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Finger Millet: Nutritional Profile and Potential Health Benefits

Purma Rishitha*[1] and Damini Soni[2]

[1-2] Department of Nutrition and Dietetics, NIMS Institute of Nutrition and Public Health, NIMS University, Jaipur - 302 131, Rajasthan, India

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Abstract

Millets which are considered superfoods have high nutritious worth when contrasted with different cereals. Finger millet, which is otherwise called ragi in India possesses a greater part of the area under development and is created in enormous sums, particularly in South India which serves as a principal food for many rural populations. Ragi contains high nutritional contents and has more advantages as an endurance crop when compared with other cereals along with numerous essential amino acids. Because of its high dietary nutritional content, it provides various health benefits like reducing blood glucose levels, helps with celiac disease, reducing anaemia, and furthermore shows various properties like anti-cancer, anti-inflammatory, anti-bacterial, and antioxidant which help in maintaining a healthy diet. The potential of ragi as a nutritional and healthy food source is often overlooked due to insufficient awareness of its diverse culinary applications. This review concentrates on the health benefits and nutritional value of ragi, as well as its traditional usage and methods for value addition.

***Key words*:** Finger millet, Production, Nutrients, Health benefits, Traditional dishes, Value addition

Since the dawn of civilization, millet has been widely consumed and has been domesticated for at least 10,000 years in Eastern Asia. The world produces 30.089 million tonnes of millet in the year 2021, of which 13.21 million tonnes (43.9% of global production) are produced in India [1]. India is the largest producer of millet in the world followed by China, Africa, Egypt, and Greece [2]. Sorghum, pearl millet, foxtail millet, proso millet, kodo millet, finger millet, little millet, and barnyard millet are among the nutrient-dense millets which are also known as super cereals [3]. They account for more than 58% of global production, however, very few Indians are aware of their nutritional worth and health benefits [4].

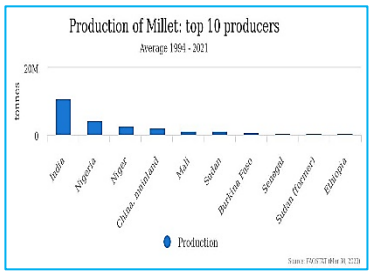


Fig 1 Top 10 millet producing countries

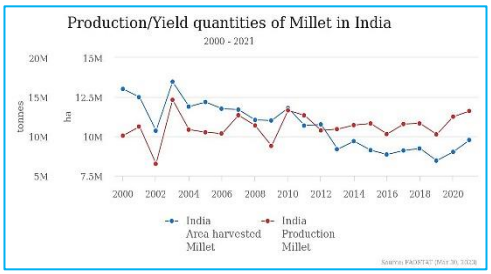
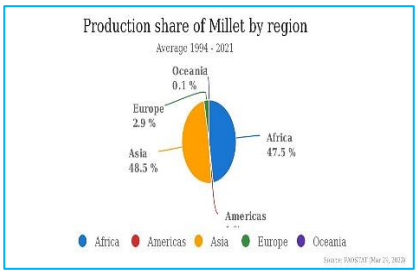


Fig 2 Production of millet in India (2000-2021)



Source: FAOSTAT [5]

Fig 3 Production of millet by region

Several developed countries underuse millet. Processing millet grains into high-value foods and beverages in developing countries has enormous potential [6]. Millets are nutritionally comparable to other major cereals and are a good source of protein, amino acids, micronutrients, phytochemicals, and minerals such as iron, manganese, copper, phosphorus, sulphur, magnesium, and zinc [7]. Millets, especially finger millet, contain polyphenols that not only have antioxidant qualities but also have antibacterial, anti-inflammatory, antiviral, anticancer, anti-platelet aggregation, and cataractogenesis inhibitory actions [8].

Finger millet

Finger millet (*Eleusine coracana*) is also called Ragi or Madwa/Mandua [9] or nachani/nachni in India; kaddo in Nepal; dagussa, tokuso, barankiya in Ethiopia; finger millet, African millet, koracan in England; wimbi, mugimbi in Kenya [10]. Ragi is the most popular millet in India and Africa and serves as the principal food for the huge sector of the residents in these countries [11] which is grown on more than four million hectares of land worldwide [12] and possesses many therapeutic properties [13]. It is grown as a rainfed crop in a variety of adverse soil and climatic conditions [14], and it is cultivated in the months of February and August and harvested in June or

***Correspondence to:** Purma Rishitha, E-mail: rishitareddy2000@gmail.com

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January [15]. Ragi accounts for 85% of production in India [16] which is cultivated over an area of 1.11 million hectares with a production of 1.98 million tonnes giving an average productivity of 1661 kg per ha [17]. The seeds of finger millet vary in diameter from 1 to 2mm which is globose and smooth [18]. The average weight of 1000 finger millet seeds are approximately 2.6g [19].

Nutritional profile

Carbohydrates and starch

Finger millet contains a higher amount of carbohydrates which is a form of non-starchy polysaccharide and dietary fibre [14]. The amount of carbohydrates in ragi is 72g/100g [21] with 1.04% free sugars, and 11.5% non-starchy polysaccharides. The composition of starch granules contains 80-85% of amylopectin along with 15-20% of amylase [22]. Ragi grains are rich in vitamin B complexes such as thiamine, riboflavin, folic acid, and niacin [23].

Protein

Finger millet contains 7.16g of protein per 100g mostly all cereals and millets contain the lowest amount of lysine compared to legumes and animal proteins [24], but finger millet is rich in amino acids, such as methionine, tryptophan and lysine [25]. It is considered as most balanced millet due to its presence of amino acids like valine, and threonine. Finger millet also contains other amino acids which lack in many starchy millets like isoleucine (4.3 g), leucine (10.8 g), methionine (3.1 g) and phenylalanine (6.0 g) [26].

Source: Indian Institute of Millets Research [20]

Fig 4 Pictures of finger millet

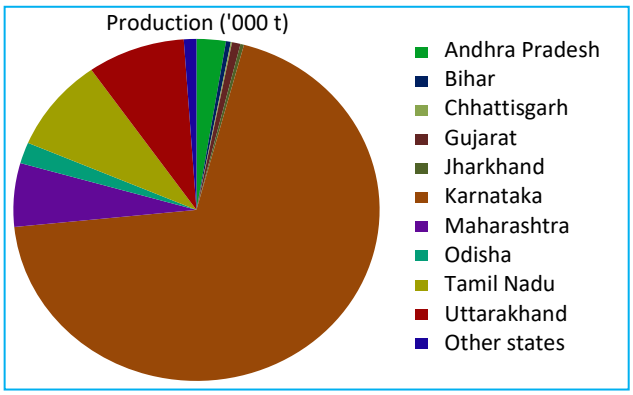
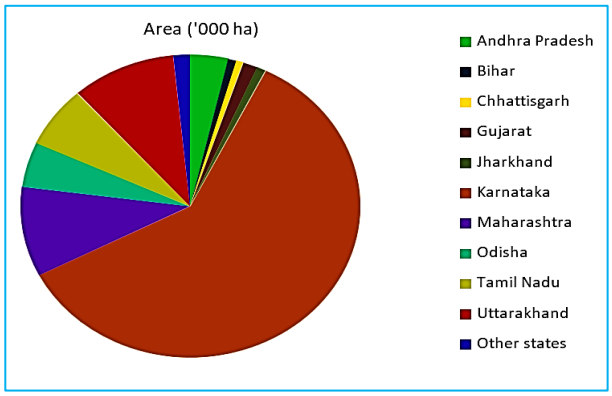


Fig 5 Production of ragi from different states of India



Source: Chandra *et al*. [3]

Fig 6 Area utilized to harvest ragi in India

Table 1 Amino acid profile of ragi

Amino acid	Amount g/100g
Histidine	2.37
Isoleucine	3.70
Leucine	8.86
Lysine	2.83
Methionine	2.74
Cystine	1.48
Phenylaniline	5.70
Threonine	3.84
Tryptophan	0.91
Valine	5.65
Alanine	6.71
Arginine	4.33
Aspartic acid	6.40
Glutamic acid	20.22
Glycine	3.59
Proline	5.42
Serine	4.81
Tyrosine	3.37

Source: ICMR 2017

Lipids

Finger millet contains a low amount of fat reducing the health risks [23]. Finger millet grains contain essential fatty acids such as linolenic acid (1.3-4.4 mg/100g) and palmitic acids (21.1-24.7mg/100g) which are beneficial for the development of brain and neural tissue. It also contains other fatty acids like oleic acid (49.8mg/100g) and linoleic acid (24.2mg/100g) [15].

Fibre

Finger millet contains 3.6g of dietary fibre per 100g and contains 22% of higher fibre when compared with other millets [26]. Finger millet contains five layered testae which is the main reason for the presence of high dietary fibre content [15]. The fibre is bulky and will be digested slowly giving the consumer satisfaction with low calories [27].

Micronutrients

The total mineral content of ragi is 2.7% [19]. Ragi is highly enriched with calcium, and it is also a rich source of other micronutrients like iron, magnesium, sodium, phosphorus, copper, and potassium. The germ, aleurone layer and pericarp are the richest portion of minerals [20]. Ragi also contains vitamins which are required by the human body for regular functioning and self-maintenance [23]. These grains possess water and fat-soluble vitamins [20] which are rich in thiamine, niacin, riboflavin, and tocopherol including vitamin C, but vitamin C is absent in dried grains [23].

Table 2 Nutritional composition of ragi

Macronutrients	Amount (g/100g)
Carbohydrates	66.82
Protein	7.16
Fat	1.92
Insoluble fibre	9.51
Soluble fibre	1.67
Total fibre	11.18
Micronutrients	Amount (mg/100g)
Thiamine (B_1)	0.37
Riboflavin (B_2)	0.17
Niacin (B_3)	1.34
Pantothenic acid (B_5)	0.29
Pyridoxine (B_6)	0.05
Vitamin-E	0.16
Calcium	364
Iron	4.62
Magnesium	146
Manganese	3.19
Phosphorus	210
Potassium	443
Sodium	4.25
Zinc	2.53

Source: ICMR 2017

Health benefits

Blood glucose lowering effect

The phytochemicals present in finger millet slow the digestion process controlling blood sugar levels in the body [20]. The phenolic seed coat of finger millet functions as an inhibitor to reduce postprandial hyperglycaemia by limiting the activity of enzymes like amylase and alpha-glucosidase which are crucial for the digestion of complex carbohydrates [28]. High fibre content reduces digestion in the human body which directly helps in reducing blood sugar levels [26]. Therefore, Regular consumption of finger millet helps in administrating unusual disorders of our body by regulating the proper blood glucose level [19].

Role in celiac disease

Gluten consumption causes immune-mediated enteropathy known as celiac disease in people who are genetically susceptible [28]. Millets are naturally gluten-free, so they are a very good choice for people who are suffering from celiac disease [19], especially finger millet is an excellent choice when compared with wheat and other common cereal grains [29].

Improvement in haemoglobin status

Finger millet is a very good source of iron and is used in diets to get recovery from anaemic conditions [20]. Finger millet is beneficial for people who contain low haemoglobin levels [26] and supplementing infants with germinated finger millet-rich foods showed a significant improvement in haemoglobin levels [30].

Other health benefits

Ragi has a rich nutritional profile and hence it shows numerous therapeutic effects [19]. The body is relaxed naturally by consumption of finger millet; hence it is used to treat depression, anxiety, migraines, and insomnia [20]. Finger millet is also reported as a good antioxidant in the dermal wound healing process in diabetes [28] and helps in good health, ageing, and metabolic syndrome [20]. Finger millet also shows anti-inflammatory activity, anti-bacterial activity, and anti-microbial activity [30]. Since ragi also possess a high calcium profile it also helps in strengthening bones [19]. Consuming green finger millet is beneficial for patients who are suffering from heart problems, liver disorders, blood pressure, and asthma [20] and for pregnant women since it enhances lactation [31]. After sprouting vitamin C increases in finger millet which results in easy uptake of iron into the bloodstream [26].

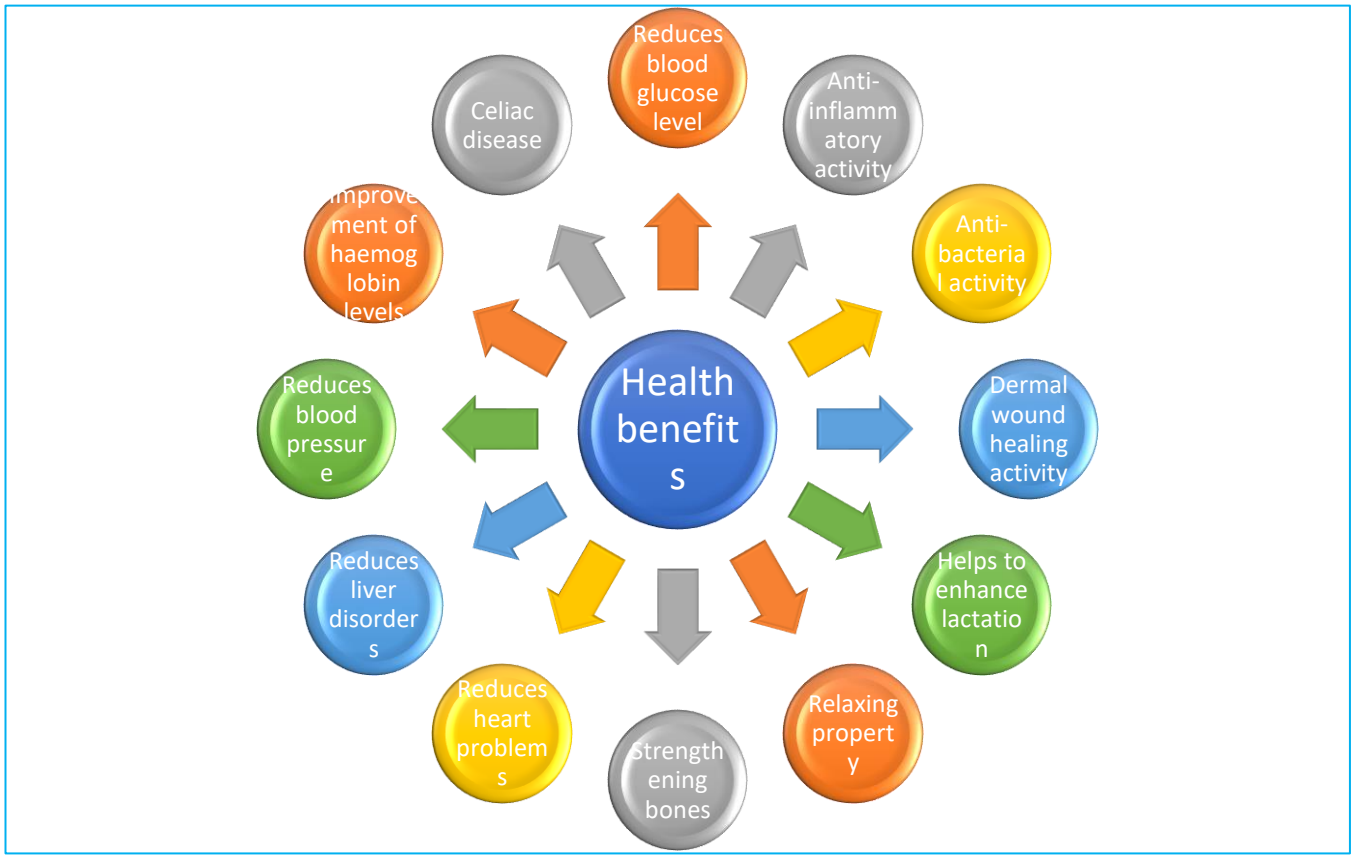


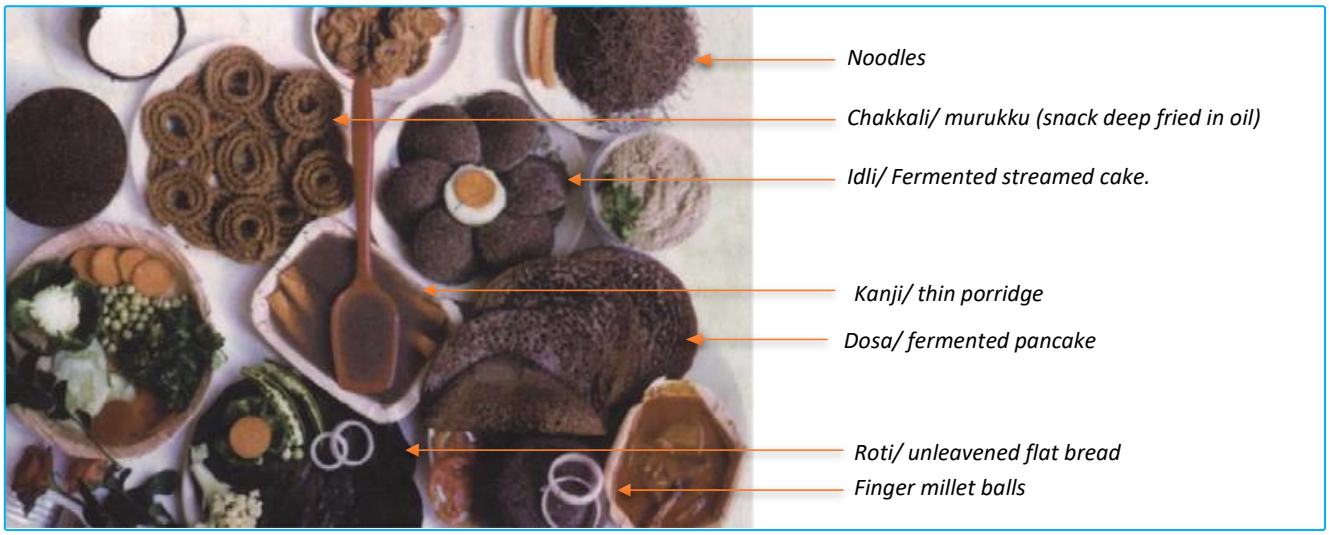
Fig 7 Health benefits of ragi

Traditional utilization of finger millet

Finger millet is a staple in South Indian kitchens. The dishes prepared in Indian kitchens are finger millet onion chapati, finger millet laddu, finger millet murukku, soft mudde, finger millet rawa chocolate pudding, finger millet vermicelli kheer, finger millet vermicelli upma, and finger millet cake [20]. The traditional foods which are prepared in India are roti, kazhi (ragi balls), and kanji (thin porridge) [30]. Many varieties like chapatis, chakli, cheela, khichri, papads, noodles, vermicelli, and many local dishes are made with the help of ragi [9]. These ragi/finger millet grains can also be utilized for preparing baking goods, flour, certain weaning foods for infants, and alcoholic and non-alcoholic beverages [23].

Value added products

Apart from the traditional dishes and recipes, ragi flour can be incorporated into many other recipes to improve its nutritional and sensory quality.



Source: Shobana *et al.* [28]

Fig 8 Traditional dishes prepared by using ragi

Pasta

Murali and Prabhasankar [32] developed healthier pasta by incorporating sprouted ragi flour and raw banana flour in the proportions 10%, 20% and 30% and also one sample with 15% ragi flour and 15% banana flour and studied the nutritive value of the pasta and concluded that the 20% level of banana and ragi flour was moderately accepted but the combination of 15% ragi flour and 15% banana flour was more potent in nutritional attributes by increased dietary fibre and mineral content and also anti-oxidant level was improved but the protein content of the pasta was decreased because banana flour and ragi flour was low in protein when compared with semolina.

Source: IIMR 2023

Fig 9 Pasta made using ragi

Cupcakes

Mane and Kadam [11] developed cupcakes supplementing ragi with different proportions such as 100:0, 70:30, 60:40 and 50:50 and evaluated the quality by organoleptic evaluation method, concluding the partial replacement of Maida i.e., 60:40 ratio is proven acceptable with overall acceptability of 7.5 enriching the product with calcium and iron.

Biscuits

Kaur *et al*. [33] developed biscuits using finger millet which is underutilized but great with its mineral content. A total of twelve cultivars were screened out for calcium content and the best cultivar which had the highest content of calcium was selected and was utilized to supplement biscuits in different proportions (0, 25, 50, and 75%). The results concluded that the calcium and crude fibre content was increased when supplemented and evaluation of sensory parameters concluded that finger millet can be successfully substituted up to 50% in wheat flour while preparing biscuits.

Cake

Desai *et al*. [34] developed a cake incorporating malted ragi flour in different compositions with other ingredients and evaluated the nutritional and sensory characteristics of the cake. The different compositions of refined wheat flour and malted ragi flour are 80:20, 60:40, 50:50, 40:60, and 30:70. As compared to the control sample, the ragi flour sample was found to be enhanced with minerals like calcium, iron, and phosphorus as well as crude fibre. The cake with the ratio of 30:70 of refined wheat flour and ragi flour had the highest mineral and fibre content, but the sensory parameters are low due to loss of sponginess and the colour difference, but the composition of 50:50 showed the same sensory scores as of control sample.

Vermicelli noodles

Lande *et al*. [35] developed a nutrient-rich vermicelli by the addition of wheat and malted ragi flour in various

compositions i.e., 90:10, 80:20, 70:30, 60:40 and 50:50 to improve the quality of vermicelli and evaluated nutritional and sensory qualities of the compositions. The results concluded that the proportion of 70:30 had a similar score to the control sample with increased amounts of protein, fibre and minerals like iron, calcium, and phosphorus.

Fig 10 Vermicelli noodles made using ragi

Fig 11 Cookies made using ragi

Source: IIMR 2023

Cookies

Rana *et al*. [36] developed cookies in which Maida is substituted with sprouted ragi millet flour at 0, 5, 10, 15, 20, and 25% levels and nutritional with sensory quality parameters are evaluated and observed the decrease in carbohydrates, proteins, fat, and energy values but also observed a significant increase in mineral content like iron, calcium, and phosphorus. The results concluded that the supplementation of sprouted ragi flour showed overall acceptability of 7.61 in 25% substituted cookie. Hence, the cookie can be substituted with 25% of sprouted ragi flour to improve the nutritional quality of the cookies.

CONCLUSION

Cereals and millets are the major products of our diet in India. Finger millet which is the staple food in the southern part of India is still underutilized by other parts of the country due to a lack of knowledge and its sensory parameters. Finger millet which is nutritious is richer in protein fat and minerals especially iron and calcium when compared with rice. Finger millet has numerous health benefits due to its fibre content and presence of calcium and iron help in bone strengthening for both children and adults. Various traditional dishes can be seen but the value addition of composite flours is being developed in many countries and is being accepted. Hence, this study concludes that being a nutritious millet and easily assessable to people of both rural and urban, finger millet can be incorporated into their diet by both traditional dishes and the addition of flour into regular or fancy dishes.

LITERATURE CITED

1. Anonymous. http://www.fao.org.in (FAOSTAT Database)
2. Singh N, Nainwal P, Dhyani A, Lall S, Kumar S. 2021. Potential health benefits of millets as dietary supplement for diabetics. *Journal of Medical Pharmaceutical and Allied Sciences* 2(2): 224-227.
3. Chandra AK, Chandora R, Sood S, Malhotra N. 2021. Global production, demand, and supply. *In*: *Millets and Pseudo Cereals*. Woodhead Publishing. pp 7-18.
4. Upadhyaya HD, Gowda CLL, Reddy VG. 2007. Morphological diversity in finger millet germplasm introduced from Southern and Eastern Africa. *Journal of SAT Agricultural Research* 3(1): 1-3.
5. Anonymous. http://www.fao.org.in (FAOSTAT Database)
6. Chandrasekara A, 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.
7. Prasanna MS, Sowjanya VS, Jaya E, Rajender G. 2020. Development of millet based instant weaning mix. *Journal of Pharmacognosy and Phytochemistry* 9(4): 1908-1913.
8. Viswanath V, Urooj A, Malleshi NG. 2009. Evaluation of antioxidant and antimicrobial properties of finger millet polyphenols (*Eleusine coracana*). *Food Chemistry* 114(1): 340-346.
9. Sinha NM, Kumari N, Dikshit N, Kant S. 2022. Ragi traditional but nutritional especially in the era of COVID-19. *Indian Journal of Clinical Practice* 32(10): 20-24.
10. Singh P, Raghuvanshi RS. 2012. Finger millet for food and nutritional security. *African Journal of Food Science* 6(4): 77-84.
11. Mane K, Kadam M. 2021. Development and quality evaluation of ragi supplemented cupcakes. *International Journal of Environment, Agriculture and Biotechnology* 6: 2.
12. Satish L, Ceasar SA, Ramesh M. 2017. Improved Agrobacterium-mediated transformation and direct plant regeneration in four cultivars of finger millet (*Eleusine coracana* (L.) Gaertn.). *Plant Cell, Tissue and Organ Culture* 131(3): 547-565.
13. Jayawardana SAS, Samarasekera JKRR, Hettiarachchi GHCM, Gooneratne J, Choudhary MI, Jabeen A. 2021. Anti-inflammatory and antioxidant properties of finger millet (*Eleusine coracana* (L.) Gaertn.) varieties cultivated in Sri Lanka. *BioMed Research International* 2021: 7744961. doi: 10.1155/2021/7744961.
14. Vennila M, Murthy C. 2021. Trend analysis of area, production and productivity of finger millet (Ragi). *Journal of Pharmacognosy and Phytochemistry* 10(2): 84-90.
15. Ramashia SE, Anyasi TA, Gwata ET, Meddows-Taylor S, Jideani AIO. 2019. Processing, nutritional composition and health benefits of finger millet in sub-Saharan Africa. *Food Science and Technology* 39: 253-266.
16. Divya GM, Krishnamurthy KN, Gowda DM. 2013. Growth and instability analysis of finger millet crop in Karnataka. *Mysore Journal of Agricultural Sciences* 47(1): 35-39.
17. Sakamma S, Umesh KB, Girish MR, Ravi SC, Satishkumar M, Bellundagi V. 2018. Finger millet (*Eleusine coracana* L. Gaertn.) production system: status, potential, constraints and implications for improving small farmer's welfare. *Journal of Agricultural Sciences* 10(1): 162-179.
18. Dida MM, Devos KM. 2006. Finger millet. *In*: *Cereals and Millets*. Springer, Berlin, Heidelberg. pp 333-343.
19. Rathore T, Singh R, Kamble DB, Upadhyay A, Thangalakshmi S. 2019. Review on finger millet: Processing and value addition. *Jr. Pharm. Innovation* 8(4): 283-329.
20. Jagati P, Mahapatra I, Dash D. 2021. Finger millet (Ragi) as an essential dietary supplement with key health benefits: A review. *International Journal of Home Science* 7(2): 94-100.

21. Kandel M, Dhami NB, Bastola A, Sudedi NR, Shrestha J. 2019. Field evaluation and nutritional benefits of finger millet (*Eleusine coracana* (L.) Gaertn.). *International Journal of Global Science Research* 6(1): 711-722.
22. Indian Council of Medical Research (ICMR). 2010. Nutrient requirements and recommended dietary allowances for Indians. A report of the Expert Group of the Indian Council of Medical Research.
23. Ramashia SE, Gwata ET, Meddows-Taylor S, Anyasi TA, Jideani AIO. 2018. Some physical and functional properties of finger millet (Eleusine coracana) obtained in sub-Saharan Africa. *Food Research International* 104: 110-118.
24. Anonymous. https://www.icmr.gov.in/ (ICMR)
25. Shingote AB, Sadawarte SK, Pawar VS, Gaikwad KK. 2021. Studies on chemical and mineral evaluation of raw rice, sorghum, ragi and green gram. *The Pharma Innovation Journal* 10(5): 337-340.
26. Chowdary DM, Bisarya D. 2020. Review of finger millet (*Eleusine coracana* L.) on nutrition and health benefits. *International Journal of All Research Education and Scientific Methods* 8(11): 1319-1323.
27. Owheruo JO, Ifesan BO, Kolawole AO. 2019. Physicochemical properties of malted finger millet (*Eleusine coracana*) and pearl millet (*Pennisetum glaucum*). *Food Science and Nutrition* 7(2): 476-482.
28. Singh E. 2016. Potential functional implications of finger millet (*Eleusine coracana*) in nutritional benefits, processing, health and diseases: A review. *International Journal of Home Science* 2(21): 151-155.
29. Saleh AS, Zhang Q, Chen J, Shen Q. 2013. Millet grains: nutritional quality, processing, and potential health benefits. *Comprehensive Reviews in Food Science and Food Safety* 12(3): 281-295.
30. Shobana S, Krishnaswamy K, Sudha V, Malleshi NG, Anjana RM, Palaniappan L, 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.
31. Chamoli V, Badoni A, Bahuguna N, Joshi N. 2018. Finger millet (*Eluesine coracana*): Nutritional status, health benefits and processing status-A review. *Journal of Pharmacognosy and Phytochemistry* 7(5S): 80-83.
32. Krishnan M, Prabhasankar P. 2010. Studies on pasting, microstructure, sensory, and nutritional profile of pasta influenced by sprouted finger millet (*Eleucina coracana*) and green banana (*Musa paradisiaca*) flours. *Journal of Texture Studies* 41(6): 825-841.
33. Kaur A, Kumar K, Dhaliwal HS. 2020. Physico-chemical characterization and utilization of finger millet (*Eleusine coracana* L.) cultivars for the preparation of biscuits. *Journal of Food Processing and Preservation* 44(9): e14672.
34. Desai AD, Kulkarni SS, Sahoo AK, Ranveer RC, Dandge PB. 2010. Effect of supplementation of malted ragi flour on the nutritional and sensorial quality characteristics of cake. *Advance Journal of Food Science and Technology* 2(1): 67-71.
35. Lande SB, Thorats S, Kulthe AA. 2017. Production of nutrient rich vermicelli with malted finger millet (Ragi) flour. *International Journal of Current Microbiology and Applied Sciences* 6(4): 702-710.
36. Rana GK, Mishra SP, Duggal A, Shukla SS, Singh NK, Rahangdale HK. 2021. Proximates and Sensoric attributes of sprouted Ragi flour (SRF) supplemented cookies. *The Pharma Innovation Journal* 10(10): 2432-2435.