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# Chemical, Nutritional, and Biomolecular Characteristics of Finger Millet (*Eleusinecoracana* L.)

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**Abstract:** Millets have long been a traditional dietary staple in arid regions worldwide. In Tamil Nadu and Gujarat, finger millet is a vital crop, while it is of lesser importance in Telangana. These grains are highly nutritious, containing abundant protein with sulfur-containing amino acids, essential fatty acids, dietary fiber, B-vitamins, and minerals like calcium, iron, zinc, potassium, and magnesium. They offer various health advantages, including lowering blood sugar levels, regulating blood pressure, and addressing thyroid, cardiovascular, and celiac diseases. Nevertheless, there have been no studies on the genetic composition, molecular mechanisms, nutritional properties, and functional characteristics of this crop. This paper reviews the empirical studies on the nutritional aspects, functional aspects and health benefits of finger millets from seed structure to processed products, which are conducted in India.

## Introduction

Millets are cultivated across approximately 17 million hectares in India, yielding 18 million tonnes (MT) annually and accounting for 10 percent of the country's food grain supply (Chapke, 2023). The total millet crop area experienced a decrease at an annual growth rate of 5.4% from 2010-11 to 2014-15. Nevertheless, recent statistics from the Ministry of Commerce and Industry indicate that India ranks as the fifth largest millet exporter globally. With a share of about 41% of the total world production in 2020, India holds the title of the world's leading millet producer. As per the Ministry of Agriculture and Farmers Welfare, India's annual millet production stands at around 12MT (Harish, M. S. et al., 2024). During her union budget (2022-23) speech, Finance Minister Smt. Nirmala Sitharaman provided support for post-harvest value addition and branding of millet products in both domestic and global markets, which is expected to greatly boost millet

production and exports. This was announced as a major initiative to promote millet production and exports during the budget speech (Anonymous, 2016).

Millets come in various types such as sorghum, pearl millet, finger millet, little millet, small millet, foxtail millet, proso millet, barnyard millet, kodo millet, Ameranthus, and other varieties. These crops are well-suited to different climates and are highly nutritious. Generally, millets are a great source of fiber, minerals, and B-complex vitamins. The high fiber content in millets and the presence of any anti-nutritional factors like phytates and tannins can affect the absorption of minerals. Some human studies have indicated that iron absorption from millets might be lower compared to rice or wheat (Hahn et al., 1983). Additionally, millets contain beneficial phytochemicals such as polyphenols, lignans, phytosterols, phytoestrogens, and phytocyanins. The antioxidants, immune modulators, and detoxifying agents provide protection against age-related degenerative diseases such as cardiovascular diseases (CVD), diabetes, and cancer (Raju, C. A. 2024). Vitamins, minerals, and essential fatty acids, besides preventing nutritional deficiency diseases, also offer benefits in preventing degenerative diseases. Millets, being non-glutinous, are suitable for individuals with gluten allergy and celiac disease. They are non-acid forming, easily digestible, and non-allergenic (Saleh et al., 2013). Millet consumption lowers blood sugar, lowers the risk of diabetes, strengthens the immune system, lowers the risk of cancer, detoxifies the body, boosts immunity in respiratory health, increases energy, strengthens the neural and muscular systems, and protects against a number of age-relateddegenerative diseases, including Parkinson's disease and metabolic syndrome (Manach et al., 2005; Scalbert et al., 2005; Chandrasekara and Shahidi, 2012). Resistant starch, oligosaccharides, lipids, and antioxidants such phenolic acids, avenanthramides, flavonoids, lignans, and phytosterols are among the vital components found in millets and are thought to provide numerous health benefits (Miller, 2001; Edge et al., 2005).

Although millets and related food products are recognized for their nutritional qualities, consumers are not well informed about them, particularly when it comes to their therapeutic and nutritional benefits. Although millet is recognized to have a strong mineral and nutritional content, the health branding was not fully utilized in the past to commercialize millet meals. Therefore, this article has been timely which deals with the review of empirical studies on the nutritional aspects, functional aspects and health benefits of millets particularly on finger millet.

These nutri-cereals are well-known for their high nutrient content, which includes minerals like calcium, iron, zinc, potassium, and magnesium as well as vital fatty acids, dietary fibre, protein, and B vitamins. Benefits to health include decreased blood sugar, blood pressure, thyroid, cardiovascular, and celiac disease symptoms. Throughout human history, these have been significant food staples, especially in Asia and Africa. Nonetheless, during the previous three decades, there has been a notable decrease in the direct intake of millets as food. The amount of millets produced in India has significantly decreased as a result of the drop in demand. Ragi production dropped from 2.2 million to 1.8 million tonnes.

In Tamil Nadu and Gujarat, finger millet is a major crop; in Telangana, however, it is a small crop. Therefore, the growing environment and the quantity of rainfall in the area have a major influence on the spatial distribution of millets, whether they are grown as allied crops or as the main crop. Grain-producing finger millet is a cereal grass. Finger millet grows to a height of 170 cm and is a sturdy, tufted, tillering annual grass (FAO, 2012; De Wet, 2006; Quattrocchi, 2006). The term "finger millet" comes from the panicle-shaped inflorescence, which has four to nineteen finger-like spikes and matures to resemble a fist (De Wet, 2006; Quattrocchi, 2006). Up to 70 alternating spikelet with four to seven tiny seeds each are carried by the spikes (Dida et al.,

2006).The seed pericarp is easily separated from the seed coat and is not dependent on the kernel (FAO, 2012).

A staple grain in many South Asian and African nations is finger millet. Because it can be readily stored for years of famine, it is also seen as a useful crop. (FAO, 2012). The grain can be cooked like rice, ground to form flour or porridge, or used to make cakes. It is also very nutritious, easily digested, and adaptable (De Wet, 2006). Grain sprouting is advised for both infants and the elderly. Additionally, finger millet is utilized to produce beer, which produces byproducts that are fed to cattle, and liquor (known as arake or areki in Ethiopia) (FAO, 2012). Although finger millet is predominantly used as a food grain, it is not as suitable for use with cattle as other grains like maize, sorghum, and pearl millet. It is occasionally used in India to feed growing animals, sick and recovering animals, and newborn calves (Sampath, 1986).

## Table 1: Nutrient Composition of Finger Millet

| **Protein (g)** | **TotalFat(g)** | **Dietary Fibre (g)** | | | **Carbohydrates (g)** | **Energy(KJ)** | **Calcium(mg)** | **Iron (mg)** |
|---|---|---|---|---|---|---|---|---|
| | | **Total** | **Insoluble** | **Soluble** | | | | |
| 07.16 ± 0.63 | 1.92 ± 0.14 | 11.18 ± 1.14 | 9.51 ± 0.65 | 1.67 ± 0.55 | 66.82 ± 0.73 | 1342 ± 10 | 364 ± 58 | 4.62 ± 0.36 |
| | | | | | | | | |
| **ThiamineB1 (mg)** | **RiboflavinB2 (mg)** | **Niacin-B3(mg)** | **Pantothenic Acid – B5(mg)** | **B6 (mg)** | **Biotin -B7(µg)** | **Folates B9 ( µg)** | | |
| 0.37 ± 00.041 | 0.17 ± 0.008 | 1.34 ± 002 | 0.29 ± 0.19 | 0.05 ± 0.007 | 0.88 ± 0.05 | 34.66 ± 4.97 | | |
| | | | | | | | | |
| **Ergocalcife(µg) Alpha** | **Tocopherols (mg)** | | **α - Tocopherol (mg)** | **Phylloquinoes – K1 (µg)** | **Lutein(µg)** | **Zeaxanthi n (µg)** | **β- Carotene** | **Total Carotenoids** |
| | **Beta** | **Delta** | | | | | | |
| 41.46 ± 3.12 | 0.09 ± 0.010 | 0.66 ± 0.06 | 0.16 ± 0.01 | 03.00 ± 0.44 | 25.53 ± 05.82 | 1.45 ± 0.23 | 01.53 ± 0.25 | 154 ± 25.6 |
| | | | | | | | | |
| **Total AvailableCHO (g)** | **Total Starch(g)** | **Glucose (g)** | **Sucrose(g)** | **Total FreeSugars (g)** | | | | |
| 62.47 ± 1.24 | 62.13 ± 1.13 | 0.25 ± 0.06 | 0.12 ± 0.02 | 034± 0.06 | | | | |
| | | | | | | | | |
| **Palmitic(mg)** | **Stearic(mg)** | **Oleic (mg)** | **Linoleic(mg)** | **Total Saturated Fatty Acids (mg)** | **Total Mono Saturated Fatty Acids (mg)** | | | |
| 290 ± 15.4 | 27.86 ± | 585 ± 36.3 | 362 ± 15.3 | 317± 17.0 | 585± 36.3 | | | |

| **istidine** | **Isoleucine** | | **Luecine** | **Lysine** | **Methionine** | **Cystine** | **Phenylalanine** | **Threonine** | **Valine** |
|---|---|---|---|---|---|---|---|---|---|
| 2.37 ± 0.46 | 3.70 ± 0.44 | | 08.86 ± 0.54 | 2.83 ± 0.34 | 2.74 ± 0.27 | 1.48± 0.23 | 5.70± 1.27 | 3.84 ± 0.45 | 5.65 ± 0.44 |

**Nutrient Composition**

About 65% of the carbohydrates in millet grains come from non-starchy polysaccharides and dietary fibre, which decrease blood cholesterol, prevent constipation, and block the release of glucose into the bloodstream during digestion. Regular millet consumers report lower incidence of duodenal ulcers, cardiovascular illnesses, and diabetes. Of all the grains, finger millet has the highest calcium concentration (344 mg/100g); it is also highly concentrated in phytates (0.48g/100g), polyphenols, and tannins (0.61%) (Thompson, 1993). Furthermore, 8.71 mg/g dry weight fatty acid and 8.47 g/dry weight protein are found in black finger millet (Glew et al, 2008).

**Nutritional Characteristics**

**Carbohydrates**

Carbohydrates into simpler parts for the growing plant to use as energy during germination. As a result, more nutrients were released from the grain and enzymes were activated by the longer germination period. The finger millet flours' respective carbohydrate contents were 71.24% to 72.57% (Dark brown, DB) and 71.44% to 72.03% (Light brown, LB). While there was no discernible change in the LB flour samples, the DB flour samples showed a discernible decline. By inducing endogenous enzymes like as α-amylase, malting accelerated the enzymatic breakdown of carbohydrates in DB flour into simple sugars, hence increasing digestibility as starch was broken down to provide energy for seed germination (Oghbaei& Prakash, 2016; Samtiya et al., 2020). Grain carbohydrate content was lowered through malting, which may help those with diabetes or obesity, among other medical concerns (Ojedokun et al., 2020).

**Starch**

A common carbohydrate found in large quantities in finger millet seeds is starch. Starch granules can be polygonal, circular, or lenticular in shape, and their sizes typically range from 1 to 120 mm (Kumar et al. 2019b). Depending on the source, plant variety, and environmental conditions, starch is made up of two polymeric components with varying contents: branching amylopectin and amylose (Pérez-Pacheco et al. 2014). Three distinct varieties of finger millet (VL-315, VL-324, and VL-347) were used to extract white starch; the starch yield ranged from 63.5 ± 1.2% to 67.9 ± 1.8% on a total seed basis. The majority of the extracted starch's industrial applications are determined by its amylose content. The best raw materials for a variety of food and pharmaceutical businesses are starches with high amylose content values (Vithu et al. 2020). Three different kinds of finger millet starch have extracted starch with amylose contents of 39.03 ± 0.6%, 37.2 ± 0.2%, and 33.5 ± 0.9%, respectively.

**Dietary Fiber**

The main dietary fibre source is finger millet. It offers a number of health advantages for non-communicable diseases (Narasinga Rao, 2003).

**Table 2: Properties of Dietary Fiber and their Health consequences**

| Function | Health consequences |
|---|---|
| Water absorbing and bulking property | Energy diluents to formulate low calorie diets |
| Increased transit time of food in the gut | Reduced risk of inflammatory bowel disease |
| Bile acid and steroid binding | Hypocholesterolaemic activity and reducing the risk of cardiovascular diseases |
| Retardation of carbohydrate absorption and impaired glucose tolerance | Management of certain type of diabetes |

**Amino acids:**
Table 3 enumerates finger millet's several essential health-promoting qualities, including a high concentration of crucial amino acids including arginine, lysine, methionine, and lecithin (Glewet al.,2008).

**Table 3: Functions of Various Amino Acids Present in Finger Millet**

| Sr. # | Functions of Amino acids |
|---|---|
| 1. | Precursor for the synthesis of nitric oxide |
| 2. | Stimulation of the release of growth hormone |
| 3. | Improves immune function and reproductive ability |
| 4. | Reduces healing time of the injuries (particularly bone) |
| 5. | Quickens repair time of damaged tissue |
| 6. | Reduces risk of heart disease and adipose tissue body fat |
| 7. | Increases muscle mass and blood circulation |
| 8. | Improve insulin sensitivity and helps in memory generation, etc. |
| 9. | Decrease blood pressure |
| 10. | Alleviates male infertility, improving sperm production and motility |

**Phospholipids**
It is discovered that 0.36% of ragi contains total phospholipid. Two of the five phospholipids were cephalins, while the remaining three were lecithins. A band of galactolipid was present (Siddique, 2010). Good concentrations of phospholipids, which include cephalins and lecithins, have additional benefits. Other cereals' phospholipids, such as those found in rice, wheat, maize, etc., are extracted and dissolved in oils, making them unavailable to consumers. These substances play a significant role in overall metabolism and, due to their concentration in the brain, are beneficial for stress management, behavioral disorders, and brain function. They safeguard the gastrointestinal tract, kidneys, liver, and lungs in addition to aiding in membrane regeneration. It is well known that these substances increase the bioavailability of other nutrients and medications.

**Minerals**
Magnesium is a micronutrient that is necessary for the maintenance of teeth, the formation of new proteins, the activity of enzymes, healthy muscle contractions, and the transmission of nerve impulses. Magnesium content in finger millet is 130 mg/100g (Gull et al., 2014). Because the phytase enzyme is more active during germination, it is anticipated that germination will result in a higher mineral content. The minerals become freely and more readily available when the phytase enzyme hydrolyzes the link between the phytic acid and the confined minerals (Iswarya& Narayanan 2016). Similarly, the finger millet's calcium content was 345.53± 0.55 mg/100 g and 352.63 ± 0.21 mg/100 g, respectively, before and after germination with roasting. The finger millet's zinc level rose to 8.71 ± 0.01 mg/100 g from 3.59 ± 0.15 mg/100 g. In finger millet, the amounts of iron rose from 3.75 ± 0.05 to 4.52 ± 0.01 mg/100 g following germination and roasting (Dhliwayo et al., 2023). Thus, in cereal-based diets, germination is a crucial processing step that can increase iron content and, thus, dietary iron consumption.

**Health Benefits of Millets**

Epidemiological research has indicated that eating millets lowers the risk of heart disease, diabetes, improves the digestive system, lowers the risk of cancer, detoxifies the body, boosts immunity in the respiratory system, increases energy, and strengthens the neural and muscular systems. It also protects against a number of degenerative diseases, including metabolic syndrome and Parkinson's disease (Manachet al.,2005; Scalbertet al., 2005; Chandrasekara and Shahidi, 2012).

**Cardiovascular Diseases**

The finger millets have been proven to considerably lower the amounts of blood triglycerides than white rice and sorghum fed rats. In hyper-lipidemic rats, finger millet lowers plasma triglycerides, perhaps preventing cardiovascular disease(Lee et al., 2010).

**Diabetes Mellitus**

Diets based on finger millet have demonstrated a decreased glycemic response because of their high fibre content and α–amylase inhibitory characteristics, which are known to lessen the absorption and digestion of starch (Kumari and Sumathi, 2002). Considerable progress has been made in the healing of cutaneous wounds by using finger millet. According to a few rat studies that also shown improved antioxidant status and blood sugar regulation (Rajasekaran et al., 2004; Shobanaet al.,2009).

**Gastrointestinal Disorders**

Controlling the digestive process can improve nutritional retention and lower the risk of developing more severe gastrointestinal disorders like colon cancer or gastric ulcers. Millets' high fibre content aids in the elimination of conditions like cramping, bloating, constipation, and excessive gas.

**Nutritional Importance of Finger Millet**

An annual plant that is commonly cultivated as a cereal in dry regions of Asia and Africa is called finger millet. It continues to be a key component of Karnataka's staple diet. Finger millet is a good source of nutrients, including calcium, along with other minerals and fibre. Below is a list of finger millet's nutritional values (Bhatt et al.,2003; Rajasekaranet al.2004).

• ***Finger millet for losing weight:***Contains an amino acid called Tryptophan that reduces appetite and aids in maintaining a healthy weight.

• ***Finger milletfor bone health:*** Its high calcium content keeps growing children's and elderly people's bones healthy; reduces the chance of fracture and delays the onset of diseases like osteoporosis.

***Finger millet for diabetes:*** Contains phytochemicals that aid in lowering blood sugar levels in diabetics and slowing down the digestive process.

• ***Finger millet for lowering blood cholesterol:*** Contains lecithin and methionine, two amino acids that lower cholesterol by removing excess fat from the liver. Additionally, it has the amino acid threonine that keeps the liver from getting fat and decreases cholesterol levels in the body.

• ***Finger milletfor anaemia:*** It is an excellent natural iron source that helps treat anaemia.

• ***Finger milletfor relaxation*****:** It is helpful for anxiety, sadness, and insomnia and naturally relaxes the body. Additionally, it helps with migraines.

• ***Finger Millet for Protein/ Amino Acids:*** Amino acids, including tryptophan, methionine, valine, isoleucine, and threonine are abundant in it. Isoleucine promotes the health of the skin, aids in blood production, and aids in muscle regeneration. Valine is a necessary amino acid that aids in tissue healing, muscular coordination, and metabolism. It aids in the body's nitrogen balance. Methionine helps the body get rid of fat and is the primary source of sulphur, which is needed to make glutathione, the body's natural antioxidant.

• ***Finger Millet for other health conditions:*** It helps prevent early ageing, degenerative disorders, and hunger. Green ragi is advised for asthma, liver problems, low blood pressure, and heart weakness.It is also advised for nursing mothers who are unable to produce enough milk.

**Health Benefits of Finger Millet (Mathanghi and Sudha, 2012)**

• Its polyphenol content is thought to be responsible for some of the health advantages. Brown finger millet has a 96% higher phenolic acid concentration than the white variant.

• Compared to other millets, Black finger millet has higher levels of valine, threonine, and lysine. It also has 8.47 g/g of dry weight protein and 8.71 mg/g of fatty acid.

• According to reports, finger millet has anti-ulcerative qualities. In diabetic rat models, finger millet diets reduced blood glucose and cholesterol (with a 36% reduction in blood glucose levels).

• Rich in dietary fibre and phenolic compounds, finger millet seed coat matter was found to have nephron-protective, anti-cataractogenic, and blood glucose and cholesterol-lowering properties in streptozotocin-induced diabetic rat models.

• Supplementing infants with the germinated finger millet-based food found to improve hemoglobin status.

• Lower serum cholesterol and triacylglycerol levels (43% and 62%, respectively) compared to diabetic controls

• Additionally, it has been observed that finger millet extracts exhibit antibacterial, anti-cataractogenic, anti-free radical scavenging, and anti-protein glycation effects "*in vitro*." Finger millet phenolics inhibit snake venom phospholipases "*in vitro*".

• High reducing power for seed coat polyphenol extract compared to the polyphenol extract from finger millet whole flour. The polyphenol extract from the finger millet seed coat has higher antioxidant activity (86%) than the polyphenol extract from the finger millet whole flour (27%).

• Offered defense against epithelialization, mucosal ulceration, enhanced synthesis of collagen, activation of fibroblasts, and mast cells.

**Summary and conclusions**

Millets have good grain qualities suitable for processing. The primary (watering, de-hulling, and milling) and secondary (fermentation, malting, extrusion, flaking, popping, and roasting) processes involved in processing grain are numerous. Being a staple and consumed at household levels, processing must be considered at both traditional and industrial levels, involving small, medium and large-scale entrepreneurs (Obilana and Manyasa, 2002; Hamad, 2012). The Millets Value Chain and Odisha Millets Mission are the projects that focuses on a few specific millet foods, with sorghum being the exception. This model can be effective in the case of finger millets, which will benefit consumers, households, and entrepreneurs by allowing them to practice and prepare various ways to prepare health-beneficial value-added product. By promoting value-added products, households, small and large businesses, self-help organizations, and entrepreneurs can increase their income levels through the preparation and manufacture of these goods. The marketing of these value-added items can enhance customers' socioeconomic

standing and general health. Therefore, the goal of this review is to raise general awareness and in addition enhance the knowledge of the finger millet and its applications in daily life among scientists, particularly chemists and nutritionists.

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**CONFLICT OF INTERESTS**
The authors declare the absence of conflict of interests.

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