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Nutraceutical Potential of Millets

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Abstract

Millets have garnered growing interest because of their exceptional nutraceutical properties. Due to their abundant supply of vital nutrients and bioactive substances, millets show significant potential in enhancing health and reducing the risk of chronic illnesses. The present paper emphasised the significant nutritional content of millets, which are devoid of gluten and abundant in protein, vitamins, and minerals, rendering them a superb dietary choice for those suffering from gluten sensitivity or those in search of functional foods. Furthermore, the present paper highlighted the main nutraceutical constituents found in millets, such as phenolic compounds, dietary fibre, carotenoids, tocopherols, and phytosterol, and their impact on human health. The exploration of future research pathways is directed towards the optimisation of nutraceuticals derived from millet, the bioavailability of phytochemicals, and the development of novel food processing procedures to augment their health-promoting characteristics. Given the increasing worldwide need for sustainable and nourishing grains, millets are well positioned to have a substantial impact on tackling nutritional and health issues in contemporary diets.

Keywords: Millet, nutraceutical, dietary fibre, carotenoid, phenolic compounds

INTRODUCTION

Nutraceuticals

The name 'Nutraceuticals' is derived from the amalgamation of 'Nutrition' and 'Pharmaceuticals' (Figure 1). Dr. Stephen De Felice—the founder and CEO of the Foundation for Innovation in Medicine—introduced the word "nutraceutical" in 1989, characterising it as "food, or components of food, that provide medical or health benefits, including disease prevention and treatment" [1]. Hippocrates—an ancient Greek figure who lived from 460 to 377 BC—is regarded as the progenitor of modern medicine. He initially posited the correlation between the intake of healthy food and the consequent health advantages over 2500 years ago [2]. The relevance of nutraceuticals, historically acknowledged, has been corroborated by contemporary medicine [3]. They offer medicinal and health advantages, encompassing the ability to cure and prevent sickness. Foods, nutritional supplements, and herbal preparations include naturally occurring bioactive substances that possess therapeutic, disease-prevention, and health-promoting properties. These substances are chemical molecules that positively influence human physiology, while not being widely recognised as nutrients. A benefit of nutritional supplements over pharmaceuticals is their absence of adverse effects [4].

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Millets

In recent years, the popularity of millets has surged owing to their remarkable nutritional profile and several health advantages. Millets were domesticated and cultivated around 10,000 years ago. Millets are grown mostly for the little seeds yielded by petite grass species of the Poaceae family. Although designated by another name, these crops are important for their nutritional content, medicinal attributes, use as animal feed, and resilience during food scarcity [5]. The Indian Council of Agricultural Research-Indian Institute of Millets

Research (ICAR-IIMR) states that nutri-cereals are grains very high in nutrients, possessing nutritional levels comparable to commonly consumed cereal meals. Except for lysine and threonine, they supply a substantial quantity of essential amino acids [6–8]. The grains are abundant in nutrients and phytochemicals. It is acclaimed for its several possible health advantages, such as promoting wound healing, preventing cardiovascular disease, and lowering blood glucose and cholesterol levels, in addition to its nutritional value [9]. Previous research has identified oxidative stress as the principal factor contributing to several chronic health diseases, including diabetes, cancer, neurological disorders, arthritis, and cardiovascular disease [10]. Antioxidants are believed to have a vital role in mitigating oxidative damage [11]. Previous studies on the phytochemical composition of millets revealed substantial quantities of antioxidants, including tocopherols, phenolics, and carotenoids [12].

CHEMICAL AND NUTRITIONAL COMPOSITION OF MILLETS

Millets possess nutritional equivalence to other cereal grains. In 2018, the Food and Agriculture Organisation (FAO) designated these cereals as "Nutri-Cereals" because of their enhanced nutritional value relative to widely cultivated cereals. They possess a broader spectrum of nutrients compared to other main grains. The consumable portion consists of a blend of vitamins and minerals, along with a mixture of fats, proteins, and carbohydrates [13] (Table 1). Millets, similar to other cereals, serve a crucial role as an energy source. The FAO (1995) stated that all grains, with the exception of finger millet, typically possess higher fat content, varying from 3.5% to 5.2%. They possess a substantial concentration of critical amino acids. Foxtail millet may serve as an exceptional protein alternative due to its elevated lysine level relative to other grains. Studies indicated that proso millet contains significantly higher concentrations of the three necessary amino acids—leucine, isoleucine, and methionine—than wheat [14].

Research indicated that millet possesses an average fat content between 3.5% and 2.2%. The lipid content is greater than that in wheat and rice, although comparable to that of maize [15]. Moreover, studies have demonstrated that millet fat has a considerably greater proportion of unsaturated fatty acids and is more readily digestible than maize fat [16]. Linoleic acid, constituting 66.68% of the overall fatty acid composition in foxtail millet, was recognised as the principal fatty acid. The subsequent fatty acids in order of frequency were oleic acid, palmitic acid, stearic acid, and linolenic acid [17]. Moreover, millet is demonstrated to possess significant quantities of micronutrients, encompassing vitamins and minerals. The millet grains included markedly elevated levels of magnesium, manganese, and phosphorus relative to other grains [18]. Studies have shown that foxtail millet may contain up to 31.36 mg of vitamin E and 0.19 mg of carotenoids per 100 g. Finger millet contains around 350 mg of calcium per 100 g (Figure 2) [15].

Millets have several biological processes that confer health advantages beyond their nutritional worth. A prior work with proso millet proteins showed that high-fat dietary circumstances elevated insulin levels and glycaemic responses in genetically obese mice with type-2 diabetes [19]. Studies have shown that aqueous extracts of foxtail millet grain exhibit enhanced antihyperglycemic properties [20]. An investigation on rats with elevated lipid levels showed that both proso millet and foxtail millet effectively reduced blood triacylglycerol levels. Furthermore, foxtail millet was associated with a decrease in C-reactive protein levels, which act as indicators of inflammation. The results demonstrated that these grains could mitigate cardiovascular diseases by favourably influencing lipid profiles and inflammatory indicators [21].

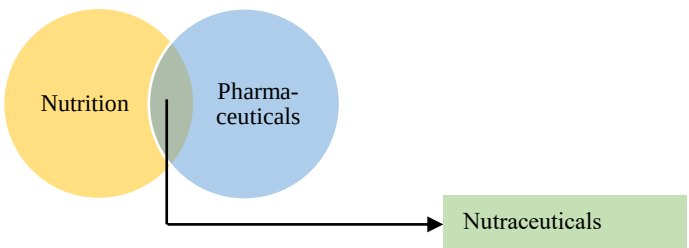

Figure 1. The theory of nutraceuticals.

Table 1. Millets' makeup of macronutrients (g/100 g).

Millet	Carb (g)	Protein (g)	Fats (g)	Dietary fiber (g)	Reference
Sorghum	67.98	9.97	1.73	10.22	[22]
Pearl millet	61.78	10.96	5.43	11.49	[22]
Finger millet	66.82	7.16	1.92	11.18	[22]
Proso millet	70.4	12.5	3.1	14.2	[23]
Foxtail millet	66.19	8.92	2.55	6.39	[22]
Kodo millet	66.6	9.8	3.6	5.2	[8]
Little millet	65.55	10.13	3.89	7.72	[22]
Barnyard millet	68.8	10.5	3.6	12.6	[24]
Amaranth	61.46	13.27	5.56	7.47	[22]
Buckwheat	54.50	12.30	3.80	7.0	[25]

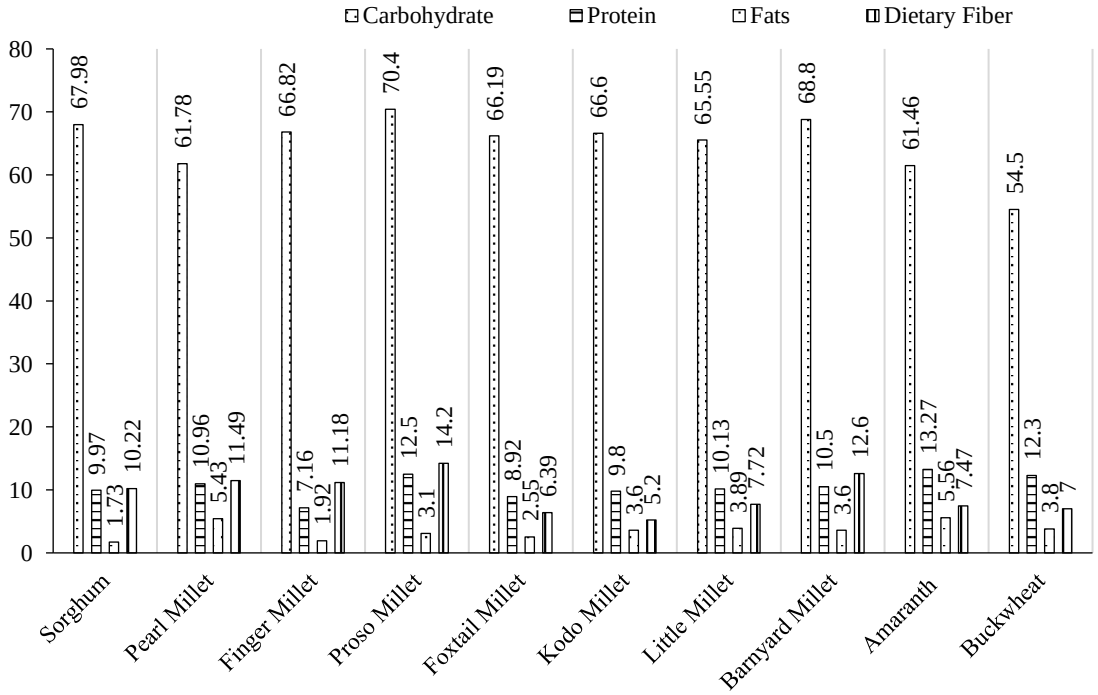

Figure 2. Bar graph representing nutritional makeup of millets.

NUTRACEUTICAL COMPONENT IN MILLETS

Besides essential components such as carbohydrates, proteins, fats, minerals, and vitamins, research indicated that bioactive phytochemicals found in whole grains, fruits, vegetables, legumes, and oilseeds may positively impact health [13].

Phenolic Compounds

Phenolic molecules, present in all plant sections, constitute a diverse array of phytochemicals that are essential for human nutrition [13]. Phenolic compounds comprise a varied collection of molecules distinguished by the presence of an aromatic ring containing one or more hydroxyl groups and numerous substitutions. Phenolic substances are classified into three main categories—flavonoids, lignans, and phenolic acids [26]. Phenolic chemicals, predominantly located in the bran layers, may be diminished during the milling process when the seed coat detaches [13]. A recent study has definitely shown that the kind of millet significantly influences both the structure and quantity of phenolic chemicals [27]. According to a study, 60% of the phenolic acids found in millet were in a bound form, while the remaining 40% were in the form of free molecules [28]. Studies have demonstrated that kodo millet

(81.64±0.15) has the highest quantity of bound polyphenols (extractable with 1% HCl), followed by foxtail millet (11.59±0.23), small millet (9.64±0.28), pearl millet (9.14±0.17), finger millet (3.83±0.18), and proso millet (2.21±0.01) [29]. Bound phenolic compounds possess features such as antiviral, anti-obesity, antidiabetic, antimutagenic, anticarcinogenic, antibacterial, and antioxidant activities. Furthermore, they possess the capacity to impede the expansion of human immunodeficiency virus (HIV), influenza viruses, and other pathogens [26]. Polyphenols inhibit glucosidase and amylase, hence averting postprandial hyperglycaemia [30, 31].

Carotenoids

Carotenoids are pigments present in several food sources. Over 600 of them have been identified and acknowledged. Carotenoids are recognised for their provitamin A action. Carotenoids are vital chemicals that function as antioxidants and provide protection against several illnesses [26]. A recent investigation found that the average quantity of carotenoids in edible millet flour ranged from 78 to 366 μg/100 g for finger, small, foxtail, and proso millets, respectively. The carotenoid concentrations in millets were comparable to those in wheat (150–200 μg/100 g) and sorghum (180–230 μg/100 g), but much lower than those in maize (1800–5500 μg/100 g) and its variations (2400–3200 μg/100 g) [12, 32].

Tocopherols

Vitamin E is a prevalent fat-soluble molecule consisting of eight distinct components. The family comprises of four saturated tocopherols and four tocotrienols, each possessing three double bonds. Four distinct varieties of tocopherols and tocotrienols exist, that is, alpha, beta, gamma, and delta [26]. It serves as a natural antioxidant to safeguard against oxidative stress caused by free radicals in the adipose tissue encasing vital organs, including the heart, muscles, neurones, and red blood cells. Furthermore, it possesses the capacity to preserve our youthfulness and serve as a prophylactic against cancer, cardiovascular disease, and the ageing process [12]. High-performance liquid chromatography (HPLC) examination of vitamin E revealed that the main constituents of vitamin E are α- and γ-tocopherols. Millet varieties were found to have a total tocopherol content ranging from 1.3 to 4.0 mg/100 g. The finger and proso millet types exhibited higher total tocopherol content (3.6–4.0 mg/100 g) as compared to the small and foxtail millet varieties (~1.3 mg/100 g) [12].

Dietary Fibres

The significance of dietary fibre has escalated in the past 20 years owing to its ability to diminish the risk of many ailments, including diverticulosis, diabetes, cardiovascular disease, and colorectal cancer. The structure of the gut is affected by the physical characteristics of fibre, and these changes may be associated, through various pathways, with functional variations in the gastrointestinal system. Viscous dietary fibre is employed to assist in the management of type II diabetes and cardiovascular disease, as well as to decrease and control blood glucose levels [33]. The concentration of Xylo-oligosaccharide in finger millet bran was determined to be 15.60%, while wheat bran had a concentration of 40% and maize bran had a concentration of 9.33% [34]. A study revealed that finger millet had a higher dietary fibre level of 18.6% and pearl millet had a higher dietary fibre content of 20.8% as compared to sorghum (14.2%), wheat (17.2%), and rice (8.3%) [35].

Phytosterol

Phytosterols, a category of sterols, predominantly reside in plant cell walls and membranes, functioning as structural constituents. Owing to their structural resemblance to cholesterol, they efficiently reduce blood cholesterol levels by modifying the absorption rate of cholesterol synthesised internally and acquired from dietary sources [26]. Pearl millet has 58 mg of phytosterols per 100 g [36]. Studies have shown that foxtail millet and proso millet have phytosterol content of 44–57 mg/100 g and 19–26 mg/100 g, respectively [5]. Phytosterol esters do not impact high-density lipoprotein (HDL) levels, however they can reduce blood serum low0density lipoprotein (LDL) cholesterol levels by as much as 14%. Consistent consumption of phytosterols may decrease the likelihood of heart disease by as much as 40%, contingent upon age and additional variables [26].

HEALTH BENEFITS

Epidemiological studies suggest that diets rich in plant-based foods, particularly whole grains, may offer protection against non-communicable diseases due to their substantial mineral and phytochemical content that enhances health. Millets are classified as functional foods due to their elevated levels of potent phytochemicals that promote health [26]. Millets contain bioactive compounds that may potentially avert several diseases, including cancer, diabetes, hypertension, and cardiovascular disorders.

Cardiovascular Disease

Millets are abundant in magnesium, believed to mitigate the effects of migraines and heart attacks. Millets provide a substantial source of phytochemicals, notably phytic acid, acknowledged for its capacity to lower cholesterol levels [37].

Diabetes

The consumption of millet has been shown to correlate with a decreased incidence of diabetes. Regulating phenolic synergy may be advantageous for the management of type-2 diabetes mellitus—a disorder characterised by elevated blood glucose levels. Phenolic synergy can inhibit amylase—an enzyme responsible for carbohydrate degradation [26]. Similar to alpha-glucosidase, pancreatic amylase is partially obstructed by millet phenolics, leading to decreased postprandial hyperglycaemia by inhibiting the enzymatic breakdown of complex carbohydrates. Processes such as malting and fermentation may alter the concentration and bioavailability of minerals by functioning as inhibitors [37].

Cancer

Millets are well-known for their elevated concentrations of "antinutrients" including phytate, tannins, and phenolic acids. In animals, these antinutrients reduce the incidence of breast and colon cancer. Studies have shown that phenolic chemicals included in millet can impede the proliferation and spread of cancer cells in laboratory environments [38].

FUTURE ASPECT

Researchers have identified a diverse array of compounds with antioxidant effects in millet. These characteristics are augmented by many processing techniques including germination, malting, and fermentation. Millet is frequently utilised as animal feed and fodder, and it serves a vital function as a food supply in areas experiencing extreme poverty. The absence of novel processing techniques has impeded the manufacture of more accessible millet-based goods. This might greatly enhance the integration of more nutritious millet cultivars into diets and their use as a fundamental component in nutritional therapies for therapeutic purposes. Future study should concentrate on creating innovative scientific approaches to assess the nutritional composition of millet, particularly examining the health advantages of its antioxidant qualities through studies including both humans and animals.

CONCLUSION

Millets are an essential crop in semiarid and tropical locations where larger cereals cannot consistently give sustainable harvests due to their brief growing season, resilience to pests and diseases, and capacity to flourish in hot and arid environments. Recently, millets have acquired increasing significance as resilient and nutrient-dense crops, providing several health advantages. Given the plethora of phytochemicals in these grains, which are currently underutilised, it is essential to conduct comprehensive and collaborative study to fully harness their potential as nutraceuticals. Millets has a nutritional profile akin to that of esteemed cereals such as rice, wheat, and barley regarding protein, carbohydrates, and caloric content. The principal health advantages of millets arise primarily from their rich content of various minerals, vitamins, and trace elements, alongside their phytochemical profile, which includes dietary fibre, polyphenols, tocopherols, and phytosterols. Numerous studies have identified an association between the regular intake of millet grains and their derivatives with a decreased risk of chronic illnesses, including diabetes, cardiovascular disease, cancer, and overall mortality. Consequently, increasing the intake of fruits, vegetables, and millet grains in one's daily diet is a practical strategy for individuals to improve their health and diminish the chance of developing

chronic diseases. Subsequent study on these crops should emphasise the exploration of more efficient processing techniques and their effects on phytochemical content and bioavailability.

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