



Review Article

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PREVENTIVE POTENTIAL OF FINGER MILLET (*RAGI ELEUSINE CORACANA L.*) IN NUTRITIONAL ANEMIA AND LIFESTYLE DISEASES: A COMPREHENSIVE REVIEW

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ABSTRACT

Finger millet (*Eleusine coracana L.*), commonly known as ragi, has been traditionally consumed in various regions, and its nutritional profile holds significant promise for combating nutritional anemia and lifestyle diseases. Rich in essential nutrients like iron, calcium, dietary fiber, and polyphenols, finger millet offers several health benefits. This review highlights its preventive potential against nutritional anemia, primarily due to its iron content, and its role in managing lifestyle diseases such as diabetes, cardiovascular diseases, and obesity. The bioactive compounds in finger millet, such as antioxidants and phytochemicals, contribute to its anti-inflammatory and cholesterol-lowering effects. Moreover, its low glycemic index aids in better blood sugar management, making it a suitable dietary option for diabetic patients. The review also discusses challenges related to bioavailability and processing methods that may affect nutrient retention. In conclusion, incorporating finger millet into diets could serve as a preventive strategy against nutritional anemia and various lifestyle diseases, promoting overall health and well-being.

Keywords: Nutritional Snacks, Nachani Benefits, Anemia Prevention, control of Malnutrition, Millet for lifestyle disorder, Finger millet, Ragi millet.

INTRODUCTION

Adequate nutrition is a fundamental pillar of individual health, playing a crucial role in maintaining overall well-being. Optimal nutrient intake is essential for the proper functioning of the body, supporting growth, development, and physiological processes.¹ notably, nutrition is precarious in the prevention of various diseases. In India, deficiencies in iron, calcium, and vitamin D are major health concerns. According to the World Health Organization (WHO), there are two billion people worldwide with anemia, with iron deficiency accounting for half of these cases. The National Family Health Survey 5 (2019-21) reports anemia prevalence among various groups: 25% in men (15-49 years), 57% in women (15-49 years), 31.1% in adolescent boys (15-19 years), 59.1% in adolescent girls, 52.2% in pregnant women (15-49 years), and 67.1% in children (6-59 months).

While malnutrition indicators among children under five years old, such as stunting, wasting, and underweight, have shown reductions per NFHS-5 (2019-21)—from 38.4% to 35.5%, 21.0% to 19.3%, and 35.8% to 32.1%, respectively—malnutrition, defined as an unintentional weight loss of more than 10%, remains a significant issue.² According to WHO, an unhealthy diet is a critical behavioral risk factor for cardiovascular diseases, contributing to hypertension, hyperglycemia, hypercholesterolemia, overweight, and obesity. If these intermediate risk factors are not addressed during primary care, they can increase the risk of myocardial infarction, stroke, heart failure,

and other cardiovascular complications. Thus, a proper diet is indispensable for the prevention and recovery from various illnesses.³

LITERATURE AND SOURCES

This review comprises multiple databases, including PubMed, Research Gate, and Google Scholar, to ensure a comprehensive collection of relevant literature. Additionally, an extensive literary search was performed across various Ayurveda texts, such as Raj Nighantu and Kaidev Nighantu, to gather valuable insights into the research evidence pertaining to the various benefits and properties of Ragi (Finger millet). The review focused on Preventive action of Ragi (Finger millet) in Nutritional Anemia and Lifestyle Diseases as well as therapeutic indications.

The primary objective was to explore the nutritional impact of Finger millet (*Eleusine coracana L.*) on nutritional anemia and lifestyle diseases. Both *in-vitro* and *in-vivo* studies addressing the benefits of Finger millet were incorporated into this review. Diverse clinical studies, including randomized cross-over studies, self-controlled case studies, and pharmacological investigations, were referred to, providing strong evidence for the impact of Finger millet on anemia and lifestyle disorders.

A thorough manual search was conducted within each article to identify additional relevant research articles. References cited in

the selected articles were also examined, and full articles were obtained and included in the study where appropriate.

Finger Millet

Millets, referred to as "Trinadhanya" in Ayurveda, are cultivated globally as minor-seeded grasses. Ayurveda recommends a diet-based treatment protocol for diseases, prominently incorporating millets.⁴Finger millet (*Eleusine coracana* L.), commonly known as ragi, is widely used in the southern regions of India and Maharashtra and is referred to as nachani in northern India. Often considered a "poor man's food."⁵ Finger Millet is prevalent in several regions of India. Archaeological evidence indicates that ragi was produced during the late Harappan period (2000–1200 BC).⁶

Synonyms	Narthakundaka, Narthaka, Nrithakunda, Malinjaka, Kanisa, Bahudala, Bhucara, Maliyasa, Katina, Guchakanisa, Lancchana, Bahupatraka, Nrthakundala ⁷
Vernacular name	Malayalam: Muttari, English: Finger millet, Hindi: Maruva, Tamil: Kelvaragu
Botanical name	Eleusine coracana Linn
Family	Poaceae

Table 2: Nutraceutical value of ragi (per 100g)¹⁰

Proteins (g) 7.3	Vitamin (g)	Minerals (mg)	Fats
Isoleucine: 275	Thiamine: 0.42	Phosphorous: 320	Fatty acids
Lysine: 181	Riboflavin: 0.19	Magnesium: 137	Linoleic acid: 362 mg
Leucine: 594	Niacin: 1.1	Calcium: 398	Oleic acid: 585 mg
Methionine: 194		Iron: 3.9	MUFA: 585 mg
Cysteine: 163		Zinc: 2.3	PUFA: 431 mg
Phenylalanine: 325		Copper: 0.47	
Threonine: 191		Manganese: 5.49	
Tryptophan: 191			
Valine: 413			

Source: Indian Food Composition Tables, NIN – 2017 and *Nutritive value of Indian foods, NIN – 2007

Table 3: Comparison of nutritional content of Finger Millet in 100 grams of dry grains (cereals).¹¹

Millet	Iron (in mg)	Calcium (in mg)	Minerals (in gm)	Fibre (in gm)	Protein (in gm)
Finger millet	3.9	344	2.7	3.6	7.3
Pearl millet	11	42	2.2	2.3	11.8
Fox tail millet	2.8	31	4	6.7	12.3
Kodo millet	1.7	35	2.6	5.2	8.3
Little millet	9.3	17	1.7	7.6	7.7
Sorghum millet	5.4	25	1.2	2	10.4
Rice	1.8	33	0.6	1	6.8
Wheat	3.5	30	1.5	2	11.8

Source: National Institute for Nutrition, Hyderabad.

Finger Millet Based Food Preparations

Following are the few examples of finger millet preparations which can be incorporated in daily diet.

- Ragi Halva:** Heat 3 to 4 teaspoons of ghee in a heavy-bottomed pan. Add ½ cup of ragi flour and stir continuously. Gradually incorporate 1 cup of hot milk, stirring until the mixture thickens. Add 1 tablespoon of Jaggery powder and ¼ teaspoon of cardamom powder and mix thoroughly.
- Ragi Laddoo:** Heat a pan and add 4 teaspoons of ghee and ragi flour over low heat. Roast until the mixture turns golden brown and aromatic. Integrate caramelized Jaggery, grated coconut, and chopped almonds, then shape the mixture into round Laddoo.
- Ragi Upma:** Dry roast ragi flour and semolina in a 2:1 ratio. In a separate pan, prepare a tempering with hot oil, mustard

Properties of Finger Millet (Ragi) According to Ayurveda

In Ayurveda, Finger millet is known as Nartaki and Madhulika. It possesses Sweet-astringent (Madhura-Kashaya) taste, cold in potency (Sheeta Veerya), a type of sweet, anabolic transformation (Madhur vipaka) and properties such as light (Laghu) and dry (Ruksha). It possesses actions such as tonic (Balya), growth promoting (Brimhan), nourishing (Tarpana) and pacifies all three Vata, Pitta and Kapha dosha.⁸

Table 1: Nutritional Composition of Finger millet (per 100 grams)⁹

Parameters	Ragi (Finger Millet)
Moisture (g)	13.1
Protein (g)	7.3
Fat (g)	1.3
Minerals (g)	2.7
Dietary fiber (g)	11.5
Carbohydrate (g)	72.0
Energy (KCal)	328

Sources: United States National Research Council/National Academy of Sciences (1982); USDA/HNIS (1995); FAO (2012)

- seeds, curry leaves, and asafetida. Sauté onions, then add carrots. Incorporate the roasted ragi-suji mixture along with salt. Cook for 2 minutes, gradually adding water and stirring continuously. Garnish with coriander leaves.
- Ragi Mudde:** Ragi Mudde is a traditional dish prepared using finger millet flour, which is cooked with water until it reaches a thick consistency and then molded into spherical shapes. It is commonly accompanied by dal or curry made from leafy greens.
- Ragi Smoothie:** Boil 1 cup of water in a pot and slowly add the ragi slurry, reducing heat as necessary. Cook for 4-5 minutes until the mixture thickens. In a blender, combine the cooked ragi mixture with banana, dates, soaked almonds, flaxseeds, chia seeds, ground cinnamon, and either almond milk or cow milk. Blend until smooth.

Nutritional and Therapeutic health benefits of Finger Millet (*Eleusine coracana* L.)

Different nutritional deficiencies commonly found in India are Kwashiorkor, Marasmus, PEM (protein-energy malnutrition),

vitamin deficiency, nutritional anemia, osteoporosis, and iron deficiency. Various research clinical as well as experimental studies identified number of nutritional and therapeutic health benefits of Finger Millets.

Table 4: Therapeutic health benefits of Finger Millet (*Eleusine coracana* L.)

Nutrient	Types of nutrient present in Ragi	Indication	References
Carbohydrate	Cellulose, glucose, hemicellulose, higher oligosaccharides, maltose, malt triose, pentose's, raffinose, resistant starch, starch, sucrose, and xylose, slow digesting starch	Diabetes and obesity	12
Proteins	Albumins, CREB-binding protein, globulin, and prolamins	Protein-energy malnutrition, maintaining homeostasis in various ailments	13
Fats	Biologically important glycosyl moieties	Anti-ageing, extremely good shelf life	14
Fiber	Crude fiber and soluble fiber	Diabetes, CVDs, gastrointestinal disorders	15
Vitamin	Fat-soluble water soluble, mostly niacin, riboflavin, and thiamine	Anemia, malnutrition, obesity	16,17, 18
Mineral	Calcium, iron, lead, magnesium, manganese, potassium, sodium, and zinc	Osteoporosis, anemia	18
Phenolic compound	Phenolic acids, and hydroxyl benzoic acid, derivatives: Gallic acid, protocatechuic acid, p-hydroxybenzoic acid, vanillic acid	Anti-carcinogenic, antioxidant, anti-inflammatory	19, 20, 21
Flavonoids	Quercetin, proanthocyanidins	Inhibits cataractogenesis, antioxidant, anti-inflammatory, anti-viral, anti-bacterial	22, 23

Research Reviews on Therapeutic Effects of Finger millet

Anemia Prevention

Tatala *et al.*, 2007 demonstrated that a germinated finger millet-based food formulation significantly enhanced the nutritional profile of diets and effectively mitigated anemia among Tanzanian children. ²⁴ Sharat *et al* 2022 conducted a comprehensive study on the nutritional impact of millet-based diets on pregnant and lactating women in Mahabubnagar. The study recorded an increase in mean body weight from 51.1 ± 2.76 kg to 52.23 ± 5.81 kg, alongside a notable improvement in hemoglobin levels, highlighting the positive effects of millet-based nutritional interventions on maternal health. ²⁵

Calcium and Bone Mineral Density Improvement

Anitha *et al.*, 2021 reported a significant retention of calcium (p < 0.05) from a finger millet-based diet, suggesting its potential to support bone accretion during childhood growth. There in vitro study demonstrated a calcium bioavailability of 28.6% from boiled finger millet, with certain processing methods increasing bioavailability to 61.4%. Irrespective of processing techniques, finger millet consistently contributes to high calcium retention and bioavailability, supporting healthy growth and mitigating complications associated with calcium deficiency. ²⁶ Sahaya Rani *et al* 2021 observed low bone mineral density (BMD) and calcium levels among premenopausal women. Their findings indicated that physical activity combined with finger millet supplementation improved both calcium levels and BMD in this demographic. ²⁷

Nutritional Impact on Children's Health

Durairaj *et al.*, 2019. studied the nutritional benefits of small millets in children. Supplementation with a multi-small millet health mix improved the nutritional status of primary school children, reflected in height, weight, and hemoglobin levels. ²⁸

Impact of Finger Millet on Non-Communicable Diseases

Diabetes Mellitus

Kavitha *et al.*, 1995. reported that meals with high fiber and complex carbohydrates, including finger millet, prevented postprandial blood glucose spikes in diabetics. ²⁹ Finger millet-based products exhibit lower glycemic indexes and elicit reduced

glycemic responses, thereby decreasing the risk of diabetes mellitus and its associated complications Kumar *et al.*, 2016. ³⁰ Anti-nutritional factors in finger millet flour may reduce starch digestibility and absorption, contributing to lower glycemic responses. ³¹ Chaudhary *et al.*, found that oral administration of finger millet-enriched milk in diabetic rats significantly reduced total cholesterol, triglycerides, LDL, and VLDL levels. ³²

Hypertension

Park *et al.*, 2021 observed that ethanol extracts of finger millet supplementation in hypertensive rats inhibited angiotensin-converting enzyme levels, enhanced antioxidant capacity, improved lipid profiles, and significantly reduced systolic blood pressure and vascular remodeling at higher doses (500 mg/kg). ³³

Chronic Obstructive Pulmonary Disease Management

Scoditti *et al.*, 2019 highlighted the role of finger millet-based diet in preventing and treating chronic obstructive pulmonary disease (COPD). Finger millet bran contains anti-inflammatory compounds beneficial for asthma-like inflammatory conditions. ³⁴

Cancer Management

The research conducted by Mahadevaswamy *et al.*, highlighted that free phenols derived from finger millets show enhanced cytotoxic effects on breast cancer cell lines, including MCF-7, MBA-MB-231, and MDA-MB-468. These phenols trigger cell cycle arrest at different phases (G0/G1 or G2/M) based on the cell line, which consequently leads to increased DNA fragmentation. As a result, there is an accumulation of cells in the Sub-G1 phase, indicative of cell death initiation. ³⁵

Panel *et al.*, 2022 found that Finger millet seed coat polyphenols inhibited aldose reductase in cataract eye lenses through non-competitive inhibition, suggesting potential for preventing cataractogenesis in humans. ³⁶

DISCUSSION

Finger millet (*Eleusine coracana*), known in Ayurveda as Nartaki, is described as having a sweet-astringent taste (Madhura-Kashaya), cold potency (Sheeta Veerya), and a sweet anabolic transformation (Madhur Vipaka). It is considered light (Laghu) and dry (Ruksha), providing strength, promoting growth, nourishing, and pacifying all three dosha (Vata, Pitta, and Kapha).

Its properties make it beneficial for treating bleeding disorders, gastric disturbances, and skin diseases. Finger millet's low glycemic index and gluten-free nature help control obesity and diabetes mellitus, which are associated with increased Kapha Dosha. It provides strength to the elderly, children, and women due to its strengthening property.³⁷

The high fiber content of finger millet slows digestion, helping control blood sugar levels in diabetics. Lakshmi Kumari *et al*, 2002 have shown that finger millet-based diets have a lower glycemic response compared to rice and wheat, aiding in diabetes management.³⁸ Finger millet is also effective in addressing malnutrition, degenerative diseases, and premature aging due to its antioxidant properties. Its low-fat content makes it suitable for obese individuals, and its carbohydrate component, being slowly digestible, promotes satiety and weight loss. Finger millet-based diets lower lipid peroxidation, reducing arteriosclerosis and providing protection against strokes and heart attacks.³⁹ Finger millet exhibits low-fat content, making it an ideal dietary component for individuals with obesity... Studies have shown that supplementation with finger millet bran effectively prevents obesity induced by a high-fat diet. In rodent models, this supplementation has also been associated with an increased abundance of beneficial gut micro flora.⁴⁰

Finger millet is rich in calcium (344 mg %), phosphorus (283 mg %), iron (3.9 mg %), protein (5–8%), and dietary fiber (15–20%), with low fat content (1.3%) primarily comprising unsaturated fats. It also contains vitamin D2 (41.60 µg/100 g), enhancing calcium absorption and bioavailability, making it beneficial for preventing nutritional anemia and supporting bone health in children and the elderly.

As Finger millet (Ragi) is a rich source of iron, folate, a B vitamin that plays a crucial role in red blood cell formation. Adequate folate intake is essential for preventing certain types of anemia. Ragi is high in dietary fiber, which aids in better absorption of nutrients from food.

Finger Millet is a potent source of natural calcium, playing a crucial role in enhancing bone strength, particularly for growing children and the elderly. Regular consumption contributes significantly to bone health, reducing the incidence of osteoporosis and minimizing fracture risk. The phytochemicals in finger millet inhibit collagen cross-linking, thereby decreasing tissue stiffness and decelerating the aging process. Its dietary fibers, both soluble and insoluble, contribute to gastrointestinal health, lowering the risk of colon cancer, coronary heart disease, and diabetes by promoting bowel mobility, preventing constipation, and soothing the digestive tract.⁴¹ Additionally, the phytochemicals and antioxidants present in finger millet exhibit substantial anti-carcinogenic properties, functioning as terminators of free radicals and singlet oxygen species.

Finger millet is also rich source of both soluble and insoluble dietary fibers, collectively referred to as roughage, which resist enzymatic degradation during the digestive process. These fibers are instrumental in mitigating gastrointestinal disorders, reducing the risk of colon cancer, coronary heart disease, and diabetes Anderson *et al.*, 2009.⁴² The insoluble fiber fraction, predominantly cellulose, enhances stool bulk and serves as a laxative by stimulating bowel motility and preventing constipation through water retention and peristalsis promotion. Soluble fibers, in contrast, facilitate the lubrication and soothing of an inflamed gastrointestinal tract, contributing to overall digestive health.

CONCLUSION

In conclusion, Finger millet (*Eleusine coracana*) is recognized and promoted as a crucial primary healthy food supplement both in India and globally. Comparative studies indicate that finger millet, relative to other cereals, offer superior nutritive values and are a rich source of essential minerals such as calcium, iron, magnesium, and potassium. Its consumption has been associated with numerous health benefits, including improved hemoglobin levels, enhanced bone health, better child nutrition, and the maintenance of blood sugar, blood pressure, and cholesterol levels.

Finger millet is particularly beneficial in rural areas as a dietary supplement for individuals suffering from energy-protein malnutrition. Its high fiber content aids digestion and its high lecithin content supports the nervous system. Additionally, as a gluten-free grain, finger millet is an excellent dietary choice for individuals with celiac disease or those following a gluten-free diet. Therefore, promoting the use of finger millet as an essential dietary supplement in daily nutrition is imperative for enhancing public health.

FUTURE SCOPE

Although there is ample preclinical evidence supporting the potential of finger millet in managing non-communicable diseases (NCDs), clinical evidence remains limited, with only one study reported. Therefore, it is crucial to conduct randomized clinical trials to confirm the clinical efficacy of finger millet, either as a standalone grain or in combination with other millets or recipes, for the prevention and management of NCDs, as well as to assess its broader health benefits for affected populations.

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