risk of yield losses due to erratic rainfall patterns or extreme weather events.

The nutritional resilience of millets further contributes to their climate-smart characteristics. They possess high nutrient content, including protein, fiber, vitamins, and minerals, which are crucial for addressing malnutrition in vulnerable populations. Incorporating millets into diverse and nutritious diets can improve food security and enhance nutritional outcomes, especially in regions prone to climate-related food insecurity. The cultivation of millets supports sustainable agricultural practices by requiring fewer inputs such as water, fertilizers, and pesticides compared to other major crops. This reduces the environmental footprint and contributes to the conservation of natural resources.

## 5. CONCLUSION

Millets offer a sustainable solution for achieving food security. Their resilience, adaptability, and nutritional value make them well-suited for cultivation in challenging environments. Embracing millets as a key component of food security strategies is crucial for building resilient and inclusive food systems. By incorporating millets into agricultural systems, we can promote climate-smart agriculture, enhance food security, and build resilience in the face of environmental changes. Further research, policy support, and awareness campaigns are necessary to fully harness the potential of millets and ensure their widespread adoption for a sustainable and climate-resilient agriculture.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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