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Health - Promoting Potential of Millet: A Review- A Certain Crop for an Uncertain Future: Economic Perspective of Millets as a Solution to Nutritional Insecurity

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Abstract: ***Millet production has experienced significant growth in recent years to address the dietary demands of the expanding global population. This crop serves as an excellent source of essential nutrients, including protein, carbohydrates, fats, vitamins, minerals, and a range of bioactive compounds. These compounds contribute to various biological activities, such as antioxidant, anti - hyperglycaemic, anti - cholesterol, anti - hypertensive effects, as well as influencing anthropometric parameters and modulating gut microbiota composition. The nutritional and functional properties of millet can be modified through processing techniques such as decortication, soaking, malting, milling, and fermentation. This review synthesizes findings from approximately 50 articles published between 2015 and 2022, sourced from databases including the Web of Science, Google Scholar, the Food and Agriculture Organization (FAO), Breeding Bid Survey (BBS), and Food Data Central (USDA). The evidence highlights that the incorporation of millet and its bioactive constituents into food products offers potential solutions to malnutrition and various health - related concerns. Additionally, this review provides critical insights into the health - promoting properties of millet, serving as a comprehensive resource for industry stakeholders, consumers, researchers, and nutritionists.***

Keywords: millet; health benefit; bioavailability; diet; gut microbiota

1. Introduction

Millet, a small - seeded grass from the Poaceae family, thrives in arid and hot climates. It has been used for both human consumption and animal feed for over 10, 000 years. According to the Food and Agriculture Organization (FAO) of the United Nations, China, India, and Niger are among the leading producers, although millet is primarily grown in Asia and Africa. Several millet varieties exist, including finger millet, proso millet, foxtail millet (FM), and pearl millet. Compared to rice and wheat, millet is richer in several macronutrients, minerals (such as iron, zinc, phosphorus, calcium, and potassium), and vitamins. However, the presence of antinutrients such as phytates, polyphenols, and tannins can reduce the bioavailability of these minerals by chelating cations. Despite this, millet's phytochemicals, particularly its phenolic compounds, possess antioxidant properties that help scavenge reactive oxygen species (ROS), reduce energy, and/or inhibit the absorption of ferric and ferrous ions through metal chelation. The grains also contain protease and amylase inhibitors, which impact their digestibility. Millet is recognized for its beneficial natural traits, including a low glycemic index, hypolipidemic effects, and antioxidant activity. Due to its high nutritional content, millet is commonly used worldwide in the preparation of noodles, nutritious soups, beverages, pancakes, and cereal porridges. This review aims to provide a comprehensive overview of the health benefits associated with millet and its impact on human health.

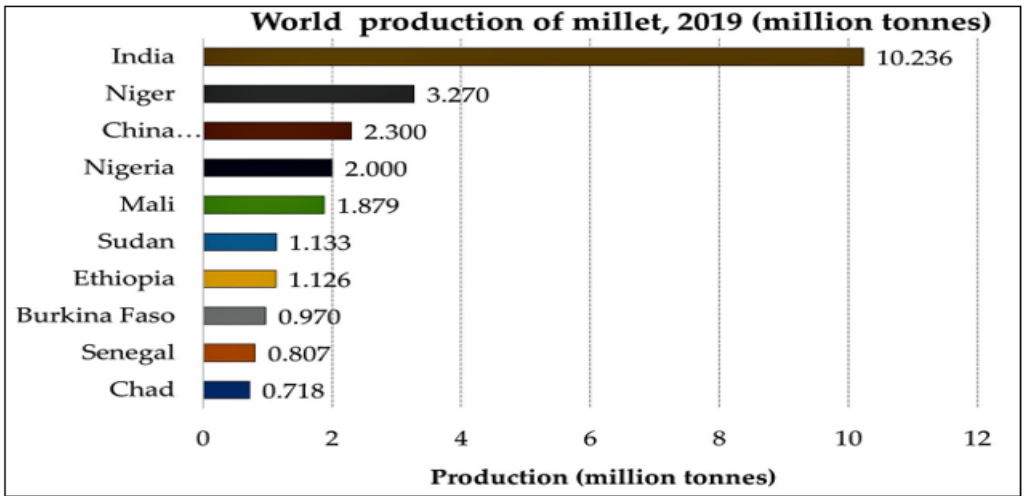

Figure 1: Millet production worldwide (million tons)

Table 1: Characteristics and Potential Health Benefits of Different Millet Varieties

Millet Type	Key Features
Foxtail Millet	Reduces the risk of colon cancer, lowers cholesterol, and has anti - diabetic properties. Aids in mitigating ethanol - induced liver damage.
Pearl Millet	Gluten - free, which helps prevent celiac disease. Boosts immune function by inhibiting Shigella - induced pathogenicity.
Finger Millet	Promotes soft tissue repair and accelerates healing. Reduces plasma triglycerides, lowering cardiovascular disease risk.
Kodo Millet	Lowers glycemic index, reduces the likelihood of diabetes, and has antioxidant properties.
Proso Millet	Gluten - free, which helps prevent celiac disease. Low glycemic index reduces the risk of type 2 diabetes.
Little Millet	High in polyphenols, which help prevent various metabolic disorders.
Barnyard Millet	Reduces apoptotic cell damage, lowering the risk of colorectal cancer. Inhibits protein glycation and glycoxidation, improving diabetes management.

2. Methodology

To provide a comprehensive overview of millet's health benefits, this study presents a detailed review based on data from the Web of Science, Google Scholar, the Food and Agriculture Organization of the United Nations (FAO), and FoodData Central (USDA) databases, covering the period from 2015 to 2022. This review includes findings from over 100 articles.

Proximate Composition of Pearl and Finger Millets (g/100 g)

Nutrient	Pear Millet	Finger Millet
Moisture Content	12.4	7.15 - 13.1
Protein	11.6 - 11.8	7.7
Fat/Lipids	4.8 - 5.0	1.8
Mineral Content	2.2 - 2.3	2.7
Dietary Fibre	11.3	15 - 22.0
Neutral Detergent Fibre	9.0	12.7
Acid Detergent Fibre	3.3	8.7
Carbohydrates	67 - 67.5	75.0 - 83.3
Gross Energy (MJ/kg)	17.0	15.8

Mineral Content (mg/100 g)

Minerals	Pearl Millet	Finger Millet
Phosphorus	296	130 - 250
Potassium	307	430 - 490
Magnesium	137	78 - 201
Calcium	42	398
Sodium	10.9	49
Zinc	3.1	2.3
iron	8.0	3.3 - 14.89

Millets as food and feed

Millet grains, rich in calcium, dietary fiber, polyphenols, and protein, are esteemed as special crops and serve as a vital food source in numerous African and Asian countries. The majority of millet production is allocated for human consumption, with a smaller portion used for beer and animal feed. In certain African regions, millet is fashioned into porridge or couscous, while in Asia, it contributes to poultry feed, proving beneficial in chicken production. Notably, pearl millet, a prevalent variety, is a key component in building, fuel, and animal feed industries.

Millet, considered an all - season crop, offers holistic benefits, including food security, fodder, nutrition, and a stable livelihood. In contrast, Seasonal crops like wheat and rice predominantly address food security concerns. The gluten - free nature of pearl millet grains, coupled with their elevated dietary fiber content compared to rice, positions them as a promising human food source. Additionally, Millets contain higher levels of essential amino acids, including leucine, isoleucine, and lysine, compared to conventional cereals such as wheat and rye. Millet's versatility extends to its widespread use in India, where it forms the base for dosa, couscous, biscuits, sushi, roti, and yeast - free pizza. India also features the production of madua, a popular finger millet beverage. Furthermore, Namibia utilizes millet in the creation of Oshikundu, a traditional drink with both alcoholic and non - alcoholic variations.

Challenges of food security in the developing countries

Food security refers to the state where individuals have both physical and economic access to safe and nutritious food to meet their dietary needs. While often attributed to the availability of agricultural products, particularly livestock, the challenges of food security extend beyond mere supply augmentation. Complex factors, such as urbanization and accessibility, contribute to these difficulties, along with institutional shortcomings and the overarching frameworks controlling economies and societies.

Climate change - induced phenomena, like the first rain shock, significantly impact food security, as evidenced in studies like Abegaz's examination of food security in Ethiopia. François et al. underscore the complexity of addressing food insecurity through casual interventions, emphasizing the need for a deeper understanding of various pathways and effective proxies for interventions. Pangaribowo et al. stress the importance of combining food insecurity indicators with socioeconomic and environmental indicators for comprehensive problem - solving.

Despite the intricate challenges, underutilized locally grown grains like millet can play a crucial role in enhancing food security, especially in developing nations. However, traditional grain crops alone may not solve all the difficulties, particularly in unprecedented circumstances like the COVID - 19 pandemic. Millets, including finger, kodo, foxtail, little, proso, and barnyard varieties, demonstrate genetic adaptation to diverse soil types, rainfall patterns, and marginal environments, making them resilient to climate change. These qualities position millets as potential substitutes for staples like wheat and rice in regions with severe weather patterns, ultimately contributing to food security.

While millet holds significant promise for improving agricultural systems and food security in Sub - Saharan Africa, it remains a neglected agro - biodiversity. Recognizing and harnessing the potential of millets can be instrumental in addressing food security challenges, particularly in the face of climate change and unforeseen global crises.

The cost benefit of using millet

Millet emerges as an economical and gluten - free cereal, costing approximately 40% less than corn. According to Silva et al., the trade value of pearl millet is less than or equal to 77.78% of corn grain prices, making it a cost - effective alternative. With higher protein content than maize, pearl millet facilitates the design of diets without the need for protein supplements, reducing overall food and feed costs.

Moreover, millet proves more cost - efficient in production compared to grains like sorghum and maize. In semi - arid regions of Brazil, pearl millet requires less water than sorghum and locally grown maize varieties. Studies replacing feedlot cattle diets with pearl millet demonstrate its cost - effectiveness, with factors like cattle prices, initial and final weights, concentrate and roughage costs influencing financial indicators. Positioning millet as a competitive grain with maize can alleviate consumption pressure and drive down prices.

Comparative studies highlight the economic advantages of millet in poultry farming. The cost of feed for live weight gain in hens fed maize is higher than groups fed finger millet, pearl millet, and sorghum. Raising broiler chickens with millet grain feed proves more affordable and efficient, boasting the lowest feed costs per kilogram and per unit weight gain, as confirmed by Medigu et al. Wilson et al. estimate a $1.4 million annual net profit advantage when using pearl millet as the sole feedstock, reaching a total estimated profit of $25, 175, 000 compared to $23, 758, 000 for maize feedstocks. These findings underscore the economic viability of millet as a strategic and cost - effective component in agricultural production.

3. Conclusion

Pearl and finger millets show promise as alternative energy sources in poultry diets, boasting competitive nutrients comparable to or higher than traditional cereals like rice, wheat, and maize. Besides their nutritional benefits for animals, millets offer health advantages for humans due to their nutraceutical content. Studies suggest that broiler diets can be supplemented with up to 100% millets without compromising chicken performance, and ruminant animals exhibit improved metrics with millet inclusion, potentially reducing feed costs in livestock production. Millet's gluten - free nature makes it a preferred grain for those with celiac disease. Despite antinutrients affecting nutrient bioavailability, various processing techniques can mitigate these effects. Further research is needed to determine optimal millet inclusion in animal diets, and raising awareness about the health significance of millets is strongly recommended.

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