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Finger millet: The mighty micro super grain

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Abstract
Finger millet (*Eleusine coracana*), originating from Ethiopia, serves as a cereal crop primarily grown in arid and semi-arid climates. The grains of finger millet contain varying percentages of carbohydrates (72-79.5%), protein (5.6-12.70%), fat (1-2%), ash (1.7-4.13%), and dietary fiber (15-22%) across different varieties. Notably, its dietary fiber content surpasses that of commonly consumed grains like rice, wheat, and maize. Finger millet boasts a higher total mineral content than other cereal grains, particularly rich in calcium (344 mg), magnesium (408 mg), and iron (5.42 mg) per 100 grams. Its fatty acid composition includes 49% oleic acid, 25% linoleic acid, and 25% palmitic acid, contributing to an overall 44.7% essential amino acids, ensuring a higher quality protein source. The grains contain about 0.3-3% phenolic compounds, which include antioxidants like tannins, phytates, arabinoxylans, and flavonoids. Various processing methods aid in reducing the anti-nutritional aspects of these compounds. Given its high fiber and calcium content, finger millet is beneficial for individuals managing conditions such as obesity, diabetes, cardiovascular disease, and osteoporosis. Additionally, finger millet allows for the creation of diverse food products like weaning foods, bakery items, roti, noodles, and macaroni.

Keywords: Finger millet, minerals, anti-nutritional factors, pre-treatments, health benefits

1. Introduction

Millets are small seeded annual species of cereal or grain crops (Shiihi *et al.*, 2011) [71]. The term millet is derived from French word "mille" that indicates thousand, it means a handful of millet contains thousand grains (Shahidi and Chandrasekhara, 2013) [69]. Millets belong to the monocotyledonous grass family *Poaceae*. Sorghum (*Sorghum vulgare*), finger millet (*Eleucine coracana*) and pearl millet (*Pennisetum glaucum*) are the major millets. Proso millet (*Panicum miliaceum*), kodo millet (*Paspalum scrobiculatum*), little millet (*Panicum miliare*), barnyard millet (*Echinochloa frumantacea*) and foxtail millet (*Setaria italica*) are the minor millets. Millets are Smart Foods (Rao *et al.*, 2021) [58]. Because of their high nutritional composition, less water and fertilizers requirement, low carbon emission during crop growth, short-duration of cultivation and being resource-efficient crops, millets are good for mankind, planet and farmers as well. Compared to other major cereal grains, millets are more nutrient-dense and can be cultivated locally with no much expenses owing to their added health benefits, which include being a source of gluten-free protein of low glycaemic index, being dietary fibre rich, and being rich in bioactive compounds (Poshadri *et al.*, 2020) [51].

Table 1: Global scenario of millets: Millets area and production region wise (2019)

Regions	Area (lakh ha)	Production (lakh ton)
Africa	489	423
Americas	53	193
Asia	162	215
Europe	8	20
Australia & New Zealand	6	12
India	138	173
World	718	863

Source: FAO Stat 2021

Finger millet is one of the major millets, consumed worldwide as a staple food especially in Asia and Africa. The nomenclature of the grain is in such a way because of its morphological structure comprising of five panicles radiating from a central point resembling human palm and fingers

(Sood *et al.*, 2017) [78]. Finger millet being a member of family *Poaceae* and sub-family *Chloridodeae* is native to Ethiopia, Africa (Pradeep & Sreerama, 2015; Sood *et al.*, 2016; Ramashia *et al.*, 2018) [52, 79, 55]. Ragi, rapoko and dagusa are other vernacular names used for finger millet in India, South Africa and Ethiopia, respectively. Finger millet is having five sub-species; *Coracana*, *Elongate*, *Plana*, *Compacta* and *Vulgaris* (Seetharam *et al.*, 1986; Tatham *et al.*, 1996) [67, 83]. The species *E. coracana* is majorly cultivated in arid and semi-arid regions of African eastern highlands and India whereas *E. vulgaris* is mainly grown in Ethiopia, Uganda and South Africa (Seetharam *et al.*, 1986) [67]. Finger millet is having different varieties such as light brown, brown, black and white (Devi *et al.*, 2014; Kumar *et al.*, 2016) [13, 32]. It can be cultivated in arid and semi-arid regions of dry climate with less rainfall and is resistance to various agro-climatic conditions like drought (Gull *et al.*, 2014) [22]. About 55-60 percent of total globally produced finger millet is cultivated in different countries of Africa (Dlamini & Siwela, 2015) [14]. India is the largest producer of finger millet worldwide (Wankhede *et al.*, 1979; Pandhere *et al.*, 2011) [92, 47] and contributes 60 percent of total production of finger millet globally (Gull *et al.*, 2014) [22]. Finger millet ranks fourth after sorghum, pearl and foxtail millet among the millets of the world in terms of production in semi-arid regions (Shiihi *et al.*, 2011; Mathur, 2012) [71, 39].

Table 2: Production of millets during last five years in India

S. No	Grains	Production in million tonnes					
		2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
1	Sorghum	4.24	4.57	4.8	3.48	4.73	5.01
2	Bajra	8.07	9.73	9.21	8.66	10.28	9.57
3	Ragi	1.82	1.39	1.99	1.24	1.74	2.35
4	Small millet	0.39	0.44	0.44	0.33	0.4	0.65
5	Nutri-cereals	14.52	16.12	16.44	13.71	17.15	17.58

Source: Ministry of Agriculture and Farmers Welfare, GOI

Finger millet contains higher amount of dietary fibre, carbohydrates, iron and calcium in comparison to other major food grains (Sood *et al.*, 2016) [79]. It is gluten free, thus beneficial for persons having coeliac disease or gluten sensitive enteropathy (Mamilarasan *et al.*, 2016) [43]. Finger millet grains are easily digestible and of low glycemic index (Manjula & Visvanathan, 2014) [57]. It is resistant to different diseases and insects but very often get damaged by fungal infestations (Usai *et al.*, 2013; Sood *et al.*, 2016) [87, 79]. This study reviews the nutritional and health benefits, different processing methods of finger mill*et al*ong with its use in different value added food items to prevent different health problems.

2. Nutritional composition of finger millet

2.1 Carbohydrates

Finger millet is a good source of carbohydrates, dietary fibre, protein and minerals like calcium, phosphorous and iron. Finger millet contains 72 to 79.5% total carbohydrates (Pore and Magar, 1979 [50]; Hulse *et al.*, 1980 [26]; Joshi and Katoch, 1990 [29]; Bhatt *et al.*, 2003) [7] in which starch is present as the main component (Pore and Magar, 1979 [50]; Wankhede *et al.*, 1979 [92]; Antony *et al.*, 1996 [4]; Nirmala *et al.*, 2000 [44]). Starch granules present in finger millet are polygonal rhombic shaped (Jideani *et al.*, 1996) [27]. Finger millet starch constitutes 80-85% amylopectin and 15-20% amylose (Wankhede *et al.* 1979 [92]; Jideani *et al.*, 1996) [27]. About 20-30% non-starch polysaccharides are present in finger millet (Bhatt *et al.*, 2003) [7]. The range of reducing and non-reducing sugar present in finger millet is found to be 1.2-1.8% (Pore and Magar, 1979) [50] and 0.03%, respectively (Nirmala *et al.*, 2000) [44]. Finger millet contains 59.5-61.2% starch, 6.2-7.2% pentosans, 1.4-1.8% cellulose and 0.04-0.6% lignins (Wankhede *et al.*, 1979) [92]. Starch digestibility of native finger millet in *in vitro* condition has been reported to be 71.67% (Mittal, 2002) [41].

2.2 Dietary fibre

Total dietary fibre content in finger millet is found to be in range of 15-22% according to different varieties of grain. Total dietary fibre (TDF), insoluble dietary fibre (IDF) and soluble dietary fibre (SDF) content of the grain has been reported to be 12%, 11% and 2%, respectively (Ramulu and Rao, 1997) [56]. Crude fibre and dietary fibre amount in some varieties of finger millet are 3.6% and 18.6%, respectively (Kamath and Belavady, 1980) [30]. Chethan and Malleshi (2007) [10] found the insoluble dietary fibre and soluble dietary fibre content in finger millet to be 15.7% and 1.4%, respectively. Total dietary fibre, insoluble dietary fibre and soluble dietary fibre of finger millet are present in concentration of 22.0%, 19.7% and 2.5%, respectively (Shobhana and Malleshi, 2007) [73].

2.3 Proteins

Finger millet contains 7% protein in general. The protein content of finger millets varies from 5.6% to 12.7% depending on the varieties of grain (Joshi and Katoch, 1990 [29]; Rao, 1994 [60]; Antony *et al.*, 1996 [4]; Gautam, 2000; Bhatt *et al.*, 2003) [7]. Singh and Srivastava (2006) [75] reported the protein content of finger millet to be in a range of 4.88-15.58% with a mean value of 9.728% after analysing 16 grain varieties. The protein content of finger millet grains has been found to be 6.7-12.3g per 100g of grains with a mean value of 9.7g per 100g after analysis of 36 genotypes of finger millet (Vadivoo *et al.*, 1998) [88]. Protein content of brown varieties is found to be higher than that of white one (Vadivoo *et al.*, 1998 [88]; Singh and Srivastava, 2006 [75]; Samantaray and Samantaray, 2007) [65]. The major fraction of protein in finger millet is found to be prolamin i.e. 24.6-36.2% (Lupien, 1990) [34].

The protein quality of finger millet is superior to the protein quality of major cereal grains like rice, wheat and maize. Finger millet contains 44.7% essential amino acids of the total amino acids (Mbithi *et al.*, 2000; Singh & Raghuvansi, 2012) [40, 76] that includes methionine, tryptophan and cysteine (Ramashia *et al.*, 2018) [55], isoleucine, leucine and phenylalanine (Sood *et al.*, 2017) [78] and lysine (Mamatha and Begum, 2013). The amino acid profile of finger millet shows better balance of lysine, tryptophan and valine (Ravindran, 1992) [63]. The prolamin fraction of finger millet contains higher proportion of glutamic acid, valine, proline, leucine, isoleucine and phenylalanine with lower amount of arginine and glycine (Lupien, 1990) [34]. Finger millet has 2.5% lysine, 13% tryptophan, 2.9% methionine, 3.1% threonine and 4% leucine and isoleucine, which provides the complementary protein value of cereals as well as pulses. Finger millet contains equal amount of sulphur containing amino acids that of milk (Antony *et al*, 1996) [4]. Mittal (2002) [41] found the *in vitro* protein digestibility of native finger millet as 62.94%.

2.3 Lipids

The crude fat content in finger millet has been found to be 1.3-1.8% (Lupien *et al.*, 1990; Bhatt *et al.*, 2003) [34, 7]. Seetharam (2001) [68] have investigated the fat content in brown and white finger millet varieties in a range of 1.2-1.4%. Total lipid content in finger millet has been found to be 5.2% which constitutes 2.2% free lipids, 2.4% bound lipids and 0.6% structural lipids. The non-polar lipids, glycolipids and phospholipids fraction of finger millet fat has been found to be 80%, 6% and 14%, respectively (Sridhar and Lakshminarayana, 1994) [80]. Finger millet is high in polyunsaturated fatty acids (Antony *et al.*, 1996) [4]. Unsaturated fatty acids and saturated fatty acids content of finger millet constitute 74.4% and 25.6%, respectively (Sridhar and Lakshminarayana, 1994) [80]. Finger millet contains 49% oleic acid, 25% linoleic acid and 25% palmitic acid as the predominant fatty acids.

2.4 Minerals

Total ash content is higher in finger millet than in commonly consumed cereal grains. Finger millet is the richest source of calcium and iron (Vijayakumari *et al.*, 2003) [90]. The ash content in finger millet has been reported to be 1.7% - 4.14% (Rao *et al.*, 1994) [60]. Most of the investigations have shown the ash content in a range of 2.1 to 2.7% (Malleshi and Desikachar, 1986; Samantaray and Samantaray, 2007; Mushtari, 1998; Bhatt *et al.*, 2003) [35, 65, 7]. Singh and Srivastava (2006) [75] found the total ash content in a range of 1.47-2.58% with 2.11% as the mean value after analysing the sixteen different varieties of finger millet. Finger millet is one of the richest source of calcium for which it is known as “poor man’s milk”. The calcium content in finger millet is about 344 mg percent (Bhatt *et al.*, 2003) [7]. Vadivoo *et al.* (1998) [88] investigated 36 genotypes of finger millet and found the calcium content in a range of 162-487 mg percent with 320.8 mg percent. The calcium content in white finger millet (329 mg percent) is found to be higher than that in brown varieties (296 mg percent) (Seetharam, 2001) [68]. Finger millet contains 3.3-14.8 mg iron per 100g grains (Babu *et al.*, 1987) [6]. Singh and Srivastava (2006) [75] found the iron content in a range of 3.61-5.42 mg /100g with 4.40 mg/100g as the mean value after analysing the sixteen varieties of finger millet. Zinc content of sixteen finger millet varieties was found to be in a range of 0.92-2.55 mg percent with a mean value of 1.34 mg percent whereas phosphorous content was reported to be 130-295 mg percent with a mean value of 180.43 mg percent (Singh and Srivastava, 2006) [75].

2.5 Vitamins

Finger millet contains both lipid soluble and water soluble vitamins such as thiamine, riboflavin, tocopherol and vitamin A and B complex are present in higher amount (Obilana and Manyasa, 2002; Chappalwar *et al.*, 2013; Devi *et al.*, 2014) [45, 13, 9]. Vitamin C content is very low or absent in dried finger millet grains (Siwela, 2009) [77]. Water soluble B vitamins are present in the germ as well as aleuronic layer of the grain whereas fat soluble vitamins are predominantly concentrated in the germ of the grain.

2.6 Polyphenolic compounds

Dark brown seed coat of finger millet is rich polyphenols in comparison to other cereal grains like rice, wheat and maize (Viswanath *et al.*, 2009) [91]. Polyphenols are mainly located in the outer layers of the seed coat i.e. pericarp, test and aleurone layer of bran portion. Ferulic acid and p-coumaric acid are two major bound phenolic compounds constituting 64-96% and 50-99%, respectively. Condensed tannins i.e. proanthocyanidins are biologically active antioxidants present in different varieties of finger millet (Dykes and Rooney, 2006). Proanthocyanidins are polyphenols of high molecular weight comprising of polymerized flavan-3-ol and flavan-3, 4-diol units. Phenolic compounds present in finger millet are mainly of three classes such as flavonoids, hydroxybenzoic acid derivatives and hydroxycinnamic acid derivatives. Other polyphenolic compounds possessing antioxidant value and other health benefits are gallic acid, vanillic acid, caffeic acid, syringic acid, quercetin, sinapic acid, para hydroxybenzoic acid and trans cinnamic acid. Brown and red varieties of finger millet contains higher (1.2-2.3%) concentration of tannins and polyphenolic compounds than the white and light coloured (0.3-0.5%) varieties (Ramachandra *et al.*, 1977) [54]. The antioxidant activity of brown or red varieties is higher (94%) than that of white varieties (4%) when assessed through DPPH method.

2.7 Anti-nutritional factors

Finger millet possesses different nutrient inhibitors such as phytates, phenols and tannins in its seed coat. The concentration of phytates and tannins varies according to the varieties of finger millet. Brown finger millet contains higher concentration of tannins and phytates than that of white finger millet. Brown finger millet contains 360 mg tannins per 100g (Rao and Prabhavati, 1982) [59]. Tannins bind to proteins and enzymes and hinder the utilization of proteins in digestive tract (Asquith and Butler, 1986) [5]. Finger millets have been find to contain high tannin content in a range of 0.04-3.74% of catechin equivalents (Rao, 1994; Antony and Chandra, 1999) [60, 3]. *In vitro* protein digestibility is inversely related to the concentration of tannin in finger millet (Ramachandra *et al.*, 1977) [54]. The tannin content of brown finger millet decreases by 54% during malting (Rao, 1994) [3]. Rao and Prabhavati (1982) [59] found soaking, roasting, germination, boiling and fermentation to be effective in reducing tannin content. Phytic acid is present in finger millet seed coat which binds with proteins and multivalent cations to form complexes (Haug and Lantzsch, 1983) [23]. Deosthale (2002) [12] found phytic phosphorous content 41% of total phosphorous. The total phytate content of finger millet has been found to be 149-150 mg/100 g (Rao, 1994) [60] and it can be reduced by 58-65% through malting in brown and white varieties of finger millet (Rao, 1994) [60]. Germination and fermentation decrease the phytic acid content by 49.2% and 66.5%, respectively. The partial retention of phytates has been found to be beneficial because of their antioxidant, antidiabetic and anticancer effects (Graf *et al.*, 1987; Thompson, 1993) [21, 85].

3. Effect of processing methods

Processing of finger millet grains through different traditional as well as modern methods makes it more acceptable for consumption by people. Traditional methods of processing are mainly practised in rural area such as soaking, germination, fermentation, malting, milling, roasting, popping and cooking

(Hemalata *et al.*, 2007; Saleh *et al.*, 2013; Dutta *et al.*, 2015) [24, 64, 15]. Modern processing methods are used in food industries to manufacture various processed finger millet products for commercial purpose (Saleh *et al.*, 2013; Subastri *et al.*, 2015). [64, 81] Traditional processing technologies like soaking, germination, popping, fermentation and cooking helps in decreasing the tannin and phenols level and increasing the micronutrients bioavailability (Devi *et al.*, 2014; Sarkar *et al.*, 2015) [13, 66].

3.1 Soaking

In soaking distilled water is added to finger millet grains to steep the grains completely and left for overnight period at room temperature. The water used for soaking is then discarded and finger millet grains are cleaned properly and extraneous materials are removed and the grains are dried. Soaking helps in removal of seed coat of the grains, reduces the phytic acid content as a result bioavailability of minerals like zinc increases (Saleh *et al.*, 2013) [64]. Shigihalli *et al.* (2018) [70] reported reduction of phytic acid by 15-18% after soaking three different varieties of finger millet for 48 hours. Phytate and trypsin inhibitor activity in finger millet grains decreased by 13.22% and 13.51%, respectively after soaking (Patel *et al.*, 2018) [48]. Rathore *et al.* (2019) [62] demonstrated reduction of tannin and phytic acid content of finger millet after soaking in distilled water or a sodium hydroxide solution for 8 hours.

3.2 Germination

Germination is a traditional process of soaking the whole grains for 2-24 hours and then spread on a damp cloth for 24-48 hours or incubated at 30^0C for 48 hours (Shimray *et al.*, 2012) [72]. Germination decreases phytic acid content of grains by 49.2%. Germination helps in improving the bioavailability of nutrients such as protein, iron, zinc, increases the vitamin C and B complex contents as well as essential amino acids, thus enhances the functional properties of grains (Mbithi-Mwikya *et al.*, 2000; Chove and Mamiro, 2010; Pushparaj and Urooj, 2011) [40, 11, 53]. The germination process facilitates hydrolysis of complex compounds like phytate, lipids and polypeptides resulting in synthesis of acid phosphate, fatty acids and amino acids (Gernah *et al.*, 2011) [20], thus improves the digestibility of finger millet products (Adedeji *et al.*, 2014) [2]. Protein, fibre and ash content of finger millet increases after germination (Owheru *et al.*, 2019) [46]. The crude fibre content of finger millet has been increased due to break down of complex polysaccharides (Laxmi *et al.*, 2015; Owheru *et al.*, 2019) [33, 46]. Sprouting of finger millet grains improves the iron bioavailability (Suma and Urooj, 2014) [82]. During germination, oxalic acid content decreases significantly through leaching process, thus improves calcium bioavailabilty (Suma and Urooj, 2014) [82]. Kumar *et al.* (2016) [32] investigated decrease in activity of trypsin inhibitors during germination.

3.3 Malting

Malting is a combined process of steeping, germination, drying, roasting, grinding and sieving to improve the total nutritive value and to reduce anti-nutritional components. Malting increases the protein and starch digestibility as finger millet develops higher amylase activity than sorghum and other millets (Malleshi and Desikachar, 1986) [35]. Malting decreases the anti-nutrient activity of phytic acid and tannins content in brown finger millet by 58% and 54%, respectively (Rao, 1994) [60]. Malting process is very much useful in preparation of weaning food products for infants (Verma and Patel, 2013). Malting of finger millet for 72-96 hours affected the total mineral content and its bioavailability positively (Platel *et al.*, 2010) [49].

3.4 Milling

Milling is the most common traditional processing method of conversion of whole grains into flour by using mortar and pestle. The milling process of grains consists of sorting, clening, hulling, branning and kilning for further processing (Rasane *et al.*, 2015) [61]. Milling helps in removal of coarse bran from the grains. Milling removes phytochemicals such as phytates and tannin, thus improves the iron bioavailability in finger millet grains (Singh and Raghuvanshi, 2012) [76].

3.5 Fermentation

Fermentation is traditional process of preparing beverages through the help of microorganisms. Finger millet is fermented most commonly to produce different fermented food and beverages in Africa (Ranasalva and Visvanathan, 2014) [57]. Fermentation is considered as an economic process for preservation of food products (Blandino *et al.*, 2003) [8]. Fermentation inhibits the growth of pathogens causing food spoilage, improves amino acid balance as well as the nutritive value and sensory quality of grains (Ranasalva and Visvanathan, 2014) [57]. Fermentation helps in reduction of anti-nutrients like trypsin inhibitor, phytates and tannins in cereal grains (Rasane *et al.*, 2015) [61]. Finger millet has been fermented using cultures of different strains (Antony and Chandra, 1999; Mbithi-Mwikya *et al.*, 2000) [3, 40].

3.6 Popping

Popping is used to produce ready to eat crunchy and porous products (Singh and Raghuvanshi, 2012) [76]. Popping process is carried out by soaking unhusked grains in water followed by mixing and heating with sand at 250^0C for 15-60 seconds (Sarkar *et al.*, 2015) [66]. Pooped products of finger millet helps in improving the aroma, taste and overall quality of grains (Thapliyal and Singh, 2015) [84]. Popping decreases the anti-nutritional factors and increases the dietary fibre content of products (Sarkar *et al.*, 2015) [66].

3.7 Roasting

Roasting is a traditional process most widely used in households of rural areas. It enhances the shelf life of grains by decreasing the chance of insect manifestations. The anti-nutritional effect of glycosides, trypsin inhibitors, saponins, hemagglutinins, goiterogenic compounds are decreased by roasting. Roasting improves the flavour of finger millet grains and increases the bioavailability of iron (Singh and Raghuvanshi, 2012; Thapliyal and Singh, 2015) [76, 84]. Roasting extend the shelf life of foods and increase the storage life of foods (Hufman and Martin, 1994) [25].

3.8 Cooking

Cooking involves boiling which softens the grain texture, helps in reducing the microbial load and increases the sensory quality of cooked grain (Khamgaonkar *et al.*, 2013) [31]. Porridge from finger millet flour can be prepared by mixing and cooking with boiling water (Emmambux and Taylor, 2013) [17].

4. Health benefits of finger millet

Finger millet is rich in carbohydrates, dietary fibre, proteins, essential amino acids, essential fatty acids, calcium, iron, phosphorous, zinc and other necessary nutients. Finger millet possess higher content of dietary fibre, thus helps in reducing hyperglycaemia. High fibre diets comprising of complex carbohydrates get digested and absorbed slowly and reduce the postprandial blood glucose level (Geetha and Parvathy, 1990) [19]. Finger millet is gluten free and of low glycaemic index, thus proved to be beneficial for patients suffering from coeliac disease and diabetes mellitus (Jideani and Jideani, 2011) [28]. Finger millet grains are rich in carbohydrates, calcium, dietary fibre, iron (Sood *et al.*, 2016) [79], magnesium and phosphorous. These nutrients reduces chances of various chronic diseases like hypertension, cardiovascular diseases, obesity, strokes, cancer and type II diabetes (Ramashia *et al.*, 2018) [55]. Polyphenolic compounds such as ferulic acid, coumaric acid, hydroxybenzoic acid, gallic acid, tannins present in finger millet grains act as antioxidants and anticarcinogenic agents that helps in scavenging action of free radicals and reactive oxygen species, thus prevents ageing and other degenerative diseases like cancers. Finger millet is one of the richest source of calcium and phosphorus. Hence consumption of finger millet is proved to be beneficial for growing children, pregnant and lactating women and the old people (Chappalwar *et al.*, 2013) [9] and for people suffering from obesity, malnutrition and diabetes (Manjula *et al.*, 2015) [38]. Finger millet contains iron in a range of 3-20% and magnesium that is helpful in reducing high blood pressure, asthma, migraines and heart attack (Saleh *et al.*, 2013; Verma and Patel, 2013) [64]. Finger millet is more nutritious as compared to other millet species (Devi *et al.*, 2014; Dlamini and Siwela, 2015) [13, 14]. The dietary fibre, non-starchy polysaccharides, polyphenols, cinnamic acid derivatives and complex mixture of benzoic acid present in finger millet being antidiabetic, antioxidant, antimicrobial and hypocholesterolemic provides protection against diet related chronic diseases (Devi *et al.*, 2014) [13].

5. Products developed from finger millet

Finger millet flour is used to prepare different traditional dishes such as porridge, mudda, pan cake, dosa, thekua, chapatti etc., different processed food products like biscuit, cookies, cake, muffins, buns, bread etc. and extruded products like noodles, vermicelli and pasta. Finger millet, being rich in carbohydrates, dietary fibre, protein, iron, calcium, magnesium, phosphorous and zinc (Sood *et al.*, 2016) [79] can be used to prepare different products to combat malnutrition and different micronutrient deficiencies e.g. anaemia. Being rich in calcium and phosphorous, finger millet based food products can be helpful for people suffering from osteoporosis, osteomalacia and other bone related disorders. As finger millet is gluten free (Muthamilarasan *et al.*, 2016) [43], easy to digest with low glycaemic index (Manjula & Visvanathan, 2014) [57] people having coeliac disease and diabetes mellitus can consume it as a substitute of wheat based products. Malted finger millet flour is very often used to prepare nutrient dense weaning food for babies. Finger millet having highest amount of calcium can be consumed by both young and elderly people to strengthen the bone and joints (Towo *et al.*, 2006) [86].

6. Conclusion

Finger millet being a grain crop that is good for mankind, good for planet and good for farmers can contribute to global food security especially for the people of low income group. Because of various health benefits posed by different phytochemicals, finger millet can be proved to be a healthy and functional food for people of all age groups, both for normal persons as well as for diseased persons. Commercialization of different traditional and modern finger millet based food products can lay a foundation to eradicate malnutrition and micronutrient deficiency disorders. Hence, there is a necessity for further research on finger millet and its utilization in preparation of different commercial low cost food products to ensure the optimal nutritional status of members of all communities.

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