Effect of roasting on functional and phytochemical constituents of finger millet (*Eleusine coracana* L.)

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Abstract

Finger millet (*Eleusine coracana* L.) is a crop with potentially tremendous but under-explored source of nutraceutical properties as compared to other regularly consumed cereals. Roasting and grinding processes render the grain digestible. On roasting of finger millet it has been observed that it’s functional and phytochemical composition such as moisture, fat, protein, phenols and antioxidant activity tends to decrease slightly whereas total carbohydrate content, ash, fibre increases along with the increase in the bio-availability of minerals like calcium and iron. Thus, this study focused on improving the nutritional quality and increasing the bioavailability of nutrients by roasting the millets for nourishing the health and to promote finger millet utilization for future prospective.

Keywords: Finger millet, roasting, bioavailability, nutraceutical, chemical composition

1. Introduction

Millet is one of the oldest food known to humans and possibly the first cereal grain used for domestic purposes. Good nutrition is a fundamental human right. In order to have a healthy population that can promote development, the relation between food, nutrition and health should be reinforced. Finger millet is a fast growing cereal crop that reaches maturity within 3-6 months and sometimes in only 45 days. Finger millet (*Eleusine coracana* L.) is important millet grown extensively in various regions of India and Africa, constitutes as a staple food for a large segment of the population in these countries. Finger millet, *E. coracana* L. is also known as ragi and *mandua* (India); *kaddo* (Nepal); *fingerhirse* (Germany); *petit mil*, *eleusine cultive*, *coracan*, *koracan* (France); *bulo* (Uganda); *kambale*, *lapoko*, *maweke*, *amale*, *bule* (Zambia); *poho*, *rapoko*, *ziyio*, *njera*, *mazhovole* (Zimbabwe); finger millet, African millet, *koracan* (England); dagussa, *tokuso*, *barankiya* (Ethiopia); *wimb*, *mugimbi* (Kenya). It ranks sixth in production after wheat, rice, maize, sorghum and bajra in India. The acidic methanol extracts from the seed coat showed high antibacterial and antifungal activity. It is a naked caryopsis with brick red-coloured seed coat and is generally used in the form of the whole meal for preparation of traditional foods, such as roti (unleavened breads or pancake), mudde (dumpling) and ambi (thin porridge). Since the millets are normally prepared from the whole meal, the dietary fiber, minerals, phenolics and vitamins concentrated in the outer layer of the grain or the seed coat form the part of the food and offer their nutritional and health benefits (Antony *et al.*, 1996) [13].

Finger millet contains about 5-8% protein, 1-2% ether extractives, 65-75% carbohydrates, 15-20% dietary fiber and 2.5-3.5% minerals (Chethan and Mallesh, 2007) [12]. It has the highest calcium content among all cereals (344 mg/100 g). However, the *millet also* contains phytyates (0.48%), polyphenols, tannins (0.61 %), trypsin inhibitory factors, and dietary fiber, which were once considered as anti nutrients” due to their metal chelating and enzyme inhibition activities but nowadays they are termed as nutraceuticals. The seed coat of the millet is an edible component of the kernel and is a rich source of phytochemicals, such as dietary fiber and polyphenols (0.2-3.0%) (Ramachandra *et al.*, 1977) [28].

Processing affects antinutritional factors such as fibre, phytate and enzyme inhibitors, which in turn can enhance or reduce the bioavailability of micro and macro- nutrients (Nestares *et al.*, 1997) [24]. Maximum utilization of the nutrient potential of the millet is limited by the presence of phytyates, phenols, tannins and enzyme inhibitors but their effect can be reduced by using processing techniques like popping, roasting, malting and fermentation. Roasting and grinding processes render the grain digestible, without the loss of nutritious components.
to the decrease in the moisture content by the heat treatment given to the samples.

3.3 Total Carbohydrates

The total carbohydrate content in raw (without roasted) and roasted samples was observed as 75.94 and 79.32 per cent respectively (Fig.1). The plant is a good source of carbohydrate when compared with the Recommended Dietary Allowance (RDA) of 130g (Pamela et al., 2005) [27]. Total carbohydrate content of finger millet has been reported to be in the range of 72 to 79.5% (Joshi and Katoch, 1990; Bhatt et al., 2003) [19, 5, 6]. The carbohydrates include starch as the main constituent being 59.4 to 70.2% (Antony et al., 1996; Nirmala et al., 2000; Mittal, 2002) [3, 25, 23]. Finger millet starch granules exhibit polygonal rhombic shape. About 80 to 85% of the finger millet starch is amylopectin and remaining 15 to 20% is amylose. Bhatt et al. (2003) [5, 6] reported that non-starch polysaccharide account for 20 to 30% of the total carbohydrates in finger millets.

![Fig 1: Moisture content, total solids (TS) and total carbohydrate content of without roasted (WR) and roasted (R) finger millet.](image)

3.4 Ash

Ash in food contributes the residue remaining after all the moisture has been removed as well as organic material have been incinerated at a temperature of about 550°C. Ash content is generally taken to be a measure of the mineral content of the original food (Onwuka, 2005) [28]. The data presented in figure 2 shows that there is an increase in the ash content of the roasted sample which was from 3.10 to 4.00 per cent. This increase in the mineral content may be attributed to reduction in phytic acid that might increase the bioavailability of minerals.

3.5 Crude Fibre

An increase in the crude fibre content from 3.90 to 4.20 per cent was observed in the finger millet sample after roasting when compared to the unroasted sample (Fig.2). Same level of fibre (3.7%) has been reported earlier (Joshi and Katoch, 1990) [19]. Kamath and Belavady (1980) [20] found 18.6% dietary fibre and 3.6% crude fibre in finger millet. Crude fibre in food is an indication of the level of non-digestible carbohydrate and lignin. It aids absorption of glucose, poison, fat and also increase fecal sample.

3.6 Crude Fat

The crude fat content in raw (without roasted) and processed (roasted) finger millet was recorded as 1.54 per cent and 1.33 per cent respectively (Fig.2). Decline in fat content upon heat treatment is due to starch lipid complex formation that are resistant to lipid extraction. Low fat content reported in the processed samples is beneficial due to their increased shelf life by decreasing the chances of rancidity (Vadivo et al., 1998) [38]. The crude fat content in finger millet has been

(Krantz et al., 1983) [21], The puffing and roasting are almost similar processes, but the volume expansion in puffing is higher (Srivastava et al., 1994) [36]. Roasting of cereals, pulses and oilseeds is a simpler and more commonly used household and village level technology which is reported to remove most antinutritional or toxic effects such as trypsin inhibitor, hemagglutinin, iotrogeneric agents, cyanogenic glycosides, alkaloids and saponins and increase storage life (Huffman and Martin, 1994) [17].

Weaving foods prepared by roasting of barnyard and finger millet increased iron bioavailability (Gahlawat and Sehgal, 1994) [14]. Bookwalter et al. (1987) [7] reported inactivation of lipase in millet flours when roasted at 97°C. Inactivation of lipase led to minimization of fat hydrolysis. Geervani et al. (1996) [15] reported significantly higher net protein utilization (NPU) from roasted millets and legumes mixes. Hence an attempt was made to study the effect of roasting on chemical composition and nutraceutical properties of finger millet.

2. Materials and Methods

The whole grain finger millet was procured from local market. The millet was first cleaned, and then roasted. The roasted finger millet was then ground to fine powder in a home blender for further analysis. The moisture percentage was determined by over drying method as per the procedure given in AOAC (2000) [1]. Association of Analytical Chemist. The total solids content was estimated by drying the weighed samples to a constant weight in hot air oven at 70±1°C. The moisture content has been recorded to decrease from 10.67 to 8.00 per cent in the roasted sample which was from 3.10 to 4.00 per cent. This figure 2 shows that there is an increase in the ash content of the roasted sample which was from 3.10 to 4.00 per cent. This increase in the mineral content may be attributed to reduction in phytic acid that might increase the bioavailability of minerals.
reported in range of 1.3 to 1.8% (Bhatt et al., 2003) [5, 6] but Antony et al. (1996) [3] have reported a higher percentage (2.1%) of crude fat. Sridhar and Lakshminarayana (1994) [35] reported total lipid content in finger millet to be 5.2% (free lipids 2.2%; bound lipids 2.4%; structural lipids 0.6%). The non polar lipid fraction was 80%, glycolipids 6% and phospholipids 14% in finger millet fat. Finger millet though low in fat content, is high in polyunsaturated fatty acids (Antony et al., 1996) [3]. The major fatty acid in finger millet was oleic acid followed by palmitic acid and linoleic acid. It had little amount linolenic acid also.

3.7 Protein
A decrease in protein content was observed in raw (without roasted) and roasted finger millet samples i.e. from 8.75 to 7.35 per cent due to protein degradation as shown in Figure 2. Singh and Srivastava (2006) [34] analyzed 16 finger millet varieties and found out that it ranged from 4.88 to 15.58% with a mean value of 9.728%. Prolamin is the major fraction on finger millet protein, being 24.6 to 36.2% of total protein. Antony and Chandra (1998) [2] reported 99.1 mg soluble proteins per 100 g in finger millet. Roasting increases the in vitro nitrogen digestion. Protein digestibility is influenced by heating, which renders the protein more susceptible to hydrolysis because of structural changes (Lewis et al., 1992) [22].

3.8 Iron
In figure 2, the data shows an increase in the iron content of roasted sample from 3.45 to 3.91 mg/100g as compared to the unroasted sample. Removal of complex polysaccharides of fibrous bran, tannins and phytates during milling improves the bioavailability of iron. The iron content of finger millet ranged from 3.3 to 14.8 mg/100g (Babu et al., 1987). Singh and Srivastava (2006) [34] reported the iron content of 16 finger millet varieties ranged from 3.61 mg/100g to 5.42 mg/100g with a mean value of 4.40 mg/100g.

3.9 Calcium
Finger millet is rich in calcium. The calcium content in raw finger millet was recorded as 337.31 mg/100g and the value for roasted finger millet was observed as 341.24 mg/100g as show in Figure 3. Calcium content of 36 genotypes of finger millet ranged from 162 to 487 mg/100g with mean value of 320.8 mg/100g (Vadivoo et al., 1998) [30]. The average calcium content (329 mg/100g) in white varieties was considerably higher than the brown (296 mg/100g) varieties (Seetharam, 2001). Bhatt et al. (2003) [5, 6] reported the calcium content of finger millet as 344 mg/100g.

3.10 Total Phenols
The total phenolic content in unroasted and roasted samples was observed as 314.24 and 223.31 mg/100g, respectively as shown in Figure 3. The reduced TPC in finger millet grains could be due to the degradation of phenolics upon heat treatment or leaching into the endosperm to form complexes with proteins and other macromolecules, thus making phenolics less extractable. Processing of finger millet like thermal or hydrothermal treatments, germination, decortication, or fermentation has been found to generally decrease the polyphenol levels resulting in a reduced radical quenching ability than that of the unprocessed grain (Towo et al., 2003; Shobana and Malleshi, 2007) [37, 12]. Towo et al. (2003) [37] reported that boiling finger millet and red sorghum for 15 min reduced their total extractable phenolics by 40 per cent and 80 per cent, respectively. Dewanto et al. (2002) [13] showed a significant increase of total free phenolics and antioxidant activity in sweetcorn following thermal treatment with increased heating times and temperatures.

3.11 Antioxidant activity (DPPH free radical scavenging activity)
Finger millet grains, particularly the seed coat, contain high amount of various phenolic compounds (mostly derivatives of benzoic acid) which have been reported to exhibit antioxidant activity (Hegde and Chandra, 2003; Chandrasekara and Shahidi, 2010) [16, 11]. The antioxidant activity in unroasted sample was recorded as 89.89 per cent which was seen to decrease to 86.78 per cent in roasted sample (Fig.3). Some researchers (Vogrincic et al., 2010; Zielinska et al., 2007) [39, 41] showed that thermal processing decreased the DPPH radical scavenging activity of buckwheat which could be due to the binding of phenolics to other molecules such as proteins or some of phenolics may not be readily extractable after the thermal processing.

4. Conclusion
Finger millet is an important staple food in parts of eastern and central Africa and India. It is non acid forming food and easy to digest. Roasting and grinding processes render the grain digestible. The chemical constituents such as moisture, fat and protein tends to decrease slightly whereas total carbohydrate content, ash, fibre increases along with the increase in the bio-availability of minerals like calcium and iron on roasting. Finger millet is source of antioxidants such as phenolic acids and glyced flavonoids. A decrease in phytochemical constituents like phenols and antioxidant activity was observed in roasted samples, which is probably

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Fig 2: Protein, crude fat, ash, crude fibre and iron content of without roasted (WR) and roasted (R) finger millet.

Fig 3: Calcium, total phenolic content and antioxidant activity of without roasted (WR) and roasted (R) finger millet.
due to the heat induced changes in the phenolic compounds. The present results reveal that finger millet is a rich source of primary metabolites and has the potentiality to be utilized as a non-conventional food to supplement the nutritional requirements of the undernourished population. It is also characterized to be a potential prebiotic and can enhance the viability of probiotics with potential health benefits.

5. References