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A review on finger millet properties, processing, health benefits, and applications

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Abstract
The review aims to discuss about the Finger millet which has numerous health promoting properties. *Eleusine coracana* is a major crop of *Poaceae* family and a great source of various types of macronutrients and micronutrients. The review has written by taking references from number of review and research articles. These articles have been collected from different databases. The nutrient content of finger millet makes it healthy and functional food and generally eaten as infant food, beverages, fermented foods, and bakery products. It is rich in protein, dietary fibre, amino acids, carbohydrate minerals, micro and macro nutrients etc. It can give several health and therapeutic advantages, such as diabetes prevention, anti-inflammatory, antibacterial, anti-diarrheal, and antioxidant capacity, phytochemical activity, antimicrobial, enzyme inhibitory properties due to its high dietary nutritious content. In urban areas the consumption of finger millet is limited as compare to rural areas as it is dark brown in colour which is not drool worthy so the concept of processing of this particular crop came for a save. This review may be useful for the further study and evaluation of nutrient contents and health benefits; also, the processing and application of the Finger millet.

Keywords: Antioxidant, amino acid, finger millet, functional food, nutrients

1. Introduction
Finger millet (*Eleusine coracana*) is one of the most cultivated millets and India plays a significant role on the World's finger millet production map as it produces around 41% of world's production followed by Africa. In world, finger millet ranks fourth in importance among millets after sorghum, pearl millet and foxtail millet (Chandra *et al.*, 2016) [2]. There are number of researches are going on finger millet applications (Fig 1). From last 10 years there were more than 23000 studies and papers published on the topic of finger millet. In the year 2019 approx. 5960 papers were published on finger millet. Indian finger millets are generally called as ragi and grown in Karnataka, Tamil Nadu, Andhra Pradesh, Odisha, Bihar and Gujarat (Begum *et al*., 2017) [1]. It can be considered as one of the functional millets as these are enriched with fibre, minerals, micronutrients, macronutrients, amino acids, fatty acids. In India, finger millet is also known as ragi which is familiar in Indian household. Ragi plays an important role in Indian everyday meal as a staple food and eaten without dehulling. It is used as baby food as it is easy to digest and packed with nutrients and minerals (Kumar *et al.*, 2016) [19]. Various types of breads, confectionaries and other food items can be made from finger millets such as Ragi bread, Ragi Dosa, Ragi Malpua, Ragi Ladoo, Ragi Mudde etc. (Varma and Patel, 2013; Mugocha *et al.*, 2000) [50, 27]. In urban areas the consumption of finger millet is limited as compare to rural areas as it's dark brown in colour which is not drool worthy so the concept of processing of this particular crop came for a save. Non-consumers of millets have benefited from the concept of processing and product development of regional and traditional millets with their specific nutrients, especially the phytochemical and micronutrients, and the processed products, ready to eat products; health foods are limitedly produced at industrial level (Varma and Patel, 2013) [50]. As per the studies ragi is a great source of calcium, magnesium, methionine, lysine, fibre, amino acid and many more nutrients. Regular intake of ragi can be beneficial against diseases like type II diabetes, cardiovascular diseases, gastrointestinal cancer, reverts skin ageing and can prevent hair loss, regulate blood circulation, control haemoglobin level, gut friendly, prevent osteoporosis in elderly women, weight losing and various other health issues (Chandra *et al*., 2016; Kumar *et al*., 2016) [2, 19]. Vital amino acids such as methionine and lysine present in finger millet which is beneficial for

revert skin ageing. Magnesium is also present in the finger millet which can prevent hair loss, regulate blood circulation (Varma and Patel, 2013) [50]. It is also an excellent source of iron which control haemoglobin level so beneficial for the people with low haemoglobin level. It is also low in fat and gluten free that helps in easy digestion. Finger millet can also prevent osteoporosis as it contains a good amount of calcium which helps to strengthen the bones. Kidney issue can be prohibited as finger millet is rich in calcium (Cormick and Belizán, 2019) [6].

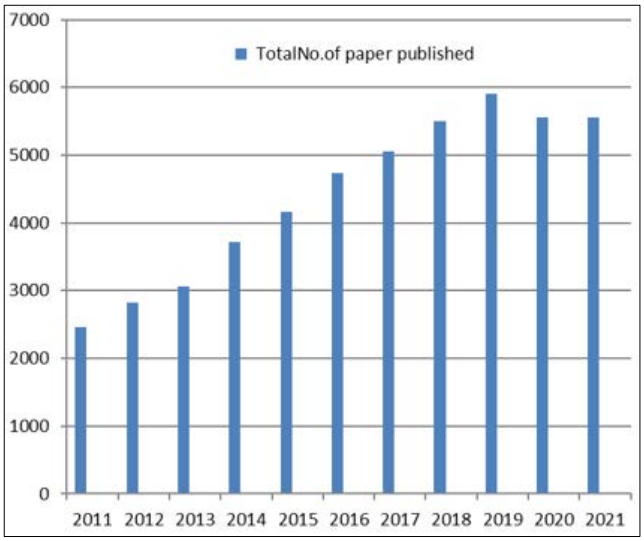

Fig 1: Graphical projection of the papers published on finger millet from last 10 years

1.1 Botanical characteristics

Eleusine coracana also known as African millet or finger millet is under the group Magnoliophyta. Finger millet comes under the family *Poaceae*. Finger millet or ragi is having a fibrous root system and it is shallow, branched, rooting at lower nodes. As the ragi grain germinates, the radical pierces its way out and forms the seminal roots and also lateral roots are formed the seminal root as the seedlings begin to grow, fibrous roots arise from the basal nodes. When seedlings are pulled out, most of the roots get turn off but very soon fresh roots develop (Vetriventhan *et al.*, 2016) [51].

Ragi is a yield of tropical and subtropical environment requires a genuinely high temperature, going from 20 to 40 °C. The ideal temperature 32°C during day time and 25 °C during evening is by all accounts more ideal for the turn of events and development of ragi crop (Vetriventhan *et al.*, 2016) [51].

2. Properties

Finger millet can be considered as super as it possesses various physio chemical, and health properties (Fig 2) properties such as follows;

2.1 Anti-inflammatory properties

Jayawardana *et al*. (2021) [18] conducted research on the varieties of finger millets and their anti-inflammatory properties. Inflammation can be defined as a defensive mechanism of our immune system. Various enzyme inhibitory activities are present in finger millet which is accountable for the anti-inflammatory characters of the finger millet such as A5-LOX enzyme inhibitory activities, XO enzyme inhibitory actvities, hyaluronidase enzyme inhibitory activities, oxidative burst inhibitory activity (Jayawardana *et al*., 2021) [18].

2.2 Anti-oxidant properties

Jayawardana *et al*. (2021) [18] and Viswanath *et al*. (2009) [52] studied on the antioxidant properties of finger millet. The antioxidant property of finger millet depends upon various factors such as total phenolic and total flavonoid contents, DPPH and ABTS cation radical scavenging activities, oxygen radical absorbance capacity, and ferrous ion chelating activity, ferric reducing antioxidant power but specially depends on the total phenolic fraction (Jayawardana *et al*., 2021; Viswanath *et al.*, 2009) [18, 52].

2.3 Antimicrobial properties

The antimicrobial activity of finger millet was studied by Viswanath *et al*. (2009) [52]. Author worked on the polyphenols extracted from the milled fraction of finger millets to determine the antimicrobial activity of finger millet by monitoring the autoxidation of β-carotene and linoleic acid emulsion in the polyphenol extracts of finger millet sample (Viswanath *et al*., 2009) [52].

2.4 Enzyme inhibitory properties

In 2009 Shobana *et al*. [38] showed in a study that finger millet shows enzyme inhibitory properties. The study found that millet phenolics had therapeutic potential in the treatment of postprandial hyperglycemia. According to the study, the finger millet seed coat contains a complex variety of phenolic chemicals from several classes, ranging from low molecular weight simple phenols to higher molecular weight polyphenols including tannins and anthocyanins. Non-competitive inhibitors of carbohydrate-hydrolyzing enzymes, these seed coat phenolics are efficient (Shobana *et al*., 2009) [38].

2.5 Phyto-chemical properties

In the year of 2020 Sk and Sudha conducted a study on phytochemical properties of finger millet. The polyphenol content, dietary fibre content and other phytochemicals extracted from the seed coats of the finger millet grains are responsible for the good storage property of finger millet and its processed foods (Sk and Sudha, 2020) [42].

2.6 Nutritional and Anti-nutritional Properties

In the year 2018, Chauhan and Sarita conducted a study on the nutritional and anti-nutritional properties of finger millet. According to their study finger millet is a great source of nutrients like calcium, iron, phosphorus, zinc, potassium, other minerals and fibre which are responsible for the nutritional properties of finger millet and antinutrients such as tannin, phytic acid, oxalic acid content and trypsin inhibitor which inhibits the nutritional properties of finger millet and acts as anti-nutritional agent (Chauhan and Sarita, 2018) [5].

2.7 Physical and chemical properties

Ramashia *et al*. (2018) [36] conducted a study on the physical and functional properties of finger millet. Milky cream of finger millet was pointedly higher in moisture content, L*, b*, C*, WAC, bulk density, dispersibility, 1000 sample weight, true density, aspect ratio and sphericity among other FM grain and FM flour. Therefore, milky cream FM flour preferred to

use by food processors and food processing industries in the making of various types of new food products that can also be consumed in urban areas especially by people who suffer from chronic diseases (Ramashia *et al.*, 2018) [36].

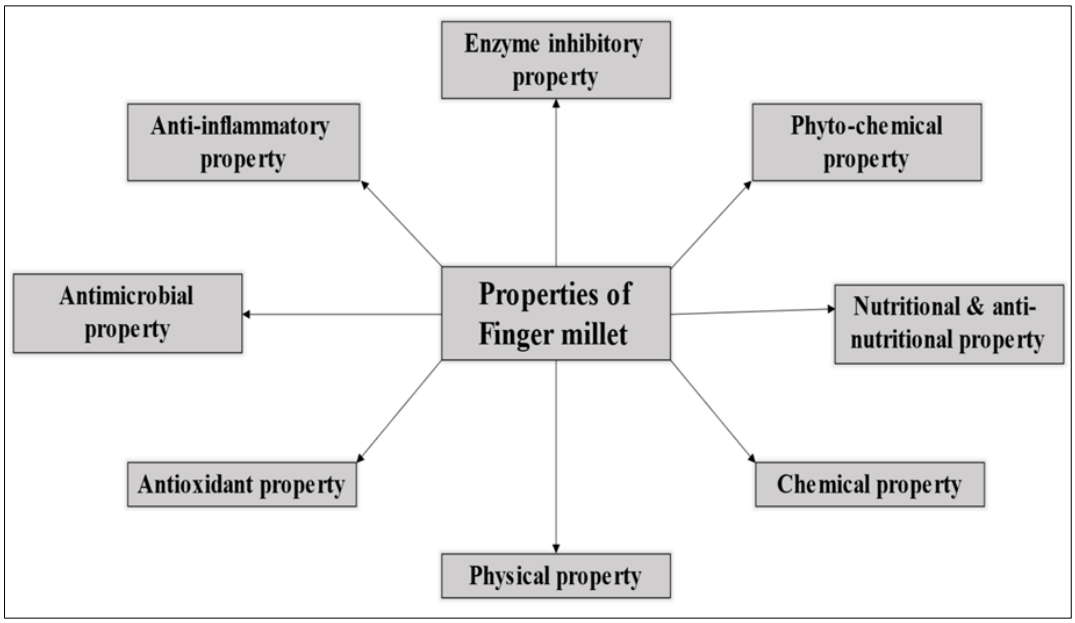

Fig 2: Health properties of finger millets (*Eleusine coracana*)

3. Processing

Crop processing can be defined as the series of some mechanical and physical processes by which the raw agricultural produces converted and handled into food grade produces or industrial raw materials. Finger millet processing can be done by cooking, soaking, fermenting, sprouting among which cooking, grinding and fermenting are common in Indian household (Shobana *et al*., 2013) [37].

Processing methods like cooking, soaking is widely used worldwide to reduce the antinutrient factors present in foods. In 2007, a study was conducted by Hotz and Gibson which stated that there was a significant reduction in polyphenols, phytate, saponins, oxalates and trypsin inhibitors in finger millet or ragi while soaking for 1-2 days in water at room temperature (Hotz and Gibson *et al*., 2007) [16]. Similarly, in 2015 Kakade and Hathan studied on the effect of cooking like boiling, steaming in finger millet or ragi which showed that after cooking there was an inactivation of heat labile antinutrients in ragi (Subhash *et al*., 2015) [44].

Fermentation is another kind of processing method which is done by the involvement of microorganisms. According to Michaelsen *et al*. (2009) [25] fermentation is the most effective and oldest method of processing and preserving foods and its helps to reduces antinutritional factors in millets (Michaelsen *et al*., 2009) [25]. In 2012, a study was conducted by Singh and Raghuvanshi which showed that an increase in the mineral availability and approachability such as calcium, zinc, phosphorous, iron 20%, 26%, 26%, 27% respectively while fermenting the millet. According to their research, there was a significant reduction in fungal infection in the germinated millet as compared to the normal one. Results also shows an enhancement in the nutritional value as there was a dominant effect on the biochemical changes (Singh and Raghuvanshi, 2012) [41].

4. Nutrient content and their health advantages

The nutrient content of finger millet has been discussed in table 1 and table 2. Fat percentage in finger millet is 1.3%, finger millet having low fat content so that it can be recommended for low fat diet. Moisture content of finger millet is 10.6 ± 1.23% as shown in table 1. Protein is a vital part of a healthy diet and they are made up of amino acids. 7.3% protein is present in finger millet as shown in table 1. Amino acids can repair muscles and bones and plant protein can provide essential amino acids for human requirements (Pihlanto *et al*., 2017). Starch is one of the primary sources of food energy for human beings. 59% starch is present in finger millet table 1. Improved diet is critical for modulation of metabolic process associated with the diseases such as obesity and type II diabetes (Zhang and Hamaker, 2017) [56]. Carbohydrates are sugar molecules and considered as the one of the major nutrients which found in food and drinks. The CHO present in finger millet is 72.6 gm. as the concern about carbohydrate is getting popularity for their role against the epidemic of obesity and its downstream cardio metabolic complications, including diabetes and cardiovascular diseases (Jayawardana *et al*., 2021) [18]. Ash (mineral matter) can defined as the inorganic residue remaining after the detonation or complete oxidation of organic matter in food. In finger millet 3% ash is present. Crude fibre is the result of an acid hydrolysis followed by an alkaline treatment. The insoluble residue contains true cellulose and insoluble lignin. Dietary fibre is made up of the indigestible parts or compounds of plants, which is pass relatively unchanged through our stomach and intestines. Plant polysaccharides and lignin, which are not hydrolyzed by endogenous enzymes in the gastrointestinal system but can be fermented by intestinal bacteria, make up dietary fibre. Many of the intestinal bacteria are involved in the carbon metabolism and amino acid synthesis which are main metabolic pathways. The total amount of dietary fibre present in finger millet is 19.1/100mg as shown in table 1. Regular consumption of dietary fibre reduced risk of all-cause mortality and death from cardio vascular diseases, cancer, diabetes, respiratory disease, infections, and other causes, suggesting that the protective effects of whole grains may be due, at least in the main part,

to its fiber component (Fuller *et al*., 2016) [12]. Crude fiber is also known as weende cellulose. Around 3.6% of crude fiber is found in finger millet as shown in the table 1.

Finger millet is a great source of phenolic acids such as gallic acid, syringic acid, ferulic acid, vanillic acid. Phenolic acids are derivatives of benzoic and cinnamic acids and these acids exhibit high antioxidant activity *in vitro* and thus are beneficial for human health. Total phenol fraction is the average of all phenolic acids present in finger millet. In each 100gm of finger millet sample around 120 mg of total phenol found. Phenol is protective against diseases due to increased oxidative stress such as several diets and age-related diseases, such as type II diabetes, cardiovascular diseases, obesity, and types of cancer. The various metabolic diseases are associated with lifestyle disorders, mainly a diet lacking in fiber and bioactive compounds (micronutrients and phytochemicals) (Chandrashekar, 2010; Shobana *et al.*, 2013) [3, 37].

Gallic acid is a trihydroxybenzoic acid which has a role as an astringent, a human xsenobiotic metabolite. 10.4 (4.4) is the presence of Gallic acid in finger millets. Research has been conducted on the effect of phytochemicals on skin physiology. According to the paper the effect of Gallic acid on the skin physiology remains unknown but that had a positive effect on the wound healing process in human keratinocytes (Yang *et al*., 2016) [55].

Syringic acid is a naturally occurring phenolic compound that is 3, 5-dimethyl ether derivative of Gallic acid, it is consider as a plant metabolite. In finger millet it is found around 11.3 (14.5) in amount. This molecule has been linked to a variety of biological activities, including anticancer, antibacterial, anti-inflammation, and anti-diabetic characteristics, as well as antioxidant and antinitrosant properties (Vo *et al.*, 2020) [53].

Ferulic acid is an antioxidant. 2.0(29.6) is quantity of ferulic acid present in finger millet as shown in the table 1. The antioxidant characteristics of ferulic acid, which are attributed to its phenolic nucleus and conjugated C3-side chain, are certainly associated to its diverse biological activities and a variety of health advantages, including those against chronic human illnesses and oxidative damage (de Oliveira and Batista, 2017) [7].

Vanillic acid is a dihydroxybenzoic acid derivative used as a flavouring agent. 5.9 (12.7) is amount of vanillic acid present in finger millet. An experiment shows that the vanillic acid exhibit nephroprotective effects against diabetes due to the antioxidant action of vanillic acid (Kumari *et al*., 2021) [21].

Finger millet comprises of several amino acids such as Cysteine, Histidine, Arginine, Threonine, Tyrosine, Valine, Methionine, Isoleucine, Leucine, Phenylalanine, Tryptophan, Lysine.

Cysteine is a semi essential proteinogenic amino acid. 0.140 is quantity of cysteine present in finger millet as shown in the table 1. Although it is classed as a non-essential amino acid, cysteine is an important source of sulphur in human metabolism and may be required for babies, the elderly, and those with specific metabolic illnesses or mal-absorption syndromes (Piste, 2013) [34].

Histidine is a nutritionally essential amino acid for humans. Amount of histidine in finger millet is 0.130. Through the conversion of histidine to histamine, histidine enhances cognitive function such as hunger, anxiety, stress reactions, and sleep (Thalacker *et al.*, 2020) [48].

Arginine or L-arginine is a semi essential amino acid that substrate for nitric oxide production by vascular endothelial and immune cells. Finger millets having 0.300 of arginine present in it. Nitric oxide production by vascular endothelial and immune cells is essential for both blood pressure regulation and immune regulation (McRae, 2016) [24].

Threonine is an essential amino acid for humans and animals. Finger millet has 0.240 of threonine amino acid. Threonine is an indispensable amino acid involved in lipid metabolism, protein synthesis, embryonic stem cell (ESC) proliferation and differentiation, and intestinal health and function.

Tyrosine is a non-essential amino acid that the body makes from another amino acid called phenylalanine. 0.220 is amount of tyrosine present in finger millet. Tyrosine intake can make beneficial effect on physiological functioning; tyrosine can exert notable acute cognitive benefits when the situation demands for an increased availability of the catecholamine (Haze *et al*., 2015).

Valine is an aliphatic and extremely hydrophobic essential amino acid in humans. 0.480 is quantity of valine in finger millet as shown in the table 1. The study conducted on traumatic brain injury (TBI) patients, as per as the study states that the intake of valine results the improvements in cognitive performance on TBI patients (Sonnay *et al.*, 2020).

Methionine is an aliphatic, sulphur-containing essential amino acid. In finger millets methionine content is 0.210. Methionine supplementation or deficiency can affect an organism's natural antioxidant capacity by causing the creation of endogenous enzymes that reduce oxidative stress, and hence DNA damage, cancer, cardiovascular disease, neuropsychiatric disorders, and neurodegenerative illnesses (Martínez *et al.*, 2017).

Isoleucine is α-amino acid which biosynthesis the proteins. Isoleucine quantity in finger millet is 0.400gm per 100 gm. Isoleucine is essential for tissue growth and development and also it hypothesized to influence glucose regulation.

Leucine is considered as one of the three essential branched chain amino acids. Around 0.690 gm leucine is found per 100gm of finger millets. It has potent anabolic properties and can act as a strong insulin secretagogue and also proposed as an effective nutritional strategy to augment postprandial muscle protein accretion and improve glycemic control (van Loon, 2012).

Phenylalanine is a direct precursor to the neuromodulator also an essential aromatic amino acid. Phenylalanine composition in finger millet is 0.310g/100g in finger millets. Phenylalanine hydroxylase deficiency is an autosomal recessive condition that causes intolerance to the essential amino acid phenylalanine in the diet. This enzyme's deficit causes a variety of illnesses, including classic phenylketonuria, moderate phenylketonuria, and mild hyperphenylalaninemia.

Tryptophan is an essential amino acid which is necessary for the vivo-biosynthesis of protein. About 0.100g/100g tryptophan is present in finger millet. It is metabolically transformed into bioactive metabolites such as serotonin, melatonin, kynurenine, and the vitamin niacin (nicotinamide), and its metabolites appear to have the potential to aid in the treatment of autism, cardiovascular disease, cognitive function, chronic kidney disease, depression, inflammatory bowel disease, multiple sclerosis, sleep, social function, and microbial infections, as well as facilitate the diagnosis of certain conditions such as human cataracts disease (Friedman, 2018).

Lysine is an essential acid to meet the nutritional requirements of humans and animals. In finger millet the

amount of lysine is 0.220g/100g. Lysine is helpful in the treatment of osteoporosis, migraine, Alzheimer's dementia, hair loss, shingles, cancer, cardiovascular diseases and aging (Singh *et al.*, 2011).

Table 1: Nutrient (Macronutrients) content of finger millets (*Eleusine coracana*)

Nutrient		Content	
Fat (gm)		1.3	
Moisture (gm)		13.1	
Protein (gm)		7.3	
Carbohydrate	Total carb (gm)	72.6	
	Starch (%)	59.5–61.2	
	Pentosans (%)	6.2–7.2	
	Cellulose (%)	1.4–1.8	
	Lignins (%)	0.04–0.6	
Ash (%)		3	**References**
Crude fiber (%)		3.6	Kumari and Morya, 2021[20]; Jagati *et al.*, 2021; Pawar *et al.*, 2020; Devi *et al.*, 2014; Shobana *et al.*, 2013[37]; Chandrashekar, 2010
Total dietary fiber (gm/ 100gm)		19.1	
Amino acid (gm/100gm)	Cysteine	0.140	
	Histidine	0.130	
	Arginine	0.300	
	Threonine	0.240	
	Tyrosine	0.220	
	Valine	0.480	
	Methionine	0.210	
	Isoleucine	0.400	
	Leucine	0.690	
	Phenylalanine	0.310	
	Tryptophan	0.100	
	Lysine	0.220	
	Whole flour		
Phenolic acid	Total	102	
	Gallic acid	10.4(4.4)	
	Syringic acid	11.3(14.5)	

Calcium (Ca) is a mineral that body needs to build and maintain strong bones and to carry out many important functions. Calcium content in finger millet is 398mg as shown in the table 2. Hypertensive disorders of pregnancy, maintaining blood pressure, building blocks of bones, colorectal adenomas are the major health benefits of calcium (Cormick and Belizán, 2019) [6]. Phosphorus (P) is a mineral found in bones and teeth. Phosphorus composition in finger millet is 320mg as shown in the table 2. Normal adults, phosphorus deprivation causes release of calcium from the skeleton and hypercalciuria and also hypercalcemia does not occur. Rickets or osteomalacia often occurs in genetic hypophosphatemia and long-standing phosphorus deficiency (Takeda *et al.*, 2012). The mineral iron (Fe) is required by the body for growth and development. Table 2 shows the iron content of finger millet, which is 3.9 mg. Iron deficiency (ID) is the most frequent micronutrient shortage globally, with young children being a particularly vulnerable population due to their fast development, which necessitates high iron requirements. Iron insufficiency also causes anaemia (Domellof *et al.*, 2014). Magnesium (Mg) is an essential element for human body function. Table 2 shows the magnesium content of finger millet, which is 137mg. Magnesium aids in the activation of vitamin D, which influences bone formation and maintenance by regulating calcium and phosphate balance. Magnesium appears to be required by all enzymes that metabolise vitamin D, as it serves as a cofactor in enzymatic activities in the liver and kidneys (Thalacker *et al.*, 2020) [48].

Sodium (Na) is an essential nutrient and is needed by the body in relatively small amount. In finger millet sodium content is about 11mg. reduced sodium intake lower BP and have great potential as public health interventions to reduce the burden of cardiovascular disease morbidity and mortality (Whelton *et al*., 2014). Potassium (K) is a mineral and also an electrolyte. Potassium composition in finger millet is 408mg.Increase of K intake lower BP and have great potential as public health interventions to reduce the burden of cardiovascular disease morbidity and mortality (Whelton *et al*., 2014). Copper (Cu) is an essential nutrient for the body. About 0.47mg of copper is found in finger millet. The copper can be toxic when present in excess, the most noticeable chronic effect being liver damage; however the composition of copper is very less in finger millets (de-Romana *et al*., 2011). Manganese (Mn) is a trace mineral that is present in very low amount in the body. In finger millet the composition of manganese is 5.49mg. Metabolically active organs like liver, kidney, and pancreas with high numbers of mitochondria, in which manganese is predominantly found, have relatively large manganese concentrations nutrients (Nielsen, 2020).

Zinc (Zn) is nutrient found throughout the body and also important to wound healing. Zinc composition in the finger millet is 2.3mg. It is required for the structure and function of many proteins and cellular components, and it plays a key role in human physiology, ranging from immune system function to cellular development, proliferation, and apoptosis, as well as the activity of numerous zinc-binding proteins (Chasapis *et al.*, 2012). Molybdenum (Mo) is an essential trace mineral. Finger millet has 0.102mg molybdenum composition in it. Molybdenum has a critical role in brain function and also molybdenum occurs as sodium molybdate and a variety of amino acid chelate forms in both multivitamin/ mineral supplements and supplements of molybdenum only or with a few other nutrients (Nielsen, 2020). Chromium (Cr) is a trace mineral that may be found in food. The amount of chromium in finger millet is 0.028mg. Chromium is thought to be a second messenger in the cell that increases the action of insulin in response to insulin (Panchal *et al.*, 2017).

Thiamine also known as B1 and it is a vitamin. Finger millet has 0.42 mg of thiamine composition in it. When thiamine is combining with glucose it boosts the energy production. Thiamine has a role in the development and prognosis of cardiovascular disorders. Screening for thiamine deficiency could be considered in patients with cardiovascular diseases (Eshak and Arafa, 2018). Riboflavin also known as B2 and it is one of the components of Vitamin B complex which are all water soluble. Riboflavin composition in finger millet is 0.19mg. The biological effects of riboflavin have been widely studied for their anti-oxidant, anti-aging, anti-inflammatory, anti-nociceptive, and anti-cancer properties (Penberthy *et al.*, 2020).

Niacin is important for general good health of body niacin is also known as vitamin B3. Niacin composition in finger millet is 2mg as shown in table 2. Vitamin B3 is the precursor to a variety of essential pyridine nucleotide structures, including oxidised and reduced forms of nicotinamide adenine dinucleotide and its phosphorylated derivatives (collectively referred to as NAD[P]), which are used in more reactions

(>470) than any other vitamin-derived molecule. Niacin deficiency is known as pellagra (Penberthy *et al.*, 2020). Vitamin E is a fat-soluble vitamin with several forms. Finger millet is consisting of 22mg of Vitamin E in it. The evidence on vitamin E's role in the primary and secondary prevention of cardiovascular disease morbidity and mortality has been reviewed (Blaner, 2013). Folic acid is the form of the vitamin found in fortified foods and dietary supplements. Total folic acid present in finger millet is 18.3µg. Folic acid intake reduces both the occurrence and the recurrence of neural tube defects; FA is the synthetic form of folates (Takeda *et al.*, 2012).

Applications

Finger millet or ragi is widely used as a healthy diet across the world. It is used as infant food, beverages, fermented foods, bakery products etc. From the ancient time ragi is considered as a great choice for infants due to its nutritional content. Malted ragi flour is used to prepare malted ragi drink which is called as "ragi malt", a nutrient rich drink and can be used as energy drink & health drinks for all age groups (Varma and Patel, 2013) [50]. In this healthy world, use of ragi in cooking is increasing day by day. Ragi or sprouted ragi is used in fermented products as a base not only to increase the taste but also enhances the food with fiber, calcium and protein content due to the reduction in antinutrients content (Varma and Patel, 2013; Mugocha *et al.*, 2000) [50, 27]. Now days, ragi is used as the base ingredient in various bakery products such as biscuits, cakes, muffins, breads, nankhatai etc. In a study found that addition of finger millet in bakery items improves the fiber and micronutrients content (Varma and Patel 2013) [50].

Table 2: Nutrient (Micronutrient) content of finger millets (*Eleusine coracana*)

Nutrient	Content	Health benefits	References
Calcium (Ca)	398mg	▪ Needed for heart muscle ▪ Builds bone ▪ Blood cell synthesis ▪ Function of blood cells	Kumari and Morya, 2021 [21]; Jagati *et al.*, 2021; Godswill *et al.*, 2020; Grasso *et al.*, 2020; Ramashia *et al.*, 2018 [36]; M Suwannasom *et al.*, 2020; Penberthy *et al.*, 2020; Eshak and Arafa, 2018; Chandra *et al.*, 2016; Kumar *et al.*, 2016 [19]; Morya *et al.*, 2015; Shobana *et al.*, 2013 [37].
Phosphorus (P)	320mg	▪ Component in bone cells ▪ Energy processing in DNA	
Iron (Fe)	3.9mg	▪ Required for proteins and enzymes ▪ Prevent anaemia ▪ Major composition in haemoglobin	
Magnesium (Mg)	137mg	▪ Required for processing ATP ▪ Beneficial for bones	
Sodium (Na)	11mg	▪ Systemic electrolyte ▪ Essential for coregulating ATP with potassium	
Potassium (K)	408mg	▪ Systemic electrolyte ▪ Essential for coregulating ATP with sodium	
Copper (Cu)	0.47mg	▪ Component of various redox enzymes	
Manganese (Mn)	5.49mg	▪ Cofactor in enzyme functions	
Zinc (Zn)	2.3mg	▪ Required for enzyme actions	
Molybdenum (Mo)	0.102mg	▪ Oxidases xanthine oxidase ▪ Sulphite oxidase ▪ Aldehyde oxidase	
Chromium (Cr)	0.028mg	▪ Lipid metabolism ▪ Glucose metabolism	
Vitamin B1 (Thiamine)	0.42mg	▪ Boosts energy production ▪ Keeps the nervous system healthy	
Vitamin B2 (Riboflavin)	0.19mg	▪ Anti-aging properties ▪ Anti-oxidant properties ▪ Anti-nociceptive properties ▪ Anti-inflammatory properties ▪ Anti-cancer properties	
Vitamin B3 (Niacin)	2mg	▪ Reduce blood pressure ▪ Deficiency causes pellagra	
Vitamin E (Tocopherol)	22mg	▪ Helps maintain skin healthy ▪ Good for eye health	
Total Folic Acid	18.3 µg	▪ Helps to make healthy red blood cells	

The study shows that finger millet based bread fermented by using baker's yeast and lactic acid bacteria (LAB), and there was a significant enhancement in the nutritional content as compared to the commercially available white breads (Mythrayee and Pavithra, 2017)

Extrusion technology can be defined as the process of making fortified and value-added products from the raw produce. Finger millet flour has good extrusion characteristics. In 2013, the research work was done on noodle made up of using finger millet flour and other flours (Varma and Patel, 2013) [50]. In 2011 research conducted on the preparation of fortified noodles with finger millet flour which turned out to be valuable for the diabetic patients due to low glycemic index (Shukla and Srivastava, 2011) [39].

Conclusion

Cereals and grains play a vital role in every household. Finger millet, commonly known as ragi in India is a nutrient packed grain and widely used in food industry. Various studies have been taken place in recent years. Ragi shows several properties like anti-inflammatory properties, anti-oxidant properties, antimicrobial properties, enzyme inhibitory

properties, phyto-chemical properties, nutritional and anti-nutritional properties, physical and chemical properties. Various studies show the nutritional content and their health benefits of finger millet or ragi which helpful in the popularity gain of ragi in the food processing industries and healthy lifestyle. The cultivation and processing are gaining acceptance among local farmers and food industrialists.

Conflict of interest

The authors have no conflict of interest to declare that are relevant to the content of this manuscript.

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