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Wadmare VB
Ph.D. Research Scholar, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Pawar VS
Head, Department of Food Process Technology, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Shinde IN
M. Tech Research Scholar, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Corresponding Author:
Wadmare VB
Ph.D. Research Scholar, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

A review of finger millet (*Eleusine coracana* (L.) its varieties, nutrient composition, cooking qualities and health benefits

Wadmare VB, Pawar VS and Shinde IN

Abstract
Millets crops are highly drought tolerant in nature. Millet is grown widely around the world for use as food and fodder. Finger millet is rich source of iron (3.9 mg per 100 gm), calcium (344 mg per 100 gm), zinc (2.3 mg per 100 gm), total dietary fiber (19.1 per cent) and carbohydrates (72.6 gm). On the occasion of World Food Day in the year 2020 two biofortified varieties of finger millet were released namely CFMV 1 (Indravathi) and CFMV 2 (Gira) that are rich in iron and calcium. The cooking time required for decorticated finger millet was found to be 6 min with 3.7 per cent solid loss. Its dietary fiber and polyphenols provide several health benefits such as anti-diabetic, protection from diet related chronic diseases, hypocholesterolaemic, antioxidant and antimicrobial effects to the people who consume finger millet regularly in their diet. Finger millet is also a good ingredient of weaning food.

Keywords: Millet, dietary fiber, calcium, iron, antidiabetic, weaning food

Introduction
Millet constitutes a variety of small-grained, warm-weather, annual cereals that are part of the grass family. These crops are highly drought tolerant in nature. Millet is grown widely around the world for use as food and fodder. Millets are important crops in the semiarid tropical regions and are indigenous to many parts of the world. For centuries, millets have served as an important staple in parts of Asia and Africa. The crop has been cultivated for at least 10,000 years in East Asia. The world total production of millet grains in year 2019 was 29,870,058 metric tons and the top producer was India with an annual output of 10,910,000 tons contributing 36.52% (FAO, 2013) [8].

A millet crop includes grasses like finger millet (*Eleusine coracana* (L.) Gaertn), pearl millet (*Pennisetum glaucm* L.) R.Br), foxtail millet (*Setaria italica* (L.) *P. Beauvois*), kodo millet (*Paspalum scorbiculatum* L.), bahiagrass (Paspalum nota-tum Flugge), little millet (*Panicum sumatrense* Roth ex Roem. & Schult.), proso millet (*Panicum miliaceum* L.), barnyard millet (*Echinochola crusgalli* (L.) *P. Beauv*), guinea grass (Chandra *et al*., 2016) [2].

Finger millet commonly known as ragi and mandua in India is one of the minor cereals a native of Ethiopia, but grown extensively in various regions of India and Africa, constitutes as a staple food that supply a major portion of calories and protein to large segments of the population in these countries especially for people of low income groups. In India, Karnataka is the leading producer of finger millet accounting to 58% of its global production, yet only a few Indians are aware about its health benefits and nutritional value. The production area of finger millet in India stands sixth after wheat, rice, maize, sorghum and bajra (O'Kennedy *et al*., 2006) [18].

In India, Karnataka is the leading producer of finger millet accounting to 58% of its global production, yet only a few Indians are aware about its health benefits and nutritional value. The production area of finger millet in India stands sixth after wheat, rice, maize, sorghum and bajra. In world, finger millet ranks fourth in importance among millets after sorghum, pearl millet and foxtail millet (Upadhyaya *et al.*, 2007) [27].

Millets are important but underutilized crops in tropical and semiarid regions of the world due to their greater resistance to pests and diseases, good adaption to a wide range of environment and their good yield of production, can withstand significant levels of salinity, short growing season, resistant to water logging, drought tolerant, requires little inputs during growth and with increasing world population and decreasing water supplies represents important crops for future human use.

The drought tolerance of finger millet may be attributed to an efficient antioxidant potential and increased signal perception. Being as hardycrop it is relatively easy to grow finger millet under stressful regimes, without hampering the net productivity. There is vast potential to process millet grains into value-added foods and beverages in developing countries. Furthermore, millets, as they do not contain gluten and therefore it is advisable for stomach (abdominal) patients (Chandrasekara and Shahidi, 2010) [3].

Rheological and functional properties are a fundamental physico-chemical properties that reflect the complex interaction between the composition, structure, molecular conformation and physico-chemical properties of food components together with the nature of environment in which these are associated (Kaur *et al*., 2006; Kinsella, 1976; Siddiq *et al*., 2009) [14, 15, 22].

Physical properties of grains are essential requirement for design of structures, machineries and equipment.

In current review attempt has been made to collect the available information from existing literature either online or offline related to the production, cooking qualities and health benefiting properties of finger millet and trying to present the collected data in a easily-documented pattern.

Millet Varieties Released on World Food Day (16 October 2020)

1. Finger Millet – CFMV 1 (Indravathi): This variety has the potential of 35-40 quintal per hectare grain yield. It is resistant to finger and neck blast disease. It has 7-8 fingers with an ear length of 8-9 cm. The variety attains its maturity at 110-115 days. It is recommended in the state of Andhra Pradesh, Tamil Nadu, Karnataka, Puducherry, and Odisha.
2. Finger Millet – CFMV 2 (Gira): The grain yield potential of this variety is 32-35 quintal per hectare and dry stover yield of 85-90 quintal per hectare. It is resistant to blast disease and stem borer. It has profused tillering and non-lodging characteristics. This variety is recommended in the state of Andhra Pradesh, Chattisgarh, Gujarat, Maharashtra, and Odisha.
3. Little Millet – CLMV 1 (JAICAR Sama 1): This variety has the grain yield potential of 18-20 quintal per hectare. This variety can give a high tillering of 8-9 tillers. It is tolerant of insect pests and foliar diseases. The amazing characteristic of this variety is that it contains high protein (14.4%) and high grain iron(58 ppm). It is recommended in the state of Maharashtra, Andhra Pradesh, Telangana, Tamil Nadu, and Puducherry.

Source: Millet Varieties Released On World Food Day (tcrconnectingagriculture.com)

Salient Features of Some Varieties of Finger Millet (1994 to 2016)

Sr. No	Variety	Institute where developed	Year of Release	Area of Adaptation	Salient features
1	VL 376	ICAR-VPKAS, Almora	2016	All ragi growing areas of country	Responsive to fertilizer and moderately resistant to blast
2	GNN-6	Waghiya Navsari agricultural University	2016	Gujarat	Moderately resistant to leaf blast and finger blast
3	VL Mandua-348	ICAR-VPKAS, Almora	2016	Uttarakhand	Suitable for organic cultivation, Resistant to neck and finger blast, Tolerant to lodging, Light copper grains
4	KMR 340	VC Farm, Mandya, UAS, Bengaluru	2016	Karnataka	White ragi variety, specially for confectionary purpose, resistant to blast and blight diseases, tolerant to stem borers and aphids
5	VR 936	ANGRAU, Vizianagaram	2012	Andhra Pradesh	Suitable for late conditions, responsive to nitrogenous fertilizers
6	KOPN 235	MPKVV, Rahuri	2011	Sub mountain and ghat zone of Maharashtra	Resistant to blast
7	GPU 67	PC Unit, Bengaluru	2009	National	Non lodging (semi dwarf)
8	Dapoli 1	KVK Dapoli	1994	Konkan region of Maharashtra	Early maturity

Source:https://www.millets.res.in/technologies/finger_millets_varieties.pdf

Nutritional Significance of Finger Millet

The main constituents of the millet kernel are seed coat (testa), embryo and endosperm. Among several varieties of finger millets such as yellow, white, tan, red, brown, or violet color, only the red-colored are cultivated extensively throughout world.

The presence of five layered testa in finger millet makes it unique compared to other millets such as foxtail millet, pearl millet kodo millet and proso millet. This could be one of the possible reasons for the higher dietary fiber content in finger millet (FAO, 1995) [7].

Gopalan *et al*., 1976 [9]; Shobhana *et al.*, 2013; Alvarez-Jubete *et al.*, 2009 [9, 21, 1] studied nutrient composition of finger millet and other minor millets. The results were as foloows. A comparative nutritional (Table 1), mineral and vitamin (Table 2), and amino acid (Table 3) profile of finger millet with other minor millets, cereals and pseudo-cereals are summarized in said table.

Table 1: Nutrient composition of finger millet with other minor millets

Minor millet	Protein (%)	Fat (%)	Starch (%)	Ash (%)	Crude fiber (%)	Total Dietary Fiber (%)	Total Phenol (mg/100gm)	Carbohydrates (gm)
Finger millet	7.3	1.3	59.0	3	3.6	19.1	102	72.6
Pearl millet	14.5	5.1	60.5	2	2	7	51.4	67.5
Proso millet	11	3.5	56.1	3.6	9	8.5	0.10	70.4
Foxtail millet	11.7	3.9	59.1	3	7	19.11	106	60.9
Kodo millet	8.3	1.4	72.0	3.6	9	37.8	368	65.9

Little millet	7.7	4.7	60.9	6.9	7.6	-	21.2	67
Barnyard millet	6.2	4.8	60.3	4	13.6	13	26.7	65.5

Shankara *et al.*, 1983 [19] and Dangeti *et al.*, 2013 [5] studied mineral and vitamin composition of finger millet and other minor millets. The results of their findings were as follows

Table 2: Mineral and Vitamin composition of Finger millet and other minor millets (mg/100gm)

Minor millet	Ca	P	Fe	Mg	Na	K	Cu	Zn	Vit B1	Vit B2	Vit B3
Finger Millet	344	283	3.9	137	11	408	0.47	2.3	0.42	0.19	1.1
Pearl millet	42	240	11	137	10	390	1.06	3.1	0.38	0.21	2.8
Proso millet	8	206	2.9	114	5	195	0.8	1.7	0.41	0.28	4.5
Foxtail millet	31	290	2.8	143	1.3	364	0.59	3.51	0.59	0.11	3.2
Kodo millet	35	188	1.7	110	4.8	141	1.60	0.7	0.15	0.09	2
Little millet	17	220	9.3	61	7.9	126	0.05	3.7	0.30	0.09	3.2
Barnyard millet	22	280	18.6	82	-	-	0.60	3	0.33	0.1	4.2

Gopalan *et al.*, 1976 [9] and Shobhana *et al.*, 2013 [21] studied amino acid profile of finger millet and other minor millets. The results of their findings were as follows

Table 3: Essential amino acid profile of finger millet and other minor millets (gm/100gm)

Minor millet	Lysine	Tryptophane	Phenylalanine	Tyrosi-ne	Methio-nine	Threo-nine	Leuci-ne	Iso-leuci-ne	Valine
Finger Millet	0.220	0.100	0.310	0.220	0.210	0.240	0.690	0.400	0.480
Pearl millet	0.190	0.110	0.290	0.200	0.150	0.240	0.750	0.260	0.330
Proso millet	0.190	0.050	0.310	-	0.160	0.150	0.760	0.410	0.410
Foxtail millet	0.140	0.060	0.420	-	0.180	0.200	0.650	0.360	0.430
Kodo millet	0.150	0.050	0.430	-	0.180	0.200	0.650	0.360	0.410
Little millet	0.110	0.060	0.330	-	0.180	0.190	0.760	0.370	0.350

Cooking qualities and Textural Properties of Finger Millet

Physical properties of grains are essential requirement for design of structures, machineries and equipment. Cooking characteristics and sensory attributes of decorticated finger millet was studied by U. Dharmaraj and others. Decorticated millet is one of the unique products from finger millet, which can be cooked to discrete grains similar to rice. The cooking qualities of decorticated millet, namely cooking time, soluble loss, and pasting profile, were studied. It was observed that decorticated millet cooks to soft textured grains within 6 min. The moisture content of the cooked grains was 71 gm/100 gm with a total soluble loss of 3.5 gm/100gm. Exposing the cooked millet to atmosphere increased its redness value by 39%. The gelatinization temperature of the decorticated millet was 68◦C and its paste showed no breakdown in the viscosity. The hardness of the cooked millet was 0.63N indicating its soft texture. The sensory analysis of the product corroborated with the instrumental results with an overall acceptability score of 8 (Dharmaraj *et al.*, 2014). The results of their experiment was as follows

Table 4: Cooking characteristics and textural properties of Decorticated Finger Millet

Parameter	Value
Cooking time (min)	6.0 ± 1.0
Moisture uptake (%)	71 ± 2.1
Swelling power (%)	350 ± 2.3
Solid loss (%)	3.7 ± 0.07
Amylose leached per 100 gm of leached solids	48 ± 0.5
Sugars (per 100g of leached solids)	0.3 ± 0.01
Hardness (N)	0.63 ± 0.031
Springiness	0.30 ± 0.021
Adhesiveness (N.s)	−0.10 ± 0.004
Cohesiveness	0.20 ± 0.011
Gumminess	0.09 ± 0.004
Chewiness	0.03 ± 0.0011

Health Benefits of Finger millet

1. Antioxidant property

Higher antioxidant capacity of finger millet is attributed to the high total phenolic content as well as flavonoids such as catechin, gallocatechin, epicatechin, procyanidin dimmer, levels of enzymatic (catalase, superoxide dismutase, glutathione peroxidase, and glutathione reductase) and non-enzymatic antioxidants like glutathione, vitamin E and C (Sripriya *et al.*, 1996; Subba Rao *et al.*, 2002; Hegde *et al.*, 2005; Chandrasekara *et al*., 2011) [23, 24, 11, 12, 4].

2. Antiprotein (glycation) property

Finger millet seed coat polyphenols are effective inhibitors of fructose induced albumin glycation (Veenashri *et al.*, 2011; Hegde *et al.*, 2002) [28, 10].

3. Antimicrobial activity

Polyphenol extract from finger millet seed coat and whole flour active against Bacillus cereus, Aspergillus niger and fermented finger millet extract suppress growth of Salmonella sp., Escherichia coli (Viswanath *et al.*, 2009) [30].

4. Antiulcerative property

Finger millet incorporated diet prevents mucosal ulceration (Towey *et al.*, 1975) [26].

5. Blood glucose lowering effect, Nephroprotective properties, Cholesterol lowering

Finger millet incorporated diets reduce serum cholesterol and phenolics from finger millet seed coat matter inhibit the intestinal-glucosidase and pancreatic amylase thus helps in controlling postprandial hyperglycemia (Hegde *et al.*, 2005; Shobana *et al.*, 2010) [11, 12].

6. Improvement on hemoglobin status in children

Finger millet is excellent plant source of natural iron. Germinated finger millet based food showed a general improvement on hemoglobin status (Tatala *et al.*, 2007) [25].

7. Production of antihypercholesterolaemic metabolites

Solid state fermentation of finger millet results in the production of metabolites like statin viz. pravastatin, lovastatin, monacolin J, pravastatin and mevastatin known as monacolins. These metabolites inhibit the enzymatic conversion of hydroxymethyl-glutarate to mevalonate by HMG- CoA reductase, which is the important step in the biosynthetic pathway of cholesterol (Manzoni *et al.*, 1999; Venkateswaran *et al.*, 2010) [16, 29].

8. Wound healing property

In diabetic patients, wound healing is impaired and studies have shown that finger millet extracts results in ameliorating this impairment by improving the nerve growth factor (NGF) production and improved antioxidant status (P. Hegde *et al.*, 2005) [11, 12].

Conclusion

Finger millet is rich source of iron, calcium and dietary fiber. Its dietary fiber and polyphenols have been recognized to offer several health benefits such as anti-diabetic, protection from diet related chronic diseases, hypocholesterolaemic, antioxidant and antimicrobial effects to its regular consumers. Moreover, it is likewise rich in carbohydrate, energy and nutrition, making finger millet an important ingredient of dietary and nutritional balanced foods. The regular use of finger millet as a nutrient and its products helps in managing different disorders of body by maintaining blood glucose homeostasis. Finger millet has require less cooking time (6 min). So it is a good ingredient of weaning food. Also the whole meal-based finger millet products may be desirable due to the protective role of seed coat matter that have health enhancing benefits.

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