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Review Article

Phyto-Pharmacological Importance with Nutritional Potential of *Eleusine coracana* Linn.: A Review

Surya Nath Pandey*, Payal Mittal, Gurfateh Singh

Department of Pharmacology, University Institute of Pharma Sciences, Chandigarh University, Mohali, Punjab, INDIA.

ABSTRACT

The majority of millet is grown in Nigeria, Mali, Faso, Burkina, Chad, China and India. There are many different types of millet found throughout the universe, but finger millet, small millet, foxtail millet, and proso millet are the most prevalent millets. Among the tiny millets, finger millet (*Eleusine coracana* (L.) Gaertn) has the most area under cultivation in India. Finger millet is the only minor cereal with better nutritional value than barley, rye, and oats, and it has exceptional features as a livelihood food product. It is one of the most significant minor millets, with a high calcium content (344 mg/100g), dietary fibre (18%), phytates (0.48%), and phenolics (0.3–3%). Other than that, it contains significant amounts of iron (3.9 mg), riboflavin (0.19 mg), thiamine (0.42 mg), and amino acids including isoleucine, phenylalanine, leucine, and methionine. Due to its nutraceutical potential, these phytochemicals make finger millet a powerhouse of health-promoting nutrients. It has anti-diabetic, anti-microbial, anti-cancer, antioxidant, anti-aging, anti-bacterial, and hepatoprotective characteristics along with other health benefits. We are exploring the potential of *Eleusine coracana* through this review.

Keywords: *Eleusine coracana*, Finger millet, Antioxidant, Health benefit, Anti-diabetic.

Correspondence:
Mr. Surya Nath Pandey
Department of Pharmacology, University Institute of Pharma Sciences, Chandigarh University, Mohali-140413, Punjab, INDIA.
Email: suryanathpandey8@gmail.com

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INTRODUCTION

The ancient plant *Eleusine coracana* L. Gaertn., also known finger millet, is important throughout Africa and Asia for its historical, cultural, and nutritional significance. It's an all tetraploid (2n = 4x = 36) annual herb which frequently developed in semi-arid and arid parts of India and Central Africa.[1-3] Ragi is also called as bird's foot, African millet, and ear (head of grain), is a type of finger millet with five spikes that radiate in a curving pattern.[4] The term finger millet comes from the panicles' shape, which resembles multiple fingers. FM is the fourth most important millet in the world, after s foxtail millet, pearl millet and sorghum.[5] This is the only millet in the Chlorideae tribe and belongs to the Poaceae family and subfamily chloridoideae. The Poaceae family includes all other millets. It is a resilient crop with a wide range of adaptability that may be cultivated in a variety of conditions. The crop can be grown everywhere in the Himalayas, from sea level to 2400 metres above mean sea level.[6] It is a major minor millet in the tropics, with over 25 nations in Africa (Eastern and Southern) and Asia growing it (from the Middle East to the Far East).[7] A number of cultivars have been identified. Afro-Asiatic forms with full-grown grains visible outside the florets and African highland varieties with grains confined inside the florets are both common in Africa and India. Finger millet is a native of Ethiopia's highlands that is grown in over twenty-five countries including Kenya, Tanzania, Uganda, Bangladesh, Nepal, East China and Sri Lanka. It is thought that Uganda or adjacent locations were the major breeding grounds for *E. coracana*, which was introduced to India approximately 3,000 years ago. Karnataka is India's largest producer of finger millet, with 58% of the global market share, yet only a small part of the population is aware of its nutritional and health benefits.[8]

Rajasthan, Maharashtra, Puducherry, Karnataka, Andhra Pradesh, Orissa, Tamil Nadu, and Goa are some of the major states in India that develop finger millets. Karnataka and Tamil Nadu are the two states that generate the most finger millet in India. The nutritional and physiological benefits of finger millet are greatly enhanced.[9]

The seeds of FM are lesser than those of pearl millet, and the average weight of 1000 finger millet seed grains is approximately 2.6 g. It has a brick red seed coat and is used to produce roti (unleavened breads or pancakes), ambali (thin porridge), and mudde (mud cake) (Dumpling). Processing millets into value-added meals and drinks has enormous potential in underdeveloped countries. Gluten-free millets grains are also suitable for gluten-intolerant patients. It is a crucial cereal crop because of its better nutritional value to rice and identical nutritional value to wheat.[10]

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In tribal, marginal, famine-prone, arid fields, and hill locations, the crop is used as a food security crop and subsistence.[11] It ensures a consistent harvest, making it a necessary crop in some ecosystems. The crop yields both edible straw and grain, that is a valuable meal for animal. Furthermore, it is a drought-tolerant, humidity-resilient crop and cereal of finger millet has a long mean life of distinct times beyond major pest disturbance.[12,13]

Eleusine coracana domestication

Eluesis, a venerable fictional city honouring the Greek goddess of agriculture Demeter, is where *Eleusine* gets its name. The Sinhalese term kurukkan, which describes the grain, is the root of the word *coracana*. De Candolle and Dixit *et al.* claimed that FM originated in India.[14,15] Indian finger millet was referred to as rajika or ragi by Sanskrit authors. According to Burkill *et al.*, *E. coracana* is the cultigen of the arid-dwelling *Eleusine indica* (L.) Gaertn., and India was the site of this species' early human selection.[16] By 5000 BC, *E. coracana* adapted in Western Uganda and the highlands of Ethiopia, and by 3000 BC, it had reached India's Western Ghats.[17,18] The two recognised finger millet races are the African highlands race and the Afro-Asian lowlands race. Investigations of the patterns of variety in the FM germplasm from Africa and Asia have repeatedly found that African collections had higher diversity than Indian collections, supporting the idea that Africa is the main source of origin. The Indian subcontinent's lengthy history of cultivation, along with human selection, has resulted in a great diversity of landraces and local cultivars. As a result, India is regarded as a secondary centre of genetic variety. FM was domesticated, according to DeWet (1995), *E. coracana* subsp. *africana* (syn. *E. africana*) is notably common in an area extending from western Uganda to the Ethiopian highlands.[19,20]

The nutritious value of finger millet is superior than that of other typical grains. It has the highest calcium (344mg) and magnesium (408mg) content of all millets. Pasta, noodles, vermicelli, and bread are some of the new bakery goods made from this millet. It is gluten-free and hence suitable for celiac disease sufferers. Milling, malting, popping, and decortication are all common millet processing procedures.[21] It is equivalent to rice in terms of protein (6-8%) and fat (1-2%), but it outperforms rice and wheat in terms of mineral and vitamin content. It is abundant in calcium (344mg/100g), dietary fibre (15-20%), and phenolic compounds from a nutritional standpoint (0.3-3%).[22]

An annual herbaceous cereal crop called *Eleusine coracana* is widely used in Asia and Africa. It comes from Africa and Asia. Karnataka is the state that produces the most finger millet in India. It is the rich source of nutrients, proteins, iron, carbohydrates, tannins, dietary fiber etc. It has various pharmacological activities such anti-diabetic, antioxidant, anti-ulcer, anti-diarrheal, anti-inflammatory and anti-microbial activity.[23]

TAXONOMICAL CLASSIFICATION

Kingdom: Plantae.

Clade: Angiosperms.

Order: Poales.

Family: Poaceae.

Genus: *Eleusine*.

Species: *E. coracana*.

VERNACULAR NAME

Hindi: Ragi.

English: Korakcan.

German: Fingerhirse.

Nepali: Kodo.

French: millet africain.

Gujarati: Nagali.

Malayalam: Muthari.

Ethno medicinal importance of *Eleusine coracana*

Eleusine coracana is well known plant of traditional medicine system. Seeds of *Eleusine coracana* Linn. is used in various diseases in the various communities where they are found. It is also used to treat diabetes used in the prevention of anaemia. It also reduces the level of cholesterol, triglycerides. It is used as antiulcer agent, antioxidant agent, immunomodulatory agent and also used as anticancer agent.[23] *Eleusine coracana* Linn.'s seed grain is a component of the plant that is used to treat a variety of diseases in the communities where it grows. It's supposed to help with diabetic management, osteoporosis prevention, and anaemia. It is also reported to help breastfeeding mothers who are having difficulty lactating improve their milk supply. When eaten, finger millet is said to induce relaxation and be beneficial in the treatment of anxiety, insomnia and depression. The crops are also utilised to help with weight loss, cholesterol lowering, tissue healing, and as an anti-aging agent.[24]

AIM OF REVIEW

An effort was undertaken to compile data on the health benefits and nutraceutical value of finger millet from the literature that was already published and to organise the data in a clear and easily-documented manner through this review.

METHODOLOGY

The original research and review articles and books were systematically searched for in the databases of Scopus, Google Scholar, Medline, and PubMed libraries using the following query

terms or combinations: "*Eleusine coracana*," "phytochemistry," "medicinal uses," "extracts," "products and formulations," "nutraceuticals, herbal and conventional medications".

Nutritional importance of *Eleusine coracana*

Finger millet is high in nutrients, particularly calcium, minerals, and fibre. The nutritional value of finger millet is good. It has 6% to 8% protein, 1% to 1.7% fat, 65% to 75% starch, 2% to 2.25% minerals, and 18% to 20% dietary fibre. When it comes to dietary fibre, calcium, and a few micronutrients, it outperforms wheat, maize, sorghum, and rice. This millet's seed coat is high in phenolic compounds, minerals, and dietary fibre.[25]

Protein

Despite the fact that different types of millet have A 5% low protein content and a 12% high protein content, the protein level of this millet ranges from 6 to 8%.[26] Prolamins make up roughly 35-50% of total proteins, while albumins and globulins make up 8-15%. It contains good amino acids profile along with 13% tryptophan, 2.5% lysine, 3.1% threonine, 4% leucine and isoleucine and 2.9% methionine.[27]

Carbohydrates

Starch, which makes up 59.4-70.2% of the total carbs in ragi, is the main source of these nutrients. The finger millet starch granules have a polygonal rhombic shape.[28] 80-85% of the starch in finger millet is made up of amylopectin, and the remaining 15-20% is made up of amylase.[29] It is estimated that finger millet contains between 72% and 79.5% of its total calories as carbohydrates.[30] In finger millet, magar and pore found reducing sugar between 1.2-1.8%, while Nirmala *et al.* found 1.5% reducing sugar and 0.03% non-reducing sugar. According to Kamath and Belavady, finger millet offers 18.6% nutritional fibre and 3.6% crude fibre. Joshi and Katoch discovered 3.7% crude fibre in finger millet.[31-34]

Minerals

There are many different mineral compositions in millet grains. Different food crops' minerals are affected by hereditary aspect and local environmental situations in the growing area. Finger millet has a greater total ash content than commonly consumed cereal grains. A range of 1.7 to 4.13% ash was found to be present.[35] According to Singh and Srivastava, the total ash content of the sixteen varieties of finger millet ranged from 1.47 to 2.58%, with a mean value of 2.11%. According to Kurien *et al.*, the husk contains about 49% of the total calcium content of finger millet. According to Sripriya *et al.*, fermentation and germination of finger millet reduced phytate concentration by 60% and enhanced mineral bioavailability.[36,37] Platel *et al.* also found that malting finger millet increased mineral bioaccessibility (iron, manganese). Decortication of finger millet lowered total mineral content but enhanced calcium, iron, and zinc bioaccessibility, whereas popping of finger millet decreased calcium bioaccessibility but increased iron and zinc bioaccessibility. The bioaccessibility of calcium, iron, and zinc was improved by malting finger millet.[38,39]

Dietary fibres

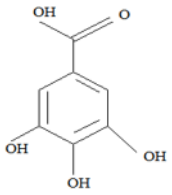
Finger millet grain has a total dietary fibre level of 22.0%, that is above than most other cereal grains, like 12.8% sorghum, 13.4% maize, 4.6% rice and 12.6% wheat. Water soluble and insoluble fibres are two types of dietary fibres. Chethan and Malleshi observed 1.4% soluble and 15.7% insoluble dietary fibre in ragi's grain, while Shobana and Malleshi discovered 19.7% insoluble, 2.5% soluble, and 22.0% total dietary fibre in finger millet.[40,41]

Phytochemicals

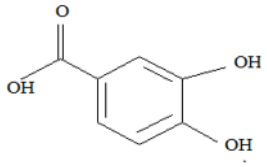
Eleusine coracana is high in proteins, vitamins dietary fibres, minerals, lipids, and polyphenols, according to research. It's also said to be high in calcium.[42] The amino acids methionine, phenylalanine, leucine, cysteine, threonine, isoleucine, histidine, tyrosine, arginine, tryptophan as well as valine are all found in finger millet, according to Ravindran *et al.* Riboflavin, ascorbic acid, ascorbic acids, niacin, tocopherols and B-vitamins are among the vitamins present in finger millet.[43-45] Polyphenols identified in the seed include chlorogenic acid, ferulic acid, vanillic acid, caffeic acid, tannic acid and gallic acid. Using high performance liquid chromatography, the crude polyphenols from *Eleusine coracana* were separated into vanillic acid (3.8%), ferulic acid (32.8), syringic acid (4.0%), gallic acid (12.6%), trans-cinnamic acid (3.6%), quercetin (5.6%), P-hydroxyl benzoic acid (17.9%), and p-couramic acid (3.6%).[46] More polyphenols were found in the seed coat of finger millets. Shobana *et al.* previously identified polyphenols such as naringenin, apigenin, (+)- catechin, diadzein, tetramers of catechin, dimers of prodelphinidin, kaempferol, methyl gallic acid, epicatechin and luteolin glycoside.[47] Banerjee *et al.* also used reverse phase HPLC to investigate whether finger millets contained any extra phenolics. It was revealed that gentisic acid, sinapic acid, and salicylic acid exist.[48] In the millet's ethyl acetate fraction, Singh *et al.* used GC-MS to discover 1,2-benzenedicarboxylic acid.[49] Polyphenols are thought to be subject for free radical-scavenging and antioxidant properties of plant extracts. FM has 0.74% oil, with 47.17% oleic acid, 24.78% linoleic acid, and 23.06% palmitic acid, according to Poonia *et al.* Tannins, alkaloids and terpenoids are found in the plant.[50,51] *Eleusine coracana* seeds have also indicated the existence of arabinoxylan, and three α-amylases have been purified from them.[52,53] From finger millet, Saxena *et al.* isolated a malfunctioned protease/amylase inhibition. Oxidative enzymes of the plant were discovered in finger millet include lipoxygenase, polyphenol oxidases, ascorbate oxidases, and peroxidases. The lipoxygenase enzymes are thought to be subject for the millet's huge level of protection in contrast to pests.[54,55] Finger millet is thought to have a range of helpful phytochemical components and nutrients, but it also contains the antinutrient phytates, which are known for their tendency to bind to essential components such as zinc,

calcium and iron, decreasing their availability in the finger millet.[56] *Eleusine coracana* is rich in minerals, fats, polyphenols, a\ carbohydrates, dietary fibres, carbohydrates and micronutrients. Finger millet contains various types of amino acids such as leucine, cysteine, histidine, tryptophan, valine, lysine, isoleucine, arginine, and threonine. Various vitamins such as riboflavin, tocopherols, ascorbic acid, thiamine and niacin are also present in *Eleusine coracana.* Different types of polyphenolic compounds like tannic acid, caffeic acid, gallic acid, cholinergic acid and vanillic acid are also found in *Eleusine coracaana.* It also contains various phytoconstituents such as naringenin, catechin, luteolin, diadzein, epicatechin, apigenin, kaempferol and phloroglucinol which are responsible for various pharmacological activities.[57,58]

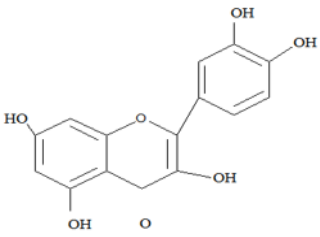
Phytochemical structures



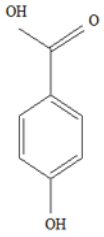
Gallic acid



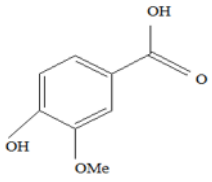
Protocatechuic acid



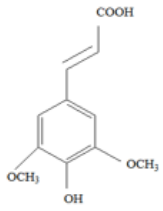
Quercetin



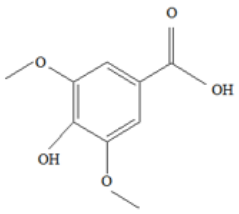
P-hydroxylbenzoic acid



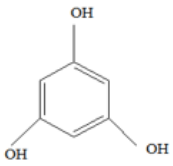
Vanillic acid



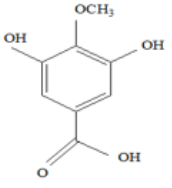
Sinapic acid



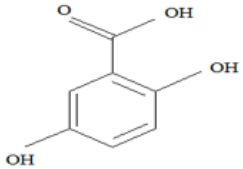
Syringic acid



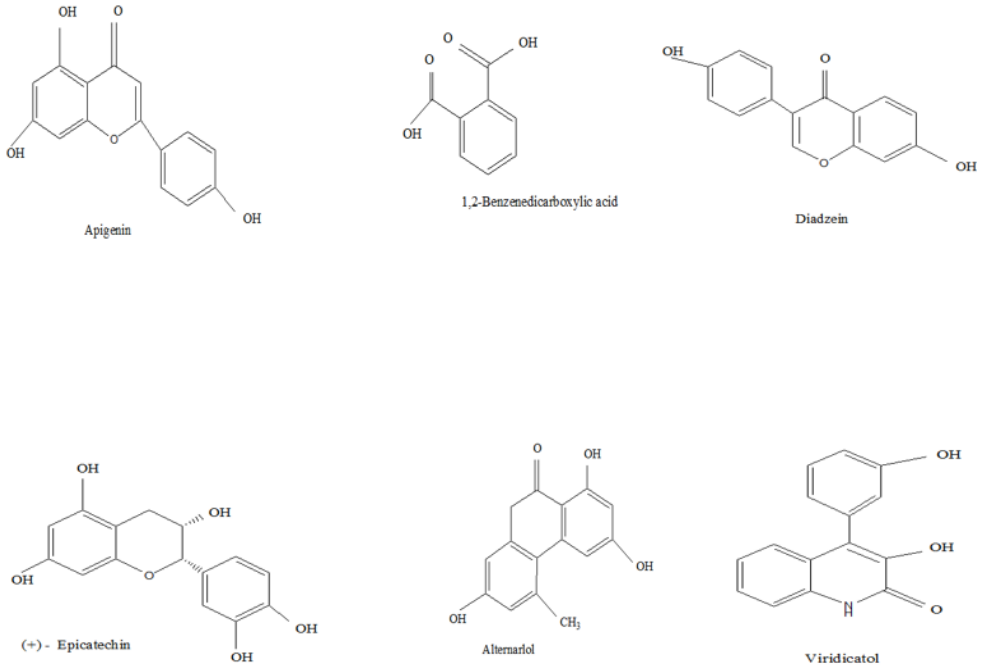
Phloroglucinol



4-O-Methyl gallic acid



Gentistic acid



Pharmacological activities

The plant's pharmacological effects have piqued curiosity due to its many ethnomedicinal uses. Several pharmacological studies on millet have been carried out in attempt to verify ethnomedicinal claims and determine its full pharmacological action (Table 1).

Antimicrobial activity

The methanol-HCl fraction of *Eleusine coracana* seed coat matter demonstrated substantial antibacterial activity, according to Mathanghi and Sudha. The existence of phenolic components in the coated millet components was linked to this function. The huge quantity of polyphenols in the millet coated seed, they continued, are responsible for the millet's exceptional preservation capabilities. They claimed that polyphenols were to blame for the antibacterial action. Inducing oxidation of microbe cell membranes and cell components, as well as an irreversible reaction along with nucleophilic amino acids in an organism, resulting in survival enzyme inactivation. Polyphenols, particularly tannins, may interact with proteins, polysaccharides and perhaps metal ions in the microbe, depriving it of necessary nutrients, according to the researchers.[59] Shukla *et al.* and Singh *et al.* both reported on the antibacterial activity of finger millet. The ethyl acetate fraction, according to Singh *et al.*, was effective against *Pseudomonas aeruginosa* (22 mm), *Shigella dysenteriae* (14 mm), *Staphylococcus aureus* (14 mm), *Enterococcus* sp (17 mm), *Proteus mirabilis* (15 mm), *Salmonella* sp. (16 mm), *Salmon* (17 mm), *Klebsiella pneumoniae* (16 mm) and it was efficient *E. coli*.[49]

Antioxidant activity

Eleusine coracana's antioxidant properties have been studied in numerous studies. Sreeramalu *et al.* revealed the antioxidant activity of extract of the FM, pulses, cereals and other millets by using the different methods like Ferric Reducing Antioxidant (FRAP) and DPPH radical scavenging method. FM has the highest antioxidant activity of all the millets evaluated in all three techniques (finger millet, maize, pearl millet, semolina, wheat, parboiled rice, sorghum, puffed rice and milled rice). The average inhibitory property was 4.54±0.81 mg/g, and the average DPPH inhibitory activity was 1.73±0.03 mg Trolox eqv/g, according to FRAP. The average reducing power activity was 4.54±0.81 mg/g. *Eleusine coracana*, according to Sudha and Mathanghi, is rich in antioxidants and has a free radical-scavenging action.[59,60] *Eleusine coracana* and other edible seeds were studied for their antioxidant effects by Ademosun and Oboh. With an EC_{50} of 8.19±0.80 g/mL, *Eleusine coracana's* aqueous seed extract has a very high phenolic content and a dose-dependent ability to scavenge DPPH.[61] The antioxidant properties of bound and free phenolic acids in the malted and native FM extract were discovered by Muralikrishna and Subba Rao. The results showed that the free phenolic acids had a higher antioxidant activity coefficient (770.00±7.8) than the bound phenolic acids (570.0±6.0) in the malted extract. According to these results, the antioxidant content of plant extracts is significantly increased by the malting process.[62] *Eleusine coracana* grains was subjected to Y-irradiation at the four different doses like 2, 5, 10 and 15 kGy. Effects of Y-irradiation on lipoxygenase activity, pasting properties and proximate

Table 1: Pharmacological activities of *Eleusine coracana*.

Sl. No.	Activity	Part used	Model	References
1	Antioxidant activity	Seeds	Rats and mice	59-65
2	Wound healing activity	Seeds	Rats	59,66
3	Anti-aging activity	Seeds	Rats	67
4	Hepatoprotective activity	Seeds	Rats	68
5	Anti-cataract activity	Seeds	Rabbit	47,69
6	Anti-lithiatic activity	Seeds	Rats	70,71
7	Anti-microbial activity	Seeds	Microbes (*Pseudomonas aeruginosa, Klebsiella pneumonia, Salmonella* sp. etc.,)	49,59
8	Anti-bacterial activity	Seeds	Pathogens (*Salmonella entrica, Bacillus subtilis, Pseudomonas aeruginosa* etc.,)	72
9	Anti-diabetic activity	Seeds	Rats	47,64,68,73-75
10	Anti-cancer activity	Seeds	Rats and cell line	49,76
11	Anti-nutritional activity	Seeds	Cell line	77,78
12	Immunomodulatory activity	Seeds	Cell line	79

composition and antioxidant potential of flour of finger millet were investigated. ϒ-irradiation enhanced protein content while decreasing moisture content, according to the findings. The finger millet flour boosted catalase, superoxide dismutase, and radical scavenging activity while decreasing malondialdehyde concentration and lipoxygenase activity.[63] Ajiboye AA *et al.* used the DPPH, nitric oxide, and hydrogen peroxide scavenging model to evaluate the ethanolic and methanolic extract of whole grain finger millet for free radical scavenging and antioxidant potential. The results showed that the ethanolic extract of finger millet scavenged the NO, DPPH, and hydrogen peroxide more than 50%. Also, it stopped the cycle of lipid peroxidation up to 8.97-65.16%, which might be brought on by photo-oxidation, auto-oxidation, or any other form of oxidative stress.[64,65]

Wound healing activity

In diabetic rats, the effect of *Eleusine coracana* on wound healing was investigated. Incisions were done on certain alloxan-induced diabetic rats after the experiment's 15-day diabetes production period. One group of diabetic rats was fed finger millet, whereas another group of diabetic rats was offered a normal diet. Normal feed was also given to the control group, which did not have diabetes. According to studies, rats fed FM recovered more quickly than those fed a regular diet. Mathanghi and Sudha also reported on the wound-healing properties of finger millet.[59,66]

Anti-aging activity

Eleusine coracana's methanol fraction has been demonstrated to have significant antioxidant activity in terms of inhibiting glycosylation and cross-linking, two processes that occur as part of the ageing process. The ability of the extract to inhibit glycosylation was discovered by incubating rat tail tendons in 50 mM glucose solution and 3 mg finger millet extract in methanol. The existence of significant levels of antioxidants in the *Eleusine coracana's* extract, as well as different chemical constituents in the seed coat, was attributed to this.[67]

Hepatoprotective activity

Pingle BR *et al.* examined an oral dose of *Eleusine coracana* extract for its ability to protect the liver against carbon tetrachloride (CCL4)-induced hepatotoxicity in experimental rats. *Eleusine coracana* extract administered orally significantly reduced levels of SGOT, SGPT, total protein, and ALP. Histopathological liver findings also demonstrated liver protection against CCl_4-induced hepatotoxicity.[68]

Anti-cataract activity

Chethan *et al.* conducted experiments on cataracted human eye lenses and discovered that finger millet can both treat and inhibit the cataract.[69] It was attributable to the millet's huge content of polyphenolic components in the coated seed. Shobana *et al.* also discovered that rats fed a 20% seed coat matter diet for six weeks after being given a 40 mg/kg body weight dosage of streptozotocin to induce diabetes had less cataract advancement than the control.[47]

Anti-lithiatic activity

Finger millet was found to be able to reduce the development of crystals and improve kidney function in studies conducted on the aqueous and ethanol fractions of the grain. The ability of finger

millet to alleviate renal pathology has also been demonstrated.[70] In male albino rats with calcium oxalate nephrolithiasis, Bahuguna *et al.* revealed that alcoholic and aqueous extract of finger millet showed the crystal growth inhibition and kidney function enhanced at the dose of 300 mg/kg.[71]

Anti-bacterial activity

Bisht A. *et al.* examined the antibacterial potential of an aqueous extract of *Eleusine coracana* seeds against several bacterial pathogens, including *Salmonella enterica* (MTCC 739), *Bacillus subtilis* (MTCC 441), *Pseudomonas aeruginosa* (MTCC 424), and *Escherichia coli* (MTCC 733). The results indicated that *Pseudomonas aeruginosa* was most effectively inhibited (MTCC 424).[72]

Anti-diabetic activity

Researchers like Shobana *et al.* have conducted anti-diabetic experiments on *Eleusine coracana*. They looked into the hypoglycemic effects of *Eleusine coracana* on diabetic rats produced by streptozotocin. According to the outcomes of their study, rats administered finger millet had a 31% lower mean fasting blood glucose.[47] In alloxan-induced diabetic rats, Rajasekaran *et al.* found that finger millet had a hypoglycaemic impact.[68] Similarly, Hegde *et al.* found that a dose of 180 mg/kg body weight of whole grain finger millet had a hypoglycemic impact on alloxan-induced diabetic rats. For 28 days, the rats were fed finger millet. The blood sugar level in diabetic rats given finger millet was found to be considerably lower, dropping from 212± 14 mg/dL to 137 ±6 mg/dL.[73] Shukla and Srivastava used 0, 30, 40, and 50% *Eleusine coracana* flour in refined wheat flour to make noodles. They noticed that consuming these noodles resulted in hypoglycemia, which they attributed to the millet's high fibre content.[74] When compared to the control group, the experimental groups fed finger millet products showed significantly lower mean peak rises in fasting blood glucose (209±64.32 mg/dL), according to Kumari and Sumathi (FBG). The two foods that generated the least mean peak elevation in FBG were whole finger millet roti (59.3±5.3 mg/dL) and germinated finger millet roti (80.1±14.8 mg/dL). The inclusion of finger millets in diets has the potential to lower blood glucose levels significantly, according to this study.[75] *Eleusine coracana* was investigated for its antidiabetic potential in STZ-induced diabetic rats by Chaudhary J. K. *et al.* Oral administration of probiotic fermented milk (PP), product (RF) and finger millet flour (RA) significantly decreased the level of blood glucose, triglycerides, cholesterol and also elevated the hepatic enzymes such as alanine transaminase and aspartate transaminase. Result proved that the finger millet enriched probiotic fermented milk has potent anti-diabetic activity.[64]

Anti-cancer activity

Millet seed extract's anti-cancer activities were discovered to be related to the millet's high polyphenol content as well as the extract's free radical scavenging activity. Fraction of ethyl acetate of finger millet extract was found to be effective against the HepG2 liver cancer cell line in a dose-dependent manner, according to Singh *et al.* Finger millet's influence on chronic myeloid leukaemia has also been studied.[49] Ragi Bifunctional Inhibitor (RBI) from *Eleusine coracana* was evaluated for its anticancer potential on human chronic myeloid leukaemia cells and it showed the cytotoxic effect on K562 chronic myeloid leukaemia cells but not against the normal human peripheral blood mononuclear cells. Induction of apoptosis and inhibition of cellular proliferation of K562 cells by ragi bifunctional inhibitor were determined by MTT assay and by using flow cytometry analysis.[76]

Anti-nutritional activity

Eleusine coracana (Finger Millet) and *Echinochloa frumentaceae* (Barnyard Millet) were evaluated for their antinutritional and nutraceutical potential by Panwar *et al. Echinochola frumentaceae* has more amount of tryptophan content, crude fibre, total carotenoids, total dietary fibre and α-tochopherol compared to *Eleusine coracana* but finger millet has more amount of ascorbic acid and methionine as compared to barnyard millet. In contrast to anti-nutritional compounds, barnyard millet has lesser phytic acid than finger millet, no significance difference was observed in trypsine inhibition activity. More amount of α-galactosidase and α-amylase was observed in barnyard millet than finger millet but finger millet has about 10-13 folds' huge calcium quantity and double amount of manganese content as compared to barnyard millet.[77,78]

Immunomodulatrory activity

Eleusine coracana was screened for its *in vitro* immunomodulatory potential in human PMN layer and *Candida albicans* by Padmavathy K *et al.* Ethanolic extract of seed of *Eleusine coracana* showed the significant effect on immunity and also showed the inhibition in mast cell degranulation which was induced by polysorbate 80. Result concludes that the *Eleusine coracana* has the potential of immunomodulatory and mast cell stabilizer.[79]

Nutraceutical significance of finger millet

Finger millet is high in minerals, vitamins, and other phytochemicals. Despite its infancy, it has shown to be a valuable source of nutraceuticals. Protein is useful in the management of protein-energy shortage as well as an ordinary relaxant in finger millet. The high phytochemical content of finger millet was supposed to help with hypercholesterolemia, cancer, neurological and cognitive disorders, cataract, diabetes, and cancer. The mineral and vitamin composition of the finger millet is said to aid in the treatment of osteoporosis and anaemia. The glycoproteins and low-fat content of millet are said to help slow down the ageing process. Diabetes, gastrointestinal issues, cardiovascular disease, gallstones, and cancer can all be helped by finger millet's high fibre content. Polyphenols found in finger

millet have antioxidant and anti-cancer effects. Anti-fungal, anti-sickling, estrogenic, anti-bacterial, and anti-mutagenic properties are claimed for P-hydroxybenzoic acid. Millet contains gentisic acid, which is analgesic, anti-arthritic, anti-inflammatory, anti-rheumatic and cytostatic. Salicylic acid has antifungal, antipyretic, anti-inflammatory, analgesic and antiseptic anti-septic properties while procatechuic acid has hepatoprotective, antioxidant, anti-inflammatory and antifungal properties. There are also anti-cytotoxic and anti-platelet aggregation properties. It has been proven to be neuroprotective and decrease the oxidation of low-density lipoproteins. Vanillic acid, which has anti-sickling characteristics, gallic acid which has bacteriostatic and antineoplastic capabilities and syringic acid, which has hepatoprotective and antibacterial properties, are all phenols found in finger millet.[80,81]

CONCLUSION

Eleusine coracana, a tropical plant found in Asia, Africa, and South America, has been employed in many civilizations not only as an edible grain as well as in conventional medicine. The plant's many parts have been used to treat and manage a variety of health issues (diabetes, cancer, gallstones, degenerative diseases, as well as to aid in weight loss in obese persons). This review focused on the plant's pharmacology, phytochemistry, pharmaceutical and nutraceutical applications, as well as its commercial potential more research is needed to isolate and develop cost-effective product(s) for use in diabetes, cancer, and as an environmentally friendly agent in the synthesis of pharmaceutical nanoparticles because phytochemicals isolated from different solvent extracts of this plant have demonstrated promising pharmacological activities in a range of disease conditions.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

STZ: Streptozotocin; **FM:** Finger millet; **SGOT:** Serum glutamic-oxaloacetic transaminase; **SGPT:** Serum glutamic pyruvic transaminase; **ALP:** Alkaline phosphatase; **CCL_4:** Carbon tetrachloride; **DPPH:** 2,2-diphenyl-1-picrylhydrazyl.

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