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Functional properties and health benefits of finger millet (*Eleusine coracana* L.): A review

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ABSTRACT

In India, ragi is the colloquial name for finger millet (*Eleusine coracana* L.). It is sometimes recognised as poor man's food. Ragi flour is used to baked items to create calcium and iron-fortified biscuits. Calcium deficiency may cause birth abnormalities and dental problems. Ragi is good source of iron, which is crucial for the production of haemoglobin in red blood cells. Nutritionally, finger millets are rich in calcium, potassium, dietary fibres and polyphenolic constituents. Some individuals are allergic to protein gluten causing immune reaction. Gluten intolerance leads to chronic inflammatory bowel disorder. An ongoing strict diet (GFD) is the only solution available for these illnesses. Gluten-free products have less nutritional content and to be more expensive other lactose food products. They are well known for their health benefits like antidiabetic, antioxidant and antimicrobial properties. Hence, finger millets are naturally gluten free, these can be consumed by both gluten intolerant as well as diabetic individuals.

Keywords: Finger millet, *Eleusine coracana*, Celiac disease, Functional foods, Gluten-free, Nutritional content.

INTRODUCTION

Millets are minor cereal which belong Poaceae family. They are annual cereal grasses with small seeds that are characterized by their capacity to thrive in much less fertile soil and for their adaptation to withstand hot and arid environments^[1]. Cultivars include foxtail millet (Kakum), proso millet (Chena), small millet (Kutki), kodo millet (Kodon), barnyard millet (Sanwa), and brown top millet in addition to sorghum (Jowar)^[2]. In ancient Indian Sanskrit literature, finger millet was known as "nrttakondaka," which refers to "Dancing grain." It was also referred to "rajika" and "markataka"^[3]. In several Indian states, finger millet was a commonly grown plant known by names like "umi" in Bihar and "nachni" in the state of Maharashtra, which means "dancer." The grains were gently roasted (sometimes following sprouting and drying), crushed and screened. The ragi flour is consumed like a salted or sweetened gruel or ball. Feeding meals can be made from ragi. Due to its resistance in harsh agro-climatic conditions, it is a well-considered crop of food refuge^[4]. These crops might add variety to the food supply and guarantee food security in terms of nutrition^[5]. When it comes to nutrition, millets offer affordable health benefits for everyday eating and support with managing conditions like diabetes, obesity, hyperlipidemia, etc^[6]. Millet is a gluten-free and inexpensive cereal (about 40%). The calcium content of ragi grain is exceptionally high (300–400 mg), around ten times that of common cereals like wheat and rice. Numerous micronutrients like thiamine, iron, magnesium, zinc, chromium and iodine are present. The millets are regarded as cool food due to high mineral content, which likely contributes to maintaining the acid-base balance in the human body. People who eat millet endure dehydration and thirst better than people who eat other foods^[7]. Round bread cakes that are traditionally leavened with baking powder are known as biscuits. It may be compared to a cracker or a cookie. It is a frequently offered snack that is very nutritious for children and those with diabetes. Those with celiac disease or gluten sensitivity are advised to follow a gluten-free diet as part of their medical nutrition therapy. Coeliac is characterised by a presence of gliadin component in gluten complex. The characteristic protein gluten present in wheat, rye and barley that offer dough its rheological qualities is intolerable to those with celiac disease. Through the patient's generation, avoiding gluten is still an effective therapy for celiac disease [8]. Most people with celiac disease, gluten sensitivity, or other related conditions go misdiagnosed and untreated. Over the past several years, gluten-free products are highly recommended. Additional gluten consumption also affects how well our brain functions^[9]. Ragi grains have various morphological characteristics. It is a little grain with only one seed, and the kernel lacks a proper caryopsis in favour of an article. Rub or soak a tiny seed coat in water to remove them. Occasionally after being threshed, it still clings to the seed. The colour of its seed is brown and endosperm is white. Kernel's size ranges between 1mm to 1.8mm and its form oval, round or globular shape^[10].

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Necessity for emerging gluten free product

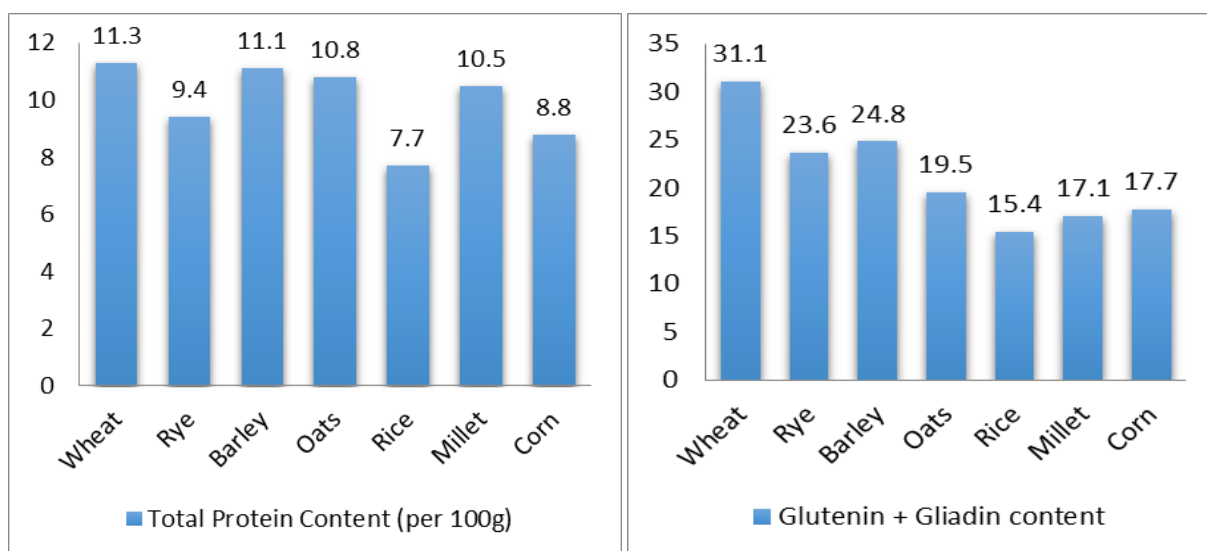
Avoiding gluten and sticking to a diet may seem easy. It's difficult since it entails not only avoiding all products and grains that contain gluten but also requires continual monitoring [11]. Major food items are made from wheat like Pasta, cakes, cookies, morning cereals, bagels, breads, and soups. Avoiding these things would necessitate a radical shift in lifestyle, which not everyone could accomplish. Thus, demand for gluten-free food items is increasing today [12]. Rapid dietary change has occurred in recent years, urbanisation, globalisation, as well as social prosperity, which has led people suffer from poor health and diseases like obesity, diabetes, disorder stroke, hypertension and a few types of cancer [13].

There has been a tremendous rise in public awareness about the benefits of functional foods or biologically active dietary ingredients which improve health [14]. Food would also help individuals avoid diseases linked to poor nutrition, alleviate hunger and improve both their physical and emotional health [15], [16]. This idea led the emergence of modern perceptions of diet and nutrition such as health foods. The term "health food" is commonly refer to any food that has nutritional or health benefits. Hence, "food" is a general phrase that can refer to any type of food, including creative foods, functional foods, organic foods, whole foods, and nutraceuticals [17].

When nutritional therapy is the only kind of treatment for an illness, health foods are essential for improving health [18]. People with this condition often have gluten sensitivities, which necessitate the avoid to gluten containing grain [19]. It is prominent in genetically susceptible individuals, resulting in unusual immune response to gluten associated prolamines [20]. Research activities in creating new technologies and gluten-free food items have also grown increasingly common as illness occurrences rise, with the shared objective of meeting the demands of a rising market [21]. Oats are considered gluten free but still there are some conflicts whether they are safe for celiac patients [22]. Therefore, many celiac patenits avoid using oats and other gluten containing products [23].

Gluten content in different cereals

The ragi outer layer contributes to the biscuit texture. Based with a sensory evaluation, a composite biscuit flour contains 10% of SCM (seed coat matter) found form naturally or hydrothermally treated millet and 20% from malted millet [24]. The ragi offers 6–8% protein, 1%–1.7% fat, 65–75% starch, 2%–2.25 minerals, and 18–20% dietary fibre. In terms of calcium, dietary fiber, and other micronutrient, its composition is superior to that of corn, wheat, rice, sorghum, and certain other grains. This finger millet outer layer is loaded with nutrients, dietary fibre, and polyphenols. [25].



Source: [26], [27]

Figure 1: Ratio of total protein content to the glutenin + gliadin content in gluten containing cereals

Composition and nutritional aspect of Ragi

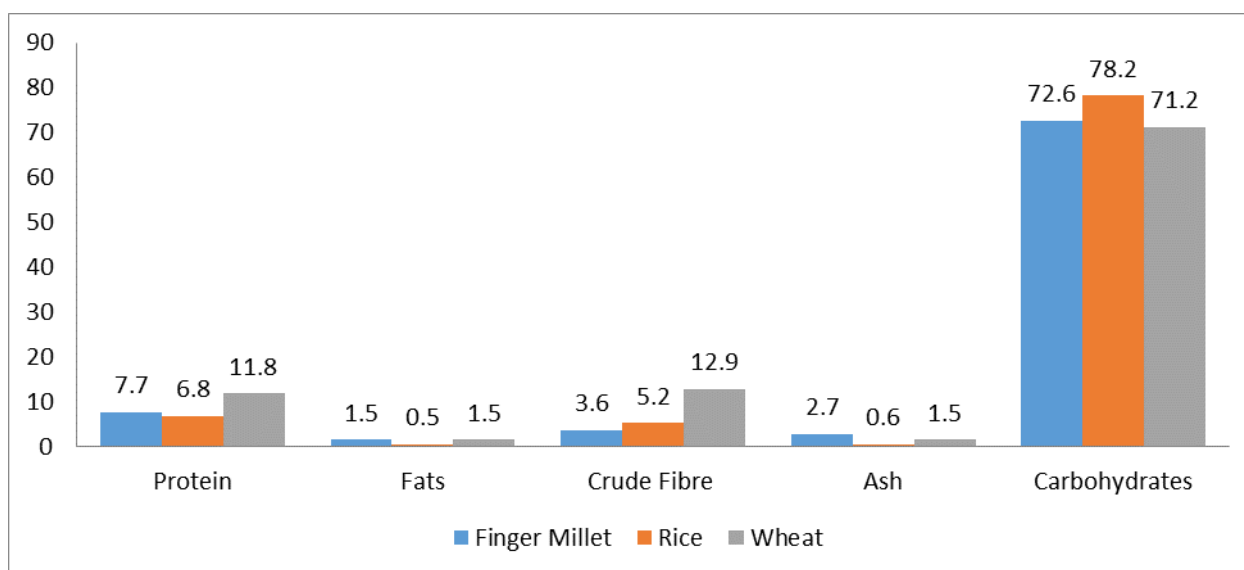
Calcium, minerals, and fibre are among the components that make ragi so nutritious. In cereal grains, the range of carbohydrates is between (72 to 79.5%) [28]. Starch makes up the majority of the carbohydrates ranging from 59.4% to 70.2% [1], [29], [30]. There is residual amylose from 15 to 20% and finger starch amylopectin close to 80-85% [28], [31], [32], [33]. In ragi, the non-starch polysaccharides account for (20 to 30) percent of the total carbs [33]. Millets' high fibre content is believed to be responsible for their hypoglycemic effects. Complex carbohydrates in high-fiber diets are slowly absorbed and then assimilated, which lowers post-meal blood sugar levels [34].

Protein ranks as millet's second most vital ingredient. Ragi is a wide range of protein content from 5.6 to 12.70%, with a 71% of its protein content [35], [36], [37], [34]: [38], [39], [40].

Essential amino acids have a significant impact on how well proteins function. The necessary proportion of finger millet's amino acids is 44.7% [41]. With regard to the ratio of essential to non-essential amino acids, ragi has a well-balanced amino acid profile. Compared to the amino group ratings system for kids aged 2 to 5, (FAO, 1991), Every other amino acid ranks higher than 1 except lysine. The amino acid tryptophan is frequently absent from grains; however, it is found in finger millet. The ratio of valine, threonine, and lysine in ragi is balanced when relative to other millets [42]. Lysine and methionine are among the millet grain's protein constituents. Proline, valine, isoleucine, leucine, and phenylalanine are all present in greater amounts in the major protein fraction than they are in arginine and glycine. Albumin and globulin fractions are also important [43]. Isoleucine is found in high concentrations. Leucine to isoleucine concentration is close to 2, similar to wheat and rice [44], [34] found a high proportion of crude fat 2.1%. Fat varies between different varieties of ragi (1.2 to 1.4%) [45]. According to Sridhar and

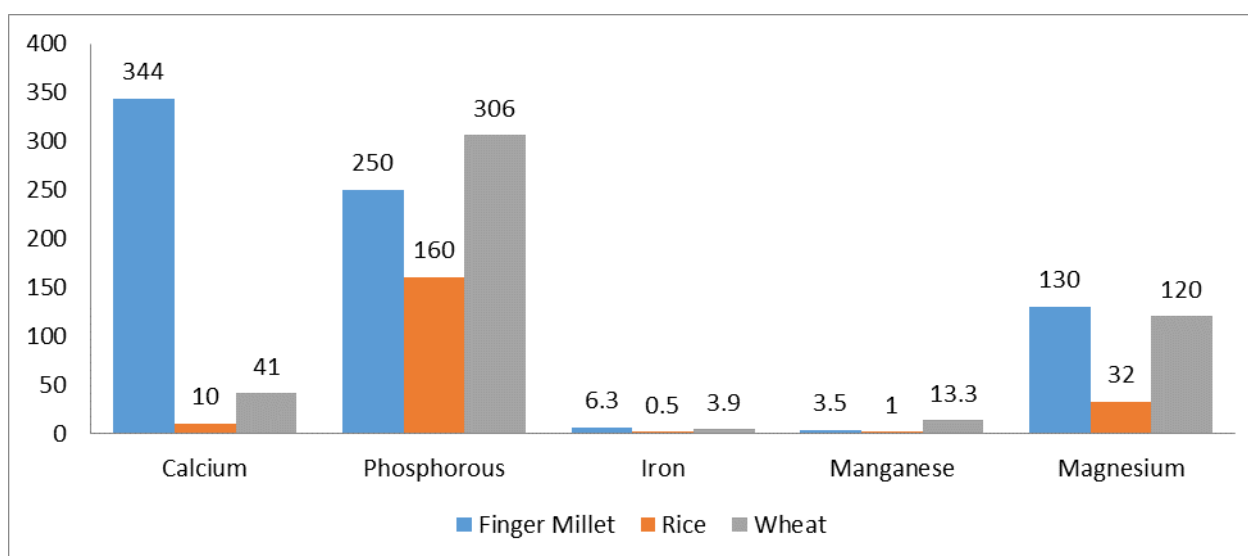
Lakshminarayana [46], free lipid, bound lipid, structural lipid and phospholipid are present. Oleic acid, palmitic acid, and linoleic acid are the main fatty acids, respectively. According to the fatty acid outline, saturated fatty acids make up (25.6 percent) of all fatty acids, whereas unsaturated fatty acids make up the majority 74.4% [46].

Finger millet includes key essential nutrients such isoleucine (4.4g), leucine (9.5g), methionine (3.1g), and phenylalanine (5.2g) that other starchy grains do not. Additionally, millets include minerals like calcium, iron, potassium, magnesium, and zinc as well as B vitamins like niacin, pyridoxine and folic acid [47].



Source: USDA Nutrient database

Figure 2: This chart depicts the comparative studies of nutritional composition among finger millet, rice and wheat. The represented values are mention in (gm).



Source: USDA Nutrient database

Figure 3: This chart depicts the comparative studies of nutritional composition among finger millet, rice and wheat. The represented values are mention in (mg).

Polyphenols and Dietary Fibre in Finger Millet

Phenols are abundant in the grain's outermost layers, including as the aleurone layer, testa, and pericarp, which serve as the primary mechanisms for the bran fraction. The phenols found in finger cereals contain ferulic acid and p-coumaric acid, which make up 64-96% and 50-99% respectively of the total ferulic and p-coumaric acid inside millet grains. Proanthocyanins, which are also referred to as condensed tannins, are reportedly present in several varieties of finger millets [48]. These polyphenols with a high molecular weight are composed of polymerized flavan-3-ol and/or flavan-3,4-diol units. Proanthocyanins are present in sufficient quantities and may reduce the health benefit and availability of minerals and proteins [49]. The

largest level of catechin equivalent (311.28 ± 3.0 mole of catechin corresponding of pure meal) was found in local finger millet, followed by foxtail millet, small millets, pearl millet and proso millets [50]. Different genotypes of ragi grains contain a variety of total tannins and phenolics. Compared to grains with brick red pigment, grains with light-coloured varieties have substantially lower overall phenolic and tannin contents. High quantities of tannin are known to exist in red-coloured cultivars with pigmented testa, which become found in the aforementioned grain tissue [51]. They discovered found among 85 kinds of Indian finger millet, brown variations were restricted (1.2–2.3%) and located in the total polyphenol interiors (as catechin equivalents [52]. Tannin satisfaction was evaluated in hilly regions and found to have less variation than base regions [53]. Finger

millet contains a higher proportion of nutritional fibre than many other cereals. The health benefits of finger millet include increased faeces volume, lower blood lipids, prevents colon cancer and fermentability characteristics [54].

Finger millets possesses functional fibre fraction called RS, which avoids enzymatic digestion and has positive benefits by reducing a number of digestive problems. [55], [56]. Bypassing digestion, it delivers short-chain fatty acids and fermentable metabolites to the colon, including butyrate, which may act as a defence against colon cancer by regulating colonic cell proliferation. Additionally, resistant starch (RS), which has medicinal advantages, improves the appearance and mouthfeel of fibres [57].

Common traditional processes used in the case of millets is puffing and popping. A RTE product with a palatable texture and flavour is popped millet and its flour. By impeding some of the anti-nutritional components, this method restores the nutritional value and improves the carbohydrates and protein digestibility [58]. Since ancient times, millet malt has been used for new-born feeding purposes as well as to make drinks using milk or tepid water and some of sugar. To prepare wearing dishes, finger millet with good malting characteristics is employed. Particularly in the regions of Karnataka and some regions of Tamil Nadu, its malting is well-liked. Malting finger millet has a noticeable impact on reducing the antinutrients while also enhancing the grain's sensory, nutritional, and digestible qualities [60]. There are various additional regional customs and preferences that are used in addition to the aforementioned dishes that employ finger millet. Modern products on the market include finger millet, such as foodles, multi-grain noodles, ragi biscuits, and ragi vermicelli. Ragi health drinks, such as Baby vita, are another example. Mineral and micronutrient content are superior to that of many cereals. Its primary use as a food has only remained in areas where it is cultivated [61]. Millets have strong long-term potential for providing consumers with nutritional security [62].

Health advantages of finger millet

Antidiabetic

Consuming meals high in fibre and complex carbohydrates helps prevent subsequent blood glucose spikes, which is essential for managing diabetes and lowers chronic vascular issues [63], [64]. According to studies, finger millet's carbohydrates were absorbed and processed far more slowly [65]. The advantages of cereal grains were related to its dietary fibre and polyphenols contents [66] which were recognized to lowers the incidence of diabetes mellitus [66] and gastrointestinal tract diseases [67].

Antioxidant

Antioxidant substances are becoming more and more common as lipid stabilizer and inhibitors of extreme oxidation [68]. The seed coat of millet contains polyphenols and its constituents, flavonoids and tannins which have multiple uses. They can act as chelators of metals, these both of singlet oxygen and reductants [46], [69]. The capacity of phenolic compounds to donate hydrogen atoms to free radicals that lack an electron via the hydroxyl groups on benzene rings results in the formation of a resonance-stabilized but much less reactive phenoxyl radical. In edible flours derived from tiny millets, endogenous antioxidants are [70].

Antimicrobial

According to [71] the phenolics in finger millet, mainly the tannins, may provide resistance to fungus infection. A structural obstacle towards fungal infection is created by phenolic compounds, particularly tannins in the grain's outermost layer. Because of the high polyphenol content of the seed coat, acidic methanol extracts of the seed coat show greater antifungal and antibacterial properties than whole wheat extracts [72].

Prevention of collagen glycation and crosslinking

Scientists studied glycation and crosslinking of collagen using kodo and finger millet methanol extract extracts. This glycation process was stopped when the collagen was supplemented with 50 mg of glucose and about 3 mg of finger millet methanolic extract. This could be because the millet grains' seed covering contains phytochemicals that were isolated from polyphenolic natural antioxidants [73].

Production and uses of Finger Millet

Finger millet (*Eleusine coracana* L) is grown in various parts of India and around the world. India produces approximately 60% of the world's finger millet. Although finger millet is rarely traded on international markets, it is important crop for adaptability and good source of fat, minerals and protein. Many of the low-income inhabitants in East Africa and South-East Asia depend on this little crop as a primary source of nutrition [74]. Both the native and malted kinds of minor millet, which is already present, are utilised to produce geriatric, infant, and nutrition products. These millet grains are ground into flour to make a variety of dishes such as pancakes, porridge, puddings, cookies, bread, rotis and other snacks [1].

In various African nations as well as the Indian Subcontinent, finger millet is a main staple meal among the traditional consumers as well as lower socioeconomic strata. It's a small cereal with tiny seeds (1.2-1.8 mm in diameter), an outer layer that is light brown and brick red with gently undulating appearance. Both its natural form and handled (malted) versions of finger millet, which is high in calcium and dietary fibre, are frequently utilised [75]. There are certain health advantages to regularly consuming meals made of millet. For example, the range of its consumption among non-traditional millet eaters is defined in accordance with its antilucerative, hypoglycemic, and hypocholesterolemic accordance [76]. Later, the ragi acceptability might be restored by serving as ready-to-eat cereal. Recently, it has been combined with other ingredients to make other biscuit concoctions. For use in human nutrition, finger millet is typically used to make roti and other dishes. Several studies have suggested that adding millet and other flour to wheat flour in different quantities to prepare bread, cookies, or other snacks has promise. The type and value of ingredients used influence the quality of a biscuit [49]; [76] [46]. Protein quantity and value of the ingredient will differ as the variety changes. As per to De La Roche and Fowler (1975), high protein tends to shorten biscuit after baking. In contrast to bread, where the qualitative and sensory role of proteins is well proven, it is difficult to pinpoint how gluten impacts the quality of biscuit dough. There are incredibly few reports on how gluten is used to make biscuits. These reports explain how wheat and ragi flour affects the physical characteristics of dough and the final quality of the biscuits produced after baking. The research determines the optimal finger millet varieties for producing biscuits [77].

Alternative Sources

Cereals that contain gluten must also be avoided, including important food items that are important providers of protein in diet. High protein

cereals which are used as gluten-free flour are listed below. Wheat has a protein concentration of (10-12%) hence celiac patients must entirely eliminate wheat from their diets.

Table 1: Alternative cereals used as gluten-free flour

Categories		Protein	Fat	Carbohydrate	Crude fibre	Dietary fibre
Cereals	Rice	7.70	2.20	73.70	1.63	2.20
	Corn	8.80	3.80	65	ND	2.20
	Sorghum	10.40	1.90	72.60	1.60	9.80
Minor cereals	Finger millet	8.20	1.80	83.30	3.50	ND
Pseudo cereals	Buckwheat	12.50	2.10	75.74	0.70	29.50
	Quinoa	16.50	5.20	69	2.30	14.20
Other Cereals		23.70	7.90	60.93	ND	7.30
Legumes	Chickpea	23.64	6.48	64.60	ND	7.30
	Soybean	36	19	35	7.5	17
	Pea	21.3	0.60	14	ND	18.4

ND= Not Determined.

Sources: [78]; [79];

CONCLUSION

Considering as finger millet is a warming grain that aids in body heating during cold or wet weather, it is regarded to be among the less inflammatory but also most edible grains on the market. Its grain's outer layer has high fibre content. People should be made aware of the nutritious content and health advantages of finger millet and the foods prepared from it. Analysing all cereal grains, it was determined to have the best nutritional and functional qualities.

Conflict of Interest

The authors declare that they have no conflict of interest.

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