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4. Finger Millet

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Abstract:

Because of its nutritional and phytochemical qualities, finger millet (Eleusine coracana L.) has become liked as a health food in recent years. The finger millet's high dietary fiber level and polyphenol content are responsible for a number of its health advantages. Using finger millet to make value-added foods and evaluating its nutritional and health characteristics is the focus of this book chapter along with its nutritional importance. It has much higher protein levels, fats, calcium, and dietary fiber than rice and wheat. Several amino acids are found in this millet, including isoleucine, leucine, methionine, and phenylalanine, which are all lacking in other starchy foods. This book chapter focuses on finger millet's amino acid profile, nutrient profile, micronutrient profile, cultivation practices, value added products, as well as their role in health benefits.

Keywords:

Millets, Finger millet, protein, phenols, amino acids, nutrition.

4.1 Introduction:

Millets are the ancient nutritional grain and are the oldest food crops grown from early human civilization. It is the staple food of semi-arid tropics of Asia and Africa (Mahendra *et al*., 2012). These crops are mostly cultivated under a variety of agro - ecological situations like plains, coast hills even diverse soil land with varying rainfall. Millets are a group of highly nutritious rich, drought tolerant crops.

These small seeded grasses belonging to poaceae family are an important source of food and fodder for millions of resource-poor farmers. These are grown as grain crops primarily on marginal lands in dry areas of temperate, sub-tropical and tropical regions thus are all-season crops cultivated round the year (Sharma *et al*., 2000). Millets are the coarse cereals known as the *"Cereal of the poor"*. Millets play important role in rainfed region of the country which contributes to 60 percent of the total area. Millet is broadly categorised into two major groups (1) Major millets viz., Sorghum [*Sorghum bicolour* L.] and Pearl millet [*Pannisetum glaucum* L.]; (2) Minor or small millets, viz., Finger millet [*Eleusine coracana* L.] Proso millet [*Paspalum scrobiulatum* L.], Barnyard millet (*Echinochloa spp.*), and little millet [*Panicum* sumatrense] [3]. Major millets Sorghum (Great millet), Bajra (Pearl millet), Ragi (*Finger millet*) and small millets viz., Korra (Foxatil millet), Little millet. Kodo millet, Proso millet and Barnyard millet are the important millet crop grown in India. These are considered as the nutri-cereals after realising their nutrient richness. Millets are high in nutrition and dietary fibre.

They serve as good source of proteins, minerals like iron, magnesium, phosphorous, potassium and various phytochemicals. The protein content in millets is 7-12 %, fat 2-5 %, carbohydrates 65-75 % and dietary fibre 15-20%. Millets are gluten free and non-allergic. Millet consumption decreases triglycerides and C reactive proteins, thus prevents cardiovascular disease. India is the world's largest producer of the millet during 2021 with a share of 43 %, followed by Niger (12%) and China (8 %).

The government has taken various steps for the promotion of the millets in the nation. 2018 was declared as "National year of millets". A sub mission on millets was run under National Food Security mission since 2018. Millets were included under the POSHAN MISSION Abhiyan by Ministry of Women & Child Development. ICAR released one variety Quinoa (Him Shakti). "13" high yielding varieties including 4 bio-fortified varieties of millets have been released.

Further to create awareness and increase the production & consumption of millets, the United States at the behest of the Government of India, declared 2023 as the "International year of the Millet".

Finger millet - Finger millet *Eleusine coracana* L., also known as dagussa, kaddo in Nepal, fingerhirse in Germany, and ragi and mandua in India, is a staple meal in several parts of eastern and central Africa and India (Anitha *et al*., 2020). Finger millet ranks fourth globally in importance, behind sorghum, pearl, and foxtail millet. Finger millet makes up 10% of the 30 million tons of millet produced globally, according to estimates (Meena *et al*., 2021).

Finger millet is an important staple grain and source of subsistence in several Asian regions. It can improve dietary intake, boost food security, encourage rural development, and support the maintenance of environmentally friendly land (Oduori *et al*., 2005). One element that can be consumed is the millet seed, which is especially rich in dietary fiber, polyphenols, phytochemicals, and calcium (Malleshi *et al*., 2003, Shrivastava *et a*l., 2012).

Though there are several varieties available, mainly red-colored ones are widely grown around the world. Unlike other millets such sorghum, pearl millet, proso millet, foxtail millet there are five layers in the seed coat of finger millet which attributes to its increased fiber content (Shobhana *et al*., 2013). Apart from this finger millet is the richest source of calcium, which is 10 times more than rice or maize and 3 times more than milk.

4.2 Nutritional Importance:

Finger millet is a nutritious food that is high in fiber, vitamins, and minerals, especially calcium. Finger millet is said to contain between 79.5 and 72.5 percent carbohydrates overall. Among the carbs, starch makes up about (59.4 to 70.2 %) of the total (Pragya *et al*., 2012). The Finger millet's kernel comprises the endosperm, embryo, and seed coat which contains a five-layer seed coat that is rich in nutritional fiber and antioxidants (Saleh *et al*., 2013). It is a crucial cereal crop because of its enormous nutritional value, which is equal to or greater than wheat and rice (Rathore *et al*., 2019)

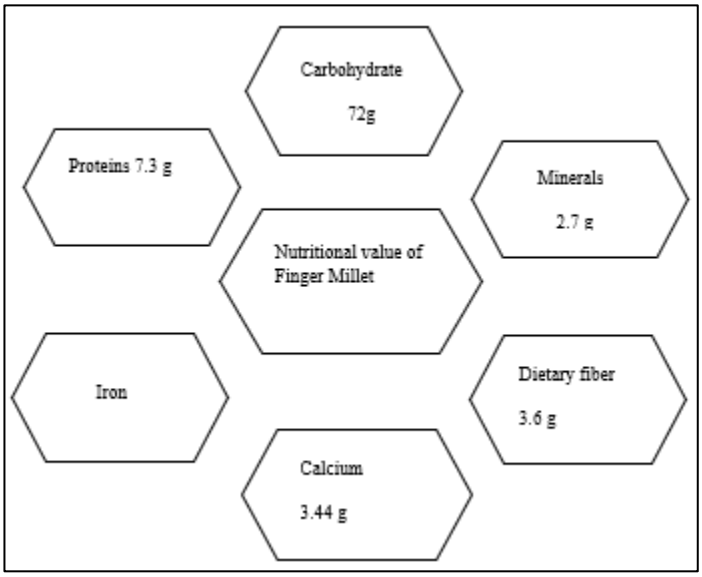

Figure 4.1: Nutritive value of Ragi/100 g (Chandra *et al.*, 2016)

4.2.1. Amino Acid:

Polished rice, maize, and refined wheat—the three grains that are most frequently consumed and widely grown but cannot offer complete protein because they contain very little of all the essential amino acids. Even when combined with other legumes that are well recognized to be excellent sources of protein, legumes also do not provide complete protein due to their low levels of the amino acid's methionine and cysteine as well as their varying levels of protein digestibility. However, when paired with millets, legumes can offer complete protein that is highly digestible and more widely available (Anitha *et al.*, 2020). Millets, which are coarse cereals and naturally high in methionine and cysteine, can be used to supplement the amino acid deficiency in chick peas and pegionpeas. A study on the influence of malting on the nutritional content of finger millet and mungbean reported a substantial increase ($p<0.05$) in free amino acid content from 12 to 24 hours of germination (Banusha *et al.*, 2013).

4.2.2 Protien:

Millet's second major component is protein with 24.6 to 36.2 per-cent of the total protein. Prolamin is the predominant protein component in finger millet. Although in FAO's recommendation 33.9 per-cent should be necessary amino acids but finger millet has 44.7 per-cent of the total amino acids. The finger millet's composition also provides a favorable essential to the total amino acid ratio. Tryptophan is typically the second most lacking in cereals but in finger millet this amino acid is abundant.

Proteins have nutritional quality if they contain essential amino acids that cannot be synthesized by the body. Poor growth in livestock and humans will be caused by a lack of one of these amino acids.

Essential amino acids are the most important aspect of protein from a nutritional stand point. Essential amino acid must be obtained from the diet because the carbon skeleton prevents the human body from synthesizing them (Mota *et al*., 2016). Essential amino acids are more essential for growth and metabolic maintenance than remaining amino acids non-essential amino acids (Mir *et al.*, 2018). Millets and other sources of protein could compensate for the lack of certain amino acids, such as lysine, in millets (Thapliyal *et al*., 2015).

4.2.3 Micronutrients:

Finding high-quality and *abundant sources* of protein and major micronutrients for a plant-based diet is needed as in w*est,* vegetarian and vegan diets are *gaining popularity whereas protein* m*icronutrient* deficiencies are still widespread *especially in Asia and Africa*. Healthy eating is essential for human *health, development, performance and well being. A wider* range of micronutrients and complete protein *is found in millets when combined with* legumes (Anitha *et al*., 2020). The finger millet contains a variety of important micronutrients (Banusha *et al*., 2013). The *peaks.* content of calcium (0.38 %), protein (6–13 %), dietary fiber (18 %), carbohydrates (65–75 *percent), minerals* (2.5–3.5 %), phytates (0.48*%*), tannins (0.61*%*), *and* phenolic compounds (0.3–3%*) and* trypsin inhibitory factors provides finger millet its nutraceutical importance. Finger millet also *known* f*or* its *beneficial* effects on health and *well-being* (Meena et al., 2021).

Finger millet is a good source of essential amino acids and nutrients, especially when it comes to calcium and other fiber (Thapliyal *et al*., 2015). Finger millet contains approximately ten times more calcium than wheat and 35 times higher than rice (Kumari *et al*., 2016). Finger millet was reported to be a rich source of minerals that could be used to overcome some health issues like anemia, bone and teeth disorders (Shibairao *et al*., 2014). The finger is pointed. Calcium and iron as well as other vital nutrients can be found in millet, which effectively tackles bonerelated health issues (Nakarani *et al*., 2021).

It has a higher proportion of crude fiber and minerals than wheat (1.2% vs. 1.2% for wheat) and rice (0.2% fiber, 0.6% minerals) (Gull *et al*., 2014).

4.2.4 Bioactive Compounds:

The nutritional value of food and the availability of bioactive substances with beneficial effects on health determine the quality of food (Cassano *et al*., 2008). Wheat, rice, and maize have been explored more for their phenolic content and bioactive properties since the grains contain a variety of health-promoting nutrients like vitamins, minerals, and phytochemicals. Millets are important besides these grains as their seed coats contain polyphenols with a chlorogenic equivalent of 0.09 to 2.44 mg per 100 grams (Yadav *et al*., 2013). Finger millet also have hypoglycemic properties (Kumari *et al*., 2002) anti-ulcerative (Chethan *et al*., 2007) and hypocholesterolemic properties.

The phytochemicals in finger millet, particularly phenolic compounds, are abundant and may help prevent chronic illnesses like diabetes, cancer, and cardiovascular diseases. The polyphenols are made up of flavanols (catechin, epicatechin), flavonoid glycosides

(catechin, epicatechin, quercetin, apigenin), and proanthocyanidins. Hydroxybenzoic (protocatechuic, p-hydroxybenzoic, and syringic) acids, hydroxycinnamic (caffeic, p-coumaric, and ferulic) acids, to a great extent, finger millet's antioxidant capabilities are derived from phenolic chemicals (Xiang *et al*., 2019). In comparison to rice, wheat, maize, and barley, finger millet grain has a dark brown seed coat and is high in polyphenols these phenolic compounds exist as free, soluble conjugates, and insoluble bound forms in the outer layers, particularly the aleurone layer, testa, and pericarp, which compose the main components of the bran fraction. Ferulic acid (64-96 percent) and p-coumaric acid are the most abundant bound phenolics in finger millets (50-99 percent). Finger millets contain proanthocyanidins, commonly known as condensed tannins (Thapliyal *et al*., 2015).

4.3 Package of Practices for Cultivation of Finger Millet:

Finger Millet (*Eleusine coracana*) commonly known as ragi, is one of the important millet crops grown for grain and fodder purpose under varied agro-climatic conditions in India. The crop requires low input and less affected by major pests and diseases and matures in 90-120 days. The high rejuvenation capacity after alleviated stress conditions makes this crop ideal for dry land farming. The major finger millet growing states in India are Karnataka, Uttarkhand Tamil Nadu, Andhra Pradesh, Orissa, Jharkhand and Maharashtra.

4.3.1 Local Names of Finger Millet:

Language		Local Names
1. Hindi	-	Ragi, Mandika
2. Bengali	-	Marwa
3. Punjabi	-	Mandhuka, Mandhal
4. Telugu	-	Ragi Chodi
5. Oriya	-	Mandia
6. Kannada	-	Ragi
7. Gujarati	-	Nagli, Bavto
8. Tamil	-	Keppagi, Ragi, Kelvaragu
9. Marathi	-	Nagli, Nachni

4.3.2 State wise Varieties of Finger Millet:

State	Varieties
A) Karnataka	GPU 28, GPU-45, GPU-48, PR 202, MR 1, MR 6, Indaf 7, ML365, GPU 67, GPU 66, KMR 204, KMR 301, KMR 340
B) Tamil Nadu	GPU 28, CO 13, TNAU 946 (CO 14), CO 9, CO 12, CO 15
C) Andhra Pradesh	VR 847, PR 202, VR 708, VR 762, VR 900, VR 936
D) Jharkhand	A 404, BM 2, VL 379
E) Orissa	OEB 10, OUAT 2, BM 9-1, OEB 526, OEB-532

State	Varieties
F) Uttarakhand	PRM-2, VL 315, VL 324, VL- 352, VL 149, VL 146, VL-348, VL-376, PES 400, VL 379
G) Chhattisgarh	BR-7, GPU 28, PR 202, VR 708 and VL 149, VL 315, VL 324, VL 352, VL 376
H) Maharashtra	Dapoli 1, Phule Nachani, KOPN 235, KoPLM 83, Dapoli-2
I) Gujarat	GN 4, GN 5, GNN 6, GNN 7
J) Bihar	RAU 8, VL 379, OEB 526, OEB 532

Source: AICRP on Pearl millet (http://www.aicpmip.res.in as on 25-02-2016)

4.3.3 Climate and Soil:

Finger millet is a short-day plant and grows best in an environment with day temperatures of 30 to 34 °C and 22 to 25 °C night temperatures along with good sunshine. It thrives best in the areas where annual rainfall is about 1000 mm.

Finger millet is cultivated on a variety of soils ranging from rich loam to poor shallow upland soils. It prefers porous and well drained loam to light red loam and sandy loam soils of good fertility and water holding capacity. The soil should be rich in organic matter. It withstands and thrives well on slightly alkaline soils too.

4.3.4 Sowing:

a. *Kharif* - June - July with the onset of monsoon
b. *Rabi*- September to October
c. Spacing: 225-30 cm (row to row), 8 – 10 cm (plant to plant). The seed should be planted 2-3 cm in depth.
d. Seed rate: 8-10 kg/ha for direct sowing, 5 kg/ha for Transplanting (Seedling of 20-25 days old are ideal for transplanting).

4.3.5 Manuring and Fertilization:

Apply Compost or farmyard manure @ 7-10 tonnes/ha about a month before sowing. Generally, fertilizer recommended to get a good crop in rainfed condition is 40:20:20 kg NPK / ha, and for irrigated is 60:30:30 kg NPK / ha. Soil test-based fertilizers application is recommended. Apply entire quantity of P and half of Nitrogen at the time of sowing and remaining half of nitrogen at first irrigation.

4.3.6 Irrigation:

Depending on soil type, weather condition and duration of variety, 8-14 irrigations are necessary.

4.3.7 Weed Management:

Two inter cultivations and one hand weeding in line sown crop is recommended. Intercultural operation using a tyne-harrow when crop is 30 days old is also recommended. In broadcast crop first weeding after 15–20 days after emergence of seedling and 2nd weeding 15-20 days after first weeding is recommended.

In assured rainfall and irrigated areas pre-emergence spray of Isoproturon @ 0.5 kg a.i./ ha. (Rainfed areas), Oxyflurofen @ 0.1 lta. i /ha (Irrigated areas) and post-emergent spray of 2, 4-D sodium salt @ 0.75 kg a.i./ha Spraying around 20-25 days after sowing effectively control weeds.

4.3.8 Disease Management:

Finger millet is affected by a variety of diseases of which blast caused by *Pyricularia grisea* is the major problem.

Symptom: The symptoms appear as circular lesions that are pointed towards either ends. The centre of the spots appears grayish and the borders become brownish. In susceptible genotypes, several of such spindle shaped spots coalesce together, leading to drying of the entire leaf. When the fungus infects the neck region, a few inches of neck just below the finger turns brownish black ultimately leading to breakage of the peduncle.

Management: The disease can be controlled by adopting resistant cultivars (GPU 28, GPU 48, GPU 45, VL Mandua 348, VL 379), Seed treatment with Carbendazim @ 2 g /kg seed and spraying of kitazin (0.1%) or Ediphefos (0.1%) or Saaf (0.2%) at 50 per cent flowering.

4.3.9 Pest Management:

Finger millet attracts several pests, of which army worm, cutworm, stemborer, shootfly and ear caterpillars are important

A. ***Stemborers****:* The larva bores into the stem, resulting in dead heart. Control: Spray the crop with Dimethioate (0.05%) or Phosphamidon (0.05%) or Monocrotophos (0.04%)
B. ***Ear Caterpillars***: Ear caterpillars appear at dough stage on ears and persist till harvest. The caterpillars bite the maturing seeds and make a fine web out of their casting and half eaten grains. This further attracts saprophytic fungi.

Control: Dust Malathion 5% @ 24 kg/ha or Quinolfos 1.5% @ 24 kg/ha or Endosulfan 4% @ 24kg/ha or Phosalone 4% @ 24 kg/ha.

4.3.10 Harvesting:

Harvest is done once the ear-heads are physiologically mature. Short duration varieties mature in 95-105 days while medium to late varieties matures in 110-125 days.

Yield: Grain 25-30 q/ha and 60-70 quintals of straw per hectare.

4.4 Industrial Usage:

The millet which is a nutritional crop refers to a variety of grass crops whose seeds are collected for human consumption or as animal feed. It is largely organic, highly digestible, naturally gluten-free, very nutrient-dense, and eaten as a whole grain (Thapliyal *et al.*, 2015).

Finger millet is becoming increasingly popular among people because of its significant nutritional value. The trendy meal is used to maintain a healthy lifestyle, avoid lifestyle problems, and treat non-communicable and chronic diseases (Saleh *et al*., 2013).

a. Finger Millet Noodle:

As people become more aware of finger millet nutritious qualities, the popularity of finger millet noodles is rising. Various combinations of noodles are possible, including noodles made solely from finger millet, fingermillet and wheat noodles are blended 1:1, and fingermillet noodles are blended 5:4:1 with wheat and soy flour. Millet flour is pretreated to help with extrusion when making exclusively millet-based noodles. It maintains a smooth texture throughout drying and cooking (Thapliyal *et al*., 2015).

b. Weaning Food:

Finger millet is one of the most abundant sources of calcium and amino acids containing sulfur. Weaning meal is created using compound malt flour which contains finger millet, bengal gram, and green gram.

This is a mixture is loaded with protein and calcium. The composite flour was soaked in water for 48 hours at 25 ℃ room temperature for 48 hours however 38 hours might be enough in summer. Ready-to-eat products are when malted grains are dried, roasted and ground using any equipment (Rathore *et al*., 2019).

c. Puffing:

Puffing or popping grains is an easy way to make ready-to-eat treats. Finger millet grain prepared for puffing, keeping its moisture level between 18 and 20 and then tempering for roughly 4-6 hours under cover. Following the HTST method, the conditioned grains are puffed by agitation on the hot sand surface maintained at high temperature (230–250 ℃) for a brief period. By crushing finger millet grain, we can make a powder that has more nutritional value by neutralizing some anti-nutritional elements and improving protein and carbohydrate digestibility (Thapliyal *et al*., 2015).

d. Porridges:

Finger millet is the cereal of choice for making porridge in India and Africa for the kids and people who are sick. It's thought to be more appetizing and has more minerals than sorghum or maize particularly when it comes to the calcium content (Mbithi *et al*., 2002)

e. Fermented Beverage:

Fermented beverages made from finger millet are also popular. Traditional mild alcoholic beverage (Kodo ko Jandh, Rakshi) consumed in Eastern Himalayan areas of the Darjeeling, Sikkim, Nepal and Bhutan which is prepared from finger millet. Jandh is an alcoholic beverage that is somewhat sour and sweet.

4.5 Health Benefits:

Ragi (*Eleusine coracana)* is a good source of carbs, proteins, dietary fiber, and minerals. It's a staple food for people from low-income backgrounds and people with metabolic disorders such diseases include diabetes and obesity (Mathanghi *et al*., 2012). The high fiber content of millets makes them hypoglycemic.

Delayed digestion and absorption of complex carbs and fiber can be caused by absorption of complex carbs and fiber.

Supplements sold worldwide contain phenolic compounds, particularly phenols, which are abundant in plant diets consumed by humans. These compounds contain various substances like antioxidants, anti-mutagenic, anti-carcinogen, anti-inflammatory, anti-oestrogenic, and anti-viral properties etc. (Ferguson *et al*., 2001).

The polyphenols are termed as "life-span essentials" because they maintain physiological functions and health in adulthood as well as later stages of life (Chandra *et al*., 2010). Millet meal flour helps in reducing hyperglycemic and oxidative stress.

Finger millet is beneficial and plays a significant role in maintaining health as majority of the phenolic chemicals in its seed coat are beneficial for human health because it contains benzoic acid derivatives have been linked to anti-oxidant properties (Hegde *et al*., 2005).

Plant polyphenols have received significant attention in recent years from health professionals, scientists as well as consumers in lowering the risk of cancer, cardiovascular and neuro-degenerative illnesses, infections, aging, and diabetes for their numerous health advantages in lowering the risk of diseases such as cancer and cardiovascular disease (Tsao *et al*., 2010).

As a trendy food for maintaining a healthy lifestyle and preventing lifestyle disorders, chronic illnesses, and non-communicable diseases, finger millet now has a profound nutritional value (Saleh *et al*., 2013, Nakarani *et al*., 2021)

4.6 References:

1. Anitha S, Govindaraj M and Kane-Potaka J. 2020. Balanced amino acid and higher micronutrients in millets complements legumes for improved human dietary nutrition. *Cereal Chemistry,* 97(1): 74–84.
2. Banusha S and Vasantharuba S. 2013. Effect of Malting on Nutritional Contents of Fingermillet and Mungbean. *J. Agric. & Environ. Sci* 13(12): 1642–1646.
3. Cassano A, Donato L, Conidi C and Drioli E. 2008. Recovery of bioactive compounds in kiwifruit juice by ultrafiltration. *Innov Food Sci Emerg* 9: 556–562.
4. Chandra A and Shahidi F. 2010. Content of insoluble bound phenolics in millets and their contribution to antioxidant capacity. *Journal of Agricultural and Food Chemistry* 58(11): 6706–6714.
5. Chandra D, Chandra S, Pallavi and Sharma AK. 2016. Review of Finger millet (*Eleusine coracana* (L.): A power house of health benefiting nutrients. *Food Science and Human Wellness, 5*(3): 149–155
6. Chethan S and Malleshi NG. 2007. Finger millet polyphenols: characterization and their nutraceutical potential. *American Journal of Food Science and Technology* 2: 582–592.
7. Ferguson LR .2001. Role of plant polyphenols in genomic stability. *Mutation Research Journal* 475: 89–111.
8. Gari JA. 2001. Review of the African millet diversity. FAO - Food and Agri- culture Organisation of the United Nations, Paper for the international work- shop on fonio, food security and livelihood among the rural poor in West Africa. IPGRI / IFAD, Bamako, Mali, 19-22 November 2001.
9. Gull A, Jan R, Nayik GA, Prasad K and Kumar P. 2014. Significance of finger millet in nutrition, health and value-added products: a review. *Magnesium (mg), 130* (32): 120.
10. Hegde PS, Rajasekaran NS and Chandra TS. 2005. Effects of the antioxidant properties of millet species on oxidative stress and glycemic status in alloxan-induced rats. *Nutrition Research* 25: 1109–1120.
11. Kumari A, Pandey A, Ann A, Raj A, Gupta A, Chauhan A and Jaiswal V. 2016. Indigenous alcoholic beverages of South Asia. *Indigenous Alcoholic Beverages of South Asia. CRC Press, New York* 501: 566.
12. Kumari LP, Sumathi S . 2002. Effect of consumption of finger millet on hyperglycemia in non-insulin dependent diabetes mel- litus (NIDDM) subjects. *Plant Foods for Human Nutrition* 57: 205–213.
13. Mahendra D. 2012. Small farmers in India: challenges and opportunities: *Emerging Economies Research Dialogue, Beijing, China*, pp. 14-15 November.
14. Malleshi NG. 2003. Decorticated finger millet (*Eleusine coracana*).US Patent No. 2003/0185951.
15. Mathanghi SK, Sudha K. 2012. Functional and phytochemical properties of finger millet *(Eleusine coracana)* for health. I*nternational Journal of Pharmaceutical Chemical and Biological Sciences* 2(4) : 431-438.
16. Mbithi Mwikya S, Van Camp J, Mamiro PRS, Ooghe W, Kolsteren P and Huyghebaert A. 2002. Evaluation of the nutritional characteristics of a finger millet based complementary food. *Journal of Agricultural and Food Chemistry*, 50 (10): 3030 – 3036.

17. Meena RP, Joshi D, Bisht J K and Kant L. 2021. Global scenario of millets cultivation. *Millets and Millet Technology:* 33-50.
18. Mir NA, Riar C S and Singh S. 2018. Nutritional constituents of pseudo cereals and their potential use in food systems: A review. *Trends in Food Science and Technology* 75: 170–180.
19. Mota C, Santos M, Mauro R, Samman N, Matos AS, Torres D and Castanheira I. 2016. Protein content and amino acids profile of pseudocereals. *Food Chemistry* 193: 55-61.
20. Nakarani UM, Singh D, Suthar KP, Karmakar N, Faldu P and Patil HE. 2021. Nutritional and phytochemical profiling of nutracereal finger millet (*Eleusine coracana* L.) genotypes. *Food Chemistry* 341: 128271.
21. 21. Oduori COA .2005. The Importance and Research Status of Finger Millet in Africa. The McKnight Foundation Collaborative Crop Research Program Workshop on Tef and Finger Millet: Comparative Genomics of the Chlori- doid Cereals at the Biosciences for East and Central Africa (BECA) ILRI, 28 -30 June 2005, Nairobi, Kenya
22. 22. Pragya Singh. 2012. Finger millet for food and nutritional security. *African Journal of Food Science* 6(4): 77–84.
23. 23. Rathore T, Singh R, Kamble DB, Upadhyay A and Thangalakshmi S. 2019. Review on finger millet: Processing and value addition. *Journal of Pharmaceutical Innovation* 8(4): 283-329.
24. 24. Saleh AS, Zhang Q, Chen J and Shen Q.2013. Millet grains: nutritional quality, processing, and potential health benefits. *Comprehensive reviews in Food Science and Food Safety* 12:281-295.
25. 25. Scalbert A, Manach C, Morand C and Remesy C. 2005. Dietary polyphenols and prevention of diseases. *Critical Reviews in Food Science and Nutrition* 45(4): 287–306.
26. Sharma KK and Ortiz R. 2000. Program for the application of genetic transformation for crop improvement in the semi-arid tropics. *In Vitro Cell Dev Biol Plant.* 2000; 36:83–92.
27. Shashi BK, Sunanda S, Shailaja H, Shankar AG and Nagarathna TK. 2007. Micronutrient composition, antinutritional factors and bioaccessibility of iron in different finger millet *(Eleusine coracana). Karnataka Journal of Agricultural Sciences* 20(3): 583-585.
28. Shibairo SI, Nyongesa O, Onwonga R and Ambuko J. 2014. Variation of nutritional and anti-nutritional contents in finger millet (*Eleusine coracana* L.) genotypes. *IOSR Journal of Agriculture and Veterinary Science* 7: 6-12.
29. 29. Shobana S, Krishnaswamy K, Sudha V, Malleshi NG, Anjana RM, Palaniappan L and Mohan V. 2013. Finger millet (Ragi, *Eleusine coracana* L.): A review of its nutritional properties, processing, and plausible health benefits. *Advances in food and nutrition research* 69: 1-39.
30. Srivastava K and Sharma AK. 2012. Nutraceutical Importance of Finger Millet (Eleusine coracana) for Improved Human Health. *The European Journal of Plant Science and Biotechnology Nutraceutical Importance of Finger Millet (Eleusine coracana) for Improved Human Health.*
31. Thapliyal V and Singh K. 2015. Finger Millet: Potential Millet for Food Security and power House of Nutrients. *International Journal of Research in Agriculture and Forestry* 2(2): 22–33.

32. Tsao R. 2010. Chemistry and biochemistry of dietary polyphenols. *Nutrients* 2(12): 1231–1246.
33. Wielen NVD, Moughan PJ and Mensink M. 2017. Amino acid absorption in the large intestine of humans and porcine models. *Journal of Nutrition* 147: 1493–1498.
34. Xiang J, Apea-Bah FB, Ndolo VU, Katundu MC and Beta T. 2019. Profile of phenolic compounds and antioxidant activity of finger millet varieties. *Food chemistry* 275: 361-368.
35. Yadav G, Singh A, Bhattacharya P, Yuvraj J and Banerjee R. 2013. Comparative analysis of solid-state bioprocessing and enzymatic treatment of finger millet for mobilization of bound phenolics. *Bioprocess and biosystems engineering* 36(11): 1563- 1569.