*Review Article*

# Underutilized Nutrient Rich Millets: Challenges and Solutions for India's Food and Nutritional Security- A Review.



## ABSTRACT

Despite the fact that the green revolution helped India becomes self-sufficient, the productivity of the wheat rice cropping system is now approaching stability. Agricultural diversification is required in order to introduce traditional grains that are both environmentally friendly and nutritionally sufficient. Ensuring food and nutrition security for all is of prime importance. However, achieving it is an enormous challenge. Available data shows the rise in hunger in many parts of the world. Agriculture in the present times faces several challenges, and versatile, less demanding, hardy, nutritious, sustainable crops such as small millets can play a role in mitigating this problem to some extent. Small millets are highly underutilized in comparison to major cereals. Overdependence on a few plant species, viz., rice, wheat, maize, and potatoes has led to marginalization and neglect of small millets. Small millets are rich in energy, complex carbohydrates, micronutrients, and phytochemicals. Studies indicate that these can be effectively utilized to combat malnutrition including both undernutrition and overnutrition. Millets are small-seeded grasses that appear to meet this requirement. These are eco-friendly and have a well-balanced macronutrient and micronutrient composition. Millets also have nutraceutical properties and can help to prevent a variety of non-communicable diseases. Soaking, roasting, germination, and fermentation procedures improve the palatability of millets while simultaneously reducing anti-nutrients, enhancing the physiochemical accessibility of micronutrients, and improving their bioavailability. Preparing value-added products and popularizing them among the general public can boost millet demand as well as farmer’s income. It is necessary to develop and popularize millet-based food products that provide poor people with convenience, flavor, texture, colour, and shelf stability at a low cost. Therefore, these superfoods have the potential of attaining food and nutritional security.

***Keywords:*** *Millets, nutritional, soaking and fermentation*

## 1.0 INTRODUCTION:

Millets are cereals from the Poaceae grass family and are considered one of the oldest cultivated crops. ‘Small millets’ is a generic term that denotes the coarse cereals. It includes finger millet (*Eleusine coracana*), foxtail millet (*Setaria italica*), proso millet (*Panicum miliaceum*), barnyard millet (*Echinochloa crusgalli*), kodo millet (*Paspalum scrobiculatum*), little millet (*Panicum sumatrense*), guinea millet (*Brachiaria deflexa*), and browntop millet (*Urochloa ramosa*) (Muthamilarasan and Prasad 2021). Millets can foster well in poor soil conditions with less water, fertilizer, and pesticides. Millet contains a comparative advantage over other cereals in terms of soil climatic adaptability, drought resistance, insect pest tolerance, and management factors. Further, health-promoting factors play an important role in tackling food security and malnutrition problems, particularly in mid and high hills. Millet features a high possibility of improving production which can be supported with subsidy, improving tourism, promoting the millet products with agro-based industries, and motivating the growing farmers. Proper local and national strategies to cope with the limitation will help to uplift millet farming from minor cereals to exportable standards (Gyawali, 2021). Millets are also believed to have nutraceutical health benefits. These include but are not limited to, an increase in digestive system well-being, a reduction in cholesterol, the prevention of heart disease, protection against diabetes, the lowering of cancer risks, and an increase in energy levels and improvement of the muscular system (Sobana *et al.,* 2009; Amadou *et al.,* 2013). In terms of agroecological traits, millets have better water-use and nitrogen-use efficiencies that enable them to withstand water-limiting conditions. For example, foxtail millet requires ~250 g of water to produce 1 g of dry biomass, whereas wheat and maize require ~450 and 500 g, respectively. Similarly, a study in finger millet reported a requirement of nitrogen fertilizer as low as 20–60 kg/ha for better productivity. Small millets are also rich in micro- and macro-nutrients, total protein, fiber, and resistant starch. For instance, finger millet is rich in calcium (~364 mg per 100 g) and potassium (~320 mg per 100 g), and little millet and barnyard millet have high iron contents (~10–18 mg per 100 g). The total protein is high in foxtail millet and barnyard millet (>10%), and crude fiber is rich in barnyard millet, little millet, foxtail millet, and fonio (~7–14%). Further, the majority of small millet is gluten-free, and therefore facilitates the preparation of low glycemic index products (Muthamilarasan and Prasad 2021). According to several researchers, millets can be an important source of essential nutrients such as amino acids, and mineral and trace elements (Anitha *et al.,* 2020). Obviously, wide variations should be evident in the nutritional composition of pearl and finger millets (FAO, 2017). (Shweta, 2015) reported that pearl millet contains higher energy compared to cereal grains such as rice and wheat, and is considered a significant source of thiamine, niacin, and riboflavin as stated by (Taylor *et al.,* 2004). Moreover, the content of minerals such as calcium, iron, and phosphorus in pearl millet is like those found in other cereals (Adeola *et al.,* 1995). In addition, finger millet grows better in colder areas that have slightly more rain (Tadele, 2020). Finger millet is known as an important cereal as it contributes significantly to nutritional well-being.

Despite its valued role and its vital contribution to the food availability of many underprivileged farmers and families, it is also a crop that is overlooked**.** To protein found in finger millet is considered superior as it encompasses vital amino acids such as lysine, threonine, and valine **(**Ravindran, 1991**).**


**Figure 1: Characteristic features of millets [Source: Muthamilarasan and Prasad 2021]**

**Nutrition Scenario and Food Security:**

'Food security' exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Availability of food, Access to food, Utilization, and food Stability are the four pillars of Food security. The term 'food security' does not clearly spell out the nutrition dimension of food of adequate sanitation, health services, and care, allowing for a healthy and active life." The world population is growing steadily which is surely not doing any help to the Food Security and Nutrition of the World instead it is a major threat. Agricultural production in general and crop production in particular, must increase substantially in order to meet the rising food demand of a population that is projected to expand by some 40 percent over the period from 2005 to 2050. Adding on to this climate change and increasing climate variability and extremes are affecting agricultural productivity, food production, and natural resources, with impacts on food systems and rural livelihoods, including a decline in the number of farmers leading to major shifts in the way in which food is produced, distributed and consumed worldwide. According to the FAO, 2019 report, more than 820 million people in the world are still hungry today, underscoring the immense challenge of achieving the Zero Hunger target by 2030. Another disturbing fact is that about 2 billion people in the world experience moderate or severe food insecurity. **(**Jeena *et al.,* 2020**).**

**2.0 Balanced diet: choices of foods to meet the requirements and role of millet**

A balanced diet is one that contains different types of food in such quantities and proportions so that the need for calories, protein, fat, vitamins, and minerals are adequately met. Depending upon the content of major nutrients, foods are classified into five food groups. They are cereals and millet; pulses and legumes; milk and meat products; fruits and vegetables; and fats. **(**Konapur et al., 2014**).** Satisfaction with hunger is the primary criterion and therefore cereals are central to the issue of food security. Cereals and millets are rich sources of calories and other nutrients but deficient in many other nutrients. They are deficient in lysine and low in protein quality compared to flesh foods and are poor in mineral bioavailability. Extensive diet surveys carried out in different parts of India both in rural and urban areas indicate that diets are not balanced. A balanced diet includes 60-70 percent of energy intake from cereals, 15-20 percent of energy intake from fats, and not more than 5 percent of energy intake from sugars**.** The diets of rural Indians are majorly based on the single staple with minimal diversification. Such a diet to some extent can ensure calorie adequacy but are deficient in several nutrients namely protein, essential fatty acids, iron, zinc, calcium, vitamin A, riboflavin, vitamin B12, ascorbic acid, and folate. According to recent survey carried out in rural India 62- 76 per cent of energy for a family is derived from cereals, 7 percent from fats and 2-5 per cent from sugars, suggesting overall adequacy of intake of calories. However, there is more than 50% deficit in fat intake compared to a balanced diet, which not only will reduce Poly Unsaturated Fatty Acid (PUFA) but also impair the bioavailability of fat-soluble vitamins and phytonutrients.

Among food groups, if looked at the distribution of nutrients such as iron, about 50 percent of it comes from cereals and millet. Cereal-millet based diet contains high amounts of phytate, which is a known inhibitor of the absorption of minerals. To ensure the bioavailability of these minerals, consumption has to be encouraged with minimally processed vegetables and fruits, milk, and meat products so that absorption of iron is improved. However, intakes of food groups that are essential for improving the bioavailability of these minerals are only one-third of the intake7 suggested as per RDA (400 vs 153 vegetables and fruits; 300 vs 103 milk and meat products CU/day) among Indians. Similarly, the requirement of folate can be met only with adequate consumption of the four food groups (cereals, pulses, vegetables in particular green leafy and meat). Thus, emphasis should be laid on providing food groups that provide both macro and micronutrients with adequate amounts to achieve food and nutrition security. **(**Konapur et al., 2014**).**

Diets of the poor will continue to be grossly inadequate for a long time to come unless there is a phenomenal improvement in their economic status to afford an adequate diet. Therefore, as an immediate measure, attempts should be made to improve the nutritional value of the cereals by the inclusion of inexpensive locally available food commodities, to prevent at least the major micronutrient deficiencies of vitamin A, iron, and zinc **(**Konapur et al., 2014**).**

**List 1 : Millets: an approach for sustainable agriculture and a healthy world (Source: Kumar et al., 2018)**

| Food Security | Nutritional Security | Safety from disease | Economic security |
|---|---|---|---|
| 1. Sustainable food source for combating hunger in changing world climate<br>**2.** Resistant to climate stress, pests and | 1. Rich in micronutrients like Calcium, iron, zinc, iodine etc.<br>2. Rich in bio active compounds | 1. Gluten free: a substitute for wheat in celiac diseases<br>2. Low GI: a good food for diabetic persons<br>**3.** Can help to combat | 1. Climate resilient crop<br>2. Sustainable income source for farmers<br>3. Low investment needed for |

| | | | |
|---|---|---|---|
| diseases | **3.** Better amino acid profile | cardiovascular disease, anaemia, calcium deficiency etc. | production<br>**4.** Value addition can lead to economic gains |

**3.0 Nutritional importance**

The preservation of human overall physical well-being depends on maintaining nutritional well-being, which is a sustained force for health and development as well as the realization of human genetic potential. Therefore, in order to solve the problems of widespread food insecurity and malnutrition, dietary quality should be taken into consideration (Singh and Raghuvanshi 2012). In addition to the benefits of their cultivation, it was found that millets have a high nutritional content that is comparable to that of major grains like wheat and rice (Parameswaran and Sadasivam 1994). In addition, millet proteins have been found to be excellent suppliers of methionine, with the exception of lysine and threonine. Millets are also rich in minerals and phytochemicals (Singh et al 2012). For instance, it has been demonstrated that pearl millet contains significant amounts of resistant starch, soluble and insoluble dietary fibers, minerals, and antioxidants. It contains 92.5% dry matter, 2.1% ash, 2.8% crude fiber, 7.8% crude fat, 13.6% crude protein, and 63.2% starch. (2003) Ali et al. The protein concentrate from foxtail millet was also characterized, and because of its high lysine level, it may be employed as a supplementary source of protein in most cereals. This makes it a possible functional food ingredient. Furthermore, finger millet is thought to provide a variety of potential health advantages, some of which are connected to its polyphenol content. Its carbohydrate content is 81.5%, protein is 9.8%, crude fibre is 4.3%, and mineral content is 2.7%, which is comparable to other cereals and millets. With higher quantities of lysine, threonine, and valine than those found in wheat (1.2% fiber, 1.5% minerals) and rice (0.2% fibre, 0.6% minerals), its crude protein is generally more evenly balanced than that of other millets (Sripriya et al 1997). Additionally, black finger millet has 8.47 g of protein and 8.71 mg of fatty acids per gram of dry weight (Glew et al 2008). Kodo millet and tiny millet had the highest dietary fibre level of any cereal, although the fat content was higher in polyunsaturated fatty acids. Unfortunately, negative alterations to these properties during processing cannot be prevented since industrial methods for processing millets are not as well developed as those used for processing wheat and rice. With the aid of value-added techniques and appropriate processing equipment, the millet grains can therefore be utilized to make a variety of nutritious food products, which may result in considerable demand from vast urban populations and unconventional millet users (Mal et al 2010).

Leucine, isoleucine, and methionine were significantly more abundant in proso millet grain than in wheat protein, and its protein concentration (11.6 percent of dry mass) was comparable to wheat (Kalinova and Moudry 2006). Because millets include all the essential elements, they can be utilized extensively to make food products including baby foods, snack foods, and nutritional food. Moreover, a greater variety of millet goods are entering daily life, including millet porridge, millet wine, and millet nutrition powder derived from both grain and flour (Liu et al 2012). An overview of the typical nutrient composition of several millet grains and other grains is given in Table 1. Because millets include all the essential elements, they can be utilized extensively to make food products including baby foods, snack foods, and nutritional food. Moreover, a greater variety of millet goods are entering daily life, including millet porridge, millet wine, and millet nutrition powder derived from both grain and flour (Liu et al 2012). An overview of the typical nutrient composition of several millet grains and other grains is given in Table 1.

Table 1–Nutrient composition of millets and other cereals (per 100 g edible portion; 12% moisture).

| Food | Protein[a] (g) | Fat (g) | Ash (g) | Crude fiber (g) | Carbohydrate (g) | Energy (kcal) | Ca (mg) | Fe (mg) | Thiamin (mg) | Riboflavin (mg) | Niacin (mg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rice (brown) | 7.9 | 2.7 | 1.3 | 1.0 | 76.0 | 362 | 33 | 1.8 | 0.41 | 0.04 | 4.3 |
| Wheat | 11.6 | 2.0 | 1.6 | 2.0 | 71.0 | 348 | 30 | 3.5 | 0.41 | 0.10 | 5.1 |
| Maize | 9.2 | 4.6 | 1.2 | 2.8 | 73.0 | 358 | 26 | 2.7 | 0.38 | 0.20 | 3.6 |
| Sorghum | 10.4 | 3.1 | 1.6 | 2.0 | 70.7 | 329 | 25 | 5.4 | 0.38 | 0.15 | 4.3 |
| Pearl millet | 11.8 | 4.8 | 2.2 | 2.3 | 67.0 | 363 | 42 | 11.0 | 0.38 | 0.21 | 2.8 |
| Finger millet | 7.7 | 1.5 | 2.6 | 3.6 | 72.6 | 336 | 350 | 3.9 | 0.42 | 0.19 | 1.1 |
| Foxtail millet | 11.2 | 4.0 | 3.3 | 6.7 | 63.2 | 351 | 31 | 2.8 | 0.59 | 0.11 | 3.2 |
| Common millet | 12.5 | 3.5 | 3.1 | 5.2 | 63.8 | 364 | 8 | 2.9 | 0.41 | 0.28 | 4.5 |
| Little millet | 9.7 | 5.2 | 5.4 | 7.6 | 60.9 | 329 | 17 | 9.3 | 0.30 | 0.09 | 3.2 |
| Barnyard millet | 11.0 | 3.9 | 4.5 | 13.6 | 55.0 | 300 | 22 | 18.6 | 0.33 | 0.10 | 4.2 |
| Kodo millet | 9.8 | 3.6 | 3.3 | 5.2 | 66.6 | 353 | 35 | 1.7 | 0.15 | 0.09 | 2.0 |

All values except protein are expressed on a dry weight basis.

Sources: Hulse *et al* (1980); United States National Research Council/National Academy of Sciences (1982); FAO (1995).

**Problems associated with millets**

- Low productivity and profitability
- Lesser bio-availability
- Less attractive color
- More processing is needed
- Marketing problems
- Lac of quality seed
- Ignorance by researchers and the government (Meena and Meena, 2018**).**

## 4.0 Processing of millets

### 4.1 Effects of Processing Technologies on the NutritionalQuality of Millet Grains

Some processing techniques are used in the creation of food products to enhance nutritional qualities, sensory qualities, and convenience. Several common home food processing and preparation methods can increase the bioavailability of micronutrients in plant-based diets. These include heat processing, fermentation, soaking, mechanical processing, and germination/malting. These methods aim to increase the bioavailability of nutrients, decrease the number of antinutrients such as phytates, or increase the physicochemical accessibility of micronutrients. The makeup of several millet grains and other grains is listed in Table 1.

## 4.2 Mechanical Processing Technologies

### *4.2.1 Decortication*

To improve their flavor and acceptability for food, millet and a number of other coarse grains are generally dehulled and given various treatments before consumption (Liu et al 2012). It has been asserted that finger millet is only used in flour-based meals since it cannot be decorticated like other cereals. This is primarily due to millet grains' diminutive size when compared to other cereal grains. But it was found that the hydrothermal treatment of millet hardened the endosperm structure and enabled its decortication. Before being decorticated, millet could not be cooked separately like rice to obtain a soft, pleasant texture in under 5 minutes. The product's pasting and dough-making abilities, together with some of its functional traits, showed that it might be used for a range of food uses (Shobana and Malleshi 2007). The nutritional profile of heatedly processed finger millet was considerably changed by decoration.

Traditional decortication of pearl millet and white sorghum was performed by hand pounding or by utilizing a mechanical device, and it was compared to abrasive decortication in the lab using similar kernel lots. Iron, zinc, phytates, lipids, fiber, and starch content, as well as the grains' decortication properties, were measured. The results showed that decortication had a number of effects on grain composition, despite the fact that there were no obvious differences between the two traditional decortication methods. Additionally, it was shown that while millets' crude fiber, dietary fiber, mineral, total phenol, and antioxidant contents were significantly reduced by decortication, their protein and fat contents were unaffected. Millets become less valuable as a food source as a result (Bagdia et al 2011). Dehulling pearl millet grains was also found to significantly (P 0.05) reduce total phytic acid, polyphenols, and tannin while improving the protein digestibility and millet's qualitative features. Shifting the pericarp during decortication lowers their contents because various nutrients (such as minerals, fibers, and antioxidants) and antinutrients (such as phytates and tannin) are largely concentrated on the outermost sections of grains (the pericarp and aleurone layer) (Hama et al 2011). Currently, millet grains are usually decorticated before eating in order to improve their edible and sensory properties as well as the look of their food products, despite the fact that decortication has been shown to reduce numerous nutritional levels, including fiber and minerals. Therefore, modern decortication equipment is required in order to quickly and commercially decorticate huge quantities of grains as opposed to using old methods.

### *4.2.2 Milling and sieving*

Millet grains are frequently ground using a non-motorized grain mill that is operated by hand or in another non-electric way, particularly in rural regions and for personal use. However, using a manual grain mill that includes a pulley system connecting it to a gas or electric engine is also an option. The impact of milling on the nutritional value of millet grains and their milling fractions has been studied by numerous researchers. According to one study, grinding pearl millet grains caused the grain's overall chemical composition to change. However, baking did not appreciably alter the nutritional value of raw pearl millet flour. In order to minimize polyphenols and phytic acid and improve protein digestion, milling and heat treatment were also used during the manufacturing of chapati, an unleavened bread. In another study, two varieties of pearl millet were ground into whole flour, semirefined flour, and a bran-rich fraction before their nutrients, antinutrients, and mineral bio-accessibility were evaluated. The results showed that the nutritional composition of semirefined flour was similar to that of whole flour, with the exception of the fat level (1.3%) Due to the partial separation of the bran section, semirefined flour was low in antinutrients and had improved mineral bio-accessibility, making it more nutrient-dense. The bran-rich fraction, a byproduct of flour milling, has a significantly ($P \leq 0.05$) higher ash concentration. The milling yield was also increased by steaming the millet at high pressures and temperatures, albeit steaming above a certain threshold had an adverse effect on the yield of head grains (Dharmaraj et al 2011).

Finger millet whole flour (WFM), sieved flour (SFM), wafers, and vermicelli were studied for their chemical composition, bioaccessible Fe, Zn, and Ca, in vitro digestible starch (IVSD), and protein (IVPD), as well as their bioactive elements (polyphenols and flavonoids). It was found that the WFM and SFM flours had very different compositions. While sifting decreased the amount of nutrients and antinutrients in WFM, it increased their digestibility and bioaccessibility. The highest amounts of total polyphenols and flavonoids were found in WFM (4.18 and 15.85 g/kg, respectively), but the highest bioaccessibility was found in SFM vermicelli (Oghbaei and Prakash 2012). Another study found that little to no nutritious value is lost after polishing barnyard millet in a rice polisher for three minutes at 8% to 10% (db) moisture content. As moisture and milling time increased, protein, fat, ash, and fiber contents also decreased (Lohani et al 2012). As a result, it is proposed that using whole grains flour in human nutrition is preferable to removing the bran fraction by sieving, which is known to be rich in nutrients, in order to promote health. As a result, grains lose some of their nutritional value and possible health advantages. Consequently, practical and motorized milling technology for millet grains is required to produce a significant amount of flour in order to ensure a consistent source for industrial food uses at a commercial scale and to help promote their utilization. As previously mentioned for decortication, milling and sieving of millet grains are primarily done manually. In exchange, millers need to have access to a consistent supply of top-notch millet grains. Future research should also focus on milling settings to increase millet flour yields while maintaining nutritional quality and composition.

**5.0 Potential Health Benefits of Millet Grains and TheirFractions**

According to epidemiological evidence from research studies, diets high in plant foods are preventative against a range of degenerative diseases, including cancer, cardiovascular disease, diabetes, metabolic syndrome, and Parkinson's disease (Chandrasekara and Shahidi 2012). Additionally, strong epidemiological evidence supports the idea that whole-grain cereals protect the body from age-related disorders like diabetes, cardiovascular disease, and other cancers. But for a long time, it was believed that whole grains' health benefits came from their fiber, vital fatty acids, vitamins, and minerals. The new research suggests that a combination of additional bioactive substances might potentially be at play, though. They are made up of tannins and phytic acid, which are antinutrients, as well as lipids, lignans, and phytosterols, which have hormonal effects. They also contain resistant starch, oligosaccharides, phenolic acids, avenanthramides, and flavonoids. Millets must also be acknowledged as functional foods and nutraceuticals since they contain dietary fibers, proteins, energy, minerals, vitamins, and antioxidants that are crucial to human health. Millets have been associated with several potential health advantages, such as the prevention of cancer and cardiovascular diseases, a decrease in the frequency of tumors, a reduction in blood pressure, cardiovascular risk, cholesterol, and the rate of fat absorption, a delay in gastric emptying, and the provision of digestive bulk. The U.S. Department of Agriculture has modified its nutritional recommendations to place grains and grain products at the bottom of the food guide pyramid in order to emphasize the importance of incorporating grains or grain products in a regular diet for optimal health (USDA 2000, 2005).

***5.1 Antioxidant contents and activities***

Research on diet and health has shown that phytochemicals, such as dietary fiber and polyphenols, have the potential to have health-promoting properties (Devi et al 2011). Increased consumption of whole grains and foods containing whole grains has been related to a lower risk of developing chronic diseases such as cardiovascular disease, type 2 diabetes, certain cancers, and all-cause mortality. Furthermore, whole grains contain unique phytochemicals that improve the nutritious value of fruits and vegetables when consumed with them (Liu 2007). Polyphenols, the largest class of phytochemicals found in plant-based foods, have been linked to a multitude of health benefits. Dietary polyphenols have received a lot of interest from nutritionists, food scientists, and consumers due to their significance to human health (Tsao 2010). Numerous varieties of millet, including kodo, finger, foxtail, proso, pearl, and tiny millets, are said to have significant quantities of phenolic compounds and to have qualities that reduce and chelate metals as well as act as antioxidants. The use of particular millets will, however, determine how efficient they are as sources of antioxidants. (Chandrasekara and Shahidi 2010).

There has been a lot of interest in studies on the antioxidant and nutraceutical properties of various signifi cant millet varieties, including finger millet, pearl millet, and foxtail millet. Reports state that proso millet ha s a polyphenol content of 29 mg per 100 g and aatocopherol content of 2.22 mg per 100 g, whereas foxtai l millet has a polyphenol content of 47 mg per 100 g and aatocopherol content of 3.34 mg per 100 g (on a wet basis) (wet basis).

A positive and significant relationship between polyphenolic content and radical cation scavenging capacity was also discovered (R2 0.9973, P 0.01). (Choi et al 2007). In a high-performance liquid chromatography (HPLC) analysis of the finger millet's polyphenols, only around 30% of the major constituent phenolics could be distinguished (Chethan and Malleshi 2007). The milling fractions of finger millet (whole flour, seed coat, 3%, 5%, and 7%) were also used to extract phenolic acids. At pH 4, 7, and 9, it was discovered that acidic methanol extracts from seed coat to entire flour were stable for up to 48 hours. They contained a lot of polyphenols (Viswanath et al 2009).

Currently, using HPLC and HPLCtandem mass spectrometry, more than 50 phenolic compounds from var ious classes have been positively or tentatively identified in four phenolic fractions of several whole millet grains, including phenolic acids and their derivatives, dehydrodiferulates,and dehydrotriferulates, flavanof monomers and dimers, flavonols, flavones, and flavanonols (kod) (MS). The insoluble bound fraction of K odo millet, however, showed the highest phenolic content and antioxidant activity in the in vitro test metho ds employed. Therefore, according to research data, millet grains can be used as functional dietary comp onents and as sources of natural antioxidants.

It has been discovered that the phenolic content and antioxidant potential of pearl millet grains are affected by dehulling and hydrothermal treatments. The decrease in antioxidant concentrations and activity is due to the oxidation and degradation processes that occur during thermal treatments including frying, boiling, and roasting. The reduction brought about by dehulling is due to the removal of the pericarp layer from the grains, which is known to be rich in polyphenol and antioxidant compounds. Millet grains, their fractions, and food items must be processed in the best possible conditions in order to maintain their quality and potential health benefits. Additionally, the increase in antioxidant contents and their activities may be attributed to the endogenous enzyme's conversion of complex components to simpler molecules with higher antioxidant activity during germination.

### *5.2 Millet for diabetics*

The characteristics of the chronic metabolic disorder known as diabetes mellitus include hyperglycemia and modifications in the metabolism of proteins, carbs, and lipids. The most common endocrine disorder, reults in inadequate insulin production (type 1) or a combination of resistance to the effect of insulin and the insulin-secretory response (type 2). Alpha-glucosidase and pancreatic amylase chemical synthetic inhibitors are crucial in the clinical therapy of postprandial hyperglycemia, despite the possibility that natural inhibitors are safer. Epidemiological studies have revealed that populations that consume millet have a lower incidence of the condition, which is supported by recommendations to consume whole grains as a means to prevent and control diabetes mellitus (American Diabetes Association 2005). Because finger millet has more fiber than rice and wheat, eating meals high in finger millet, for instance, led to noticeably lower plasma glucose levels, mean peak rise, and area under the curve. The lower glycemic response of whole finger-millet-based diets may also be due to the antinutritional elements in whole FMF, which are known to limit starch digestion and absorption. Furthermore, in early diabetic rats with poor wound healing, finger millet eating has been shown to influence skin antioxidant status, nerve growth factor (NGF) production, and wound healing parameters. The main causes of slower wound healing in diabetic rats are higher levels of oxidative stress markers and lower levels of antioxidants. However, four weeks of finger millet feeding to diabetic animals decreased glucose levels and improved antioxidant status, hastening the healing of cutaneous lesions. Dehulled and heated barnyard millet is beneficial for type 2 diabetes, according to studies. Dehulled millet has a low glycemic index of 50.0, while heat-treated millet has a low glycemic index of 41.7. (Ugare et al 2011).

***5.3 Millet and cardiovascular disease***

Obesity, smoking, eating poorly, and not exercising all increase the risk of heart attacks and strokes. In most nations around the world, cardiovascular disease is common and on the rise. Rats fed a diet of native and processed starch from barnyard millet had the lowest levels of blood sugar, serum cholesterol, and triglycerides when compared to rats fed a diet of rice and other minor millets (Kumari and Thayumanavan 1997). Additionally, in genetically obese type-2 diabetic mice fed a high-fat diet, giving proso millet protein increased plasma levels of adiponectin and high-density lipoprotein (HDL) cholesterol (Park et al 2008). Additionally, rats fed finger millet and proso millet had significantly lower serum triglyceride concentrations than groups of hyperlipidemic rats fed white rice and sorghum. Additionally, the sorghum group considerably outperformed the white rice, finger millet, and proso millet groups in terms of serum total, HDL, and low-density lipoprotein (LDL) cholesterol levels. In hyperlipidemic rats, finger millet and proso millet reduce plasma triglycerides and prevent cardiovascular disease. Additionally, the inhibitory effects of phenolic extracts on in vitro copper-mediated oxidation of human LDL cholesterol were examined using a range of dietary model systems, such as cooked minced pork and stripped corn oil. At a final concentration of 0.05 mg/mL, millet extracts decreased the percentage of LDL cholesterol that was oxidized by 1% to 41%. All types of the foods used in this study demonstrated effective lipid oxidation suppression, although kodo millet showed the greatest prevention of lipid peroxidation, being comparable to butylated hydroxy anisole at 200 ppm (Chandrasekara and Shahidi 2011b).

***5.4 Millet and aging***

A major contributor to diabetes issues and aging is nonenzymatic glycosylation, a chemical reaction between the amino group of proteins and the aldehyde group of reducing sugars (Monnier 1990). Millet grains are full of antioxidants and phenolics despite the fact that it has been established that phytates, phenols, and tannins can contribute to antioxidant activity important for health, aging, and metabolic syndrome. Additionally, it was found that the glycation and cross-linking of collagen could be stopped by methanolic extracts of kodo and fin-ger millet. Millets may therefore aid in delaying the aging process.

**6.0 Contributing towards nutrition security through millet**

India’s food security is dependent on only two crops- wheat and rice. Millets, which were the basis for food and farming system in India, production, and consumption has drastically decreased for a variety of reasons, millions of hectares of dry land have been left unused by farmers. If these lands can be brought under cultivation, they can create livelihoods in the most impoverished parts of India. Likewise, not only food security will be ensured but also food sovereignty. Many programs are being implemented by the Government of India where cereals are provided at subsidized prices to poorer households, but Food Security Bill is supposed to be the first program that has introduced millet to the Public Distribution System (PDS). As previously discussed, the mineral content of millets is higher than that of other cereals but its bioavailability is inhibited due to anti-nutrient factors. There is scientific evidence that proves that the mineral availability of millets can be enhanced by following simple and cost-effective home processing methods such as soaking, malting, popping, puffing, germination, and fermentation has proven to enhance the availability of nutrients from millets. In view of this, if beneficiaries of food security bills are educated about these simple techniques, nutrition security will also be addressed along with food security to an extent within the given means.

**7.0 Summary**:

This review presents the most recent research that has been conducted to improve the nutritional value of millet grains and the food products made from them. The studies' findings show that millet grains have amounts of various nutrients that are good for your health and on par with major grains. These nutrients include dietary fiber, minerals, vitamins, and phytochemicals like phenolic compounds. They may also offer a number of health benefits. However, novel processing and preparation methods are needed to improve the bioavailability of the micronutrients and the standard of millet diets. Further research is needed to determine the bioavailability, metabolism, and health advantages of millet grains and their numerous constituents in people. In order to promote the use of millet rains in urban areas and open up new markets for farmers to enhance their income, it is also required to develop highly improved millet products.

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