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Finger Millet: Potential Millet for Food Security and power House of Nutrients

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ABSTRACT

The growing public awareness of nutrition and health care research substantiates the potential of photo chemicals such as polyphenols and dietary fibers on their health beneficial properties. Hence there is no need to identify newer sources of neutraceuticals and other natural and nutritional material with the desirable functional characteristics. Fingertail millet (Eleusine coracana), is known for several health benefits and some of the health benefits are attributed to its polyphenol and dietary fiber contents. It is a major staple food crop in India for people of low income groups. Nutritionally, it is importance is well recognized because for its high content of calcium (0.38%), dietary fiber (18%) and phenolic compound (0.03%-3%). They are also recognized for their health beneficial effects, anti diabetic, anti tumerogenic, atherosclerogenic effects, antioxidants and anti microbial properties. The millets are source of antioxidants, such as dietary fibres (soluble and insoluble), phenolic acids and glycated flavonoids. Millet foods are characterized to be potential prebiotic and can enhance the viability or functionality of probiotics with significant health benefits.

Hence the review deals with the nutrient composition, nature of polyphenols and dietary fibers of finger millet, consumption, processing, and their role with respect to the health benefits associated with millets.

Keywords: Health and Nutrition

INTRODUCTION

Millets are one of the cereals besides the major wheat, rice, and maize. Millets are major food sources for millions of people, especially those wholive in hot and humid areas of the world. They are grown mostly in marginal areas under agricultural conditions in which major cereals fail to give substantial yields (Adekunle, 2012).Millets are important foods in many under developed countries because of their ability to grow under adverse weather conditions like limited rainfall. In contrast, millet is the major source of energy and protein for millions of people in dry country. It has been reported that millet has many nutritious and medical functions (Obilana and Manyasa, 2002; Yang et al., 2012).

The term “Millet” (A Nutritional Crop) is applied to various grass crops whose seeds are harvested for human food or animal feed. Millets include five species, Panicum, Setaria, Echinochloa, Pennisetum, and Paspalum, all of the tribe Paniceae; one genus, Eleusine, in the tribe Chlorideae; and one genus, Eragrostis, in the tribe Festuceae (Beaglehole, 2003).Millets are a major food source in arid and semi-arid parts of the world. Millets are excellent sources of carbohydrates, protein, fatty acids, minerals, vitamins, dietary fiber and polyphenols. The four major types are Pearl millet (Pennisetum glaucum), which comprises 40% of the world production, Foxtail millet (Setariaitalica) (Yang et al., 2012), Proso millet or whitemillet (Panicum miliaceum), and Finger Millet (Eleusine coracana).foxtail millet is an economically important crop grown and consumed all over the world, especially in India, China, and other parts of Asia, North Africa, and the Americas. It is very nutritious, consumed as a whole grain, easily digested, naturally gluten free and is essentially organic.

NUTRITIONAL COMPOSITION OF RAGI

Nutritionally, finger tail millet is good source of nutrients especially of calcium, other minerals and fibre. Toatal carbohydrate content of finger millet has been reported to be in the range of 72 to 79.5% (Pore and Magar, 1979; Hulse et al., 1980; Joshi and Katoch, 1990; Bhatt et al., 2003).

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Finger millet (Eleusine coracana), also known as ragi is a good source of carbohydrate, protein, dietary fibre and minerals, and an important staple food for people under lowsocio- economic group (Sripriya, et al., 1997) and those suffering from metabolic disorders like diabetes and obesity (Mathanghi & Sudha 2012). It is important because of its excellent storage properties and nutritive value (Shashi et al., 2007). Its dietary fibre and mineral content is markedly higher than wheat, rice, and fairly well balanced protein (Ravindran, 1991).Millets have hypoglycemic effect, which is attributed to high fibre content. The complex carbohydrates along with the fiber are slowly digested and absorbed thus bring reduction in postprandial glucose (Geetha and Parvathy, 1990).

Table1. *Proximate Composition of Finger Millet*

Component(g/100gm,dry basis)	Finger Millet (Native Grain)
Protein	7.7
Ash	2.7
Fat	1.5
Toatal carbohydrate	72.6
Crude Fibre	3.6

Reference: Nutrient Data Base by USDA

The second major component of millet is protein. Prolamin is the major fraction on finger millet protein, being 24.6 to 36.2% of total protein (Lupien, 1990). Antony and Chandra (1998) reported 99.1 mg soluble proteins per 100 g in finger millet.The quality of protein is mainly a function of its essential amino acids. Finger millet contains 44.7% essential amino acids (Mbithi et al., 2000) of the total amino acids, which is higher than the 33.9% essential amino acids in FAO reference protein (FAO, 1991). Also, finger millet amino acid profile gives a good ratio of essential to total amino acids. When compared to FAO amino acid scoring pattern for children 2 to 5 years old (FAO, 1991), lysine was limiting while all other amino acids scored higher than that of 1. Tryptophan is usually the second most deficient amino acid in cereals. However, is not deficient in finger millet. Threonine too was not deficient, in contrast to rice, wheat and sorghum (FAO, 1968). Among millets, finger millet is relatively better balanced in essential amino acids because it contains more lysine, thereonine and valine (Ravindran, 1992). Lysine content and the methionine content of the protein are inversely correlated with the protein content of the finger millet grain. The fractions of albumin and globulin contain a good compliment of essential amino acids and the prolamin fraction contains higher proportion of glutamic acid, proline, valine, isoleucine, leucine and phenylalanine but low, arginine and glycine (Lupien, 1990). The isoleucine content of finger millet is high. Leucine and isoleucine ratio is almost equal to that of rice and wheat (Indira and Naik, 1971)

Table2. *Amino acid profiles of Finger Millet*

Amino Acid (g/100gm)	**Finger Millet (native grain(d)**
Essential Amino Acid	
Isoleucine	4.3
Leucine	10.8
Lysine	2.2
Methionine	2.9
Phenylanaline	6.0
Threonine	4.3
Valine	6.3
Histadine	2.3
Tryptophan	NA
Non Essential Amino Acid	
Alanine	6.
Arginine	3.4
Aspartic Acid	5.7
Cystine	NA
Glutamic Acid	23.2
Glysine	3.3
Serine	5.3
Tyrosine	3.6
Proline	9.9
*PER	2.0
Protein Efficiancy Ratio	

Ref: Devi et al (2011)

Antony et al. (1996) reported that finger millet had sulphur containing amino acids equal to that of milk. Rao (1994) reported1.40% of PER, 76% of protein digestibility and 35 NPU for a diet containing 100% finger millet. In vitro protein digestibility ranged from 55.4 to 88.1% in 32 varieties of finger millet (Ramachandra et al., 1977). Antony and Chandra (1998, 1999) reported in vitro protein digestibility in the range of 50 to 65%. The authors observed a negative correlation of in vitro protein digestibility with phytates, phenols, tannins and antitryptic activity. Mittal (2002) reported IVPD of native finger millet flour as 62.94%.

The crude fat content in finger millet has been reported in range of 1.3 to 1.8% (Bhatt et al., 2003; Singh et al., 2003; Malleshi and Desikachar, 1986; Lupien, 1990) but crude fat (2.1%) has been reported byAntony et al (1996). The fat content in brown and white varieties of finger millet ranged from 1.2 to 1.4% (Seetharam, 2001). Sridhar and Lakshminarayana (1994) 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). The major fatty acid in finger millet was oleic acid followed by palmitic acid and linoleic acid. It had little amount linolenic acid also. The fatty acid profile showed that saturated fatty acids account for 25.6% while unsaturated fatty acids accounts for 74.4% of total fatty acids (Sridhar and Lakshminarayana, 1994).

Calcium content of 36 genotypes of finger millet ranged from 162 to 487 mg% with mean value of 320.8 mg% (Vadivoo et al., 1998). The average calcium content (329 mg%) in white varieties was considerably higher than the brown (296 mg%) varieties (Seetharam, 2001). Bhatt et al. (2003) reported the calcium content of finger millet as 344 mg%. The iron content of finger millet ranged from 3.3 to 14.8 mg% (Babu et al., 1987). Singh and Srivastava (2006) reported the iron content of 16 finger millet varieties ranged from 3.61 mg/100g to 5.42 mg% with a mean value of 4.40 mg/100g. According to Vijayakumari et al. (2003) Ragi is very rich source of calcium and iron. The deficiency of calcium may lead to bone and teeth disorder, iron deficiency leading to anemia can be overcome by introducing finger millet in our daily diet. Singh and Srivastava (2006) observed that the zinc content of the sixteen varieties of finger millet ranged from 0.92 to 2.55 mg% with a mean value of 1.34 mg%. The phosphorous content ranged from 130 to 295 mg% with a mean value of 180.43 mg% (Singh and Srivastava, 2006).

Millets in general are rich sources of vitamin B but available data are very meager on vitamin content of millets. Gopalan et al. (1999) have reported 45μg carotene per 100 g of finger millet while Bhaskaracharya (2001) reported that finger millet is very poor source of β-carotene (0 to 1 μg/100g). Vitamin A content of finger millet has been reported to be 6 retinol equivalents (nap.edu, 1996).

POLYPHENOLS AND DIETARY FIBER

Finger millet grain has a dark brown seed coat, rich in polyphenols compared to many other cereals such as barley, rice, maize and wheat. These Phenolics are not equally distributed in the grain, but are mainly concentrated in the outer layers, namely, aleuronelayer, testa, and pericarp, which form the main components of the bran fraction. The Phenolic compounds in grains exist as free, soluble conjugates and insoluble bound forms. Major boundphenolics present in finger millets are ferulic acid and p-coumaric acid, and the bound phenolicfraction account for 64–96 and 50–99% of total ferulic acid and p-coumaric acid contents of milletgrains, respectively. Varieties of Finger millets are also reported to contain proanthocyanidins, alsoknown as condensed tannin (Dykes and Rooney2006). These are high-molecular weight polyphenols that consist of polymerized flavan-3-ol and/or flavan-3, 4-diol units. Proanthocyanidins are biologically active; these may lower the nutritional value and biological availability of proteins and minerals when present insufficient quantities (Chavan2001). So far the millet varieties studied, local finger millet had the highest content(311.28±3.0) micro mol of catechin equivalent/ g of defatted meal) followed by finger (Ravi), foxtail, little, pearl, and proso millets. These values for millets were higher than those reported for barley (Chandra sekara & Shahidi. 2010).

Finger millet grain genotypes have varied total tannin and Phenolic contents. Grains with light colored types contain much lower total phenolics and tannin compared to brick red pigmented types. Red colored varieties having pigmented testa are known to contain much tannin content and these are located in the said tissue of the grain (Siwela et al2007). They observed that brown varieties contained

(1.2– 2.3%) higher proportions of polyphenols than white (0.3– 0.5%) varieties (Ramachandra, 1997). Considerable differences (0.19 3.37%) in the total polyphenol contents (as catechin equivalents) among 85 Indian finger millet varieties have been reported (Shankara1991)Tannin content was estimated in hilly region varieties was found to beless compared to base region varieties. These noticeable differences between polyphenols content in white and brown varieties could be due to the presence of the red pigments, such as anthocyanins, which are generally polymerized phenolics present in brown cultivars. Phenolics found in finger millet fall into three classes namely hydroxyl benzoic acid derivatives, Hydroxycinnamic acid derivatives and Flavonoids having basic skeleton of C6–C1, C6–C3 and C6-C3–C6. The compounds indentified in this minor millet are as Gallic acid, protocatechuic acid, p-hydroxybenzoic acid, vanillic acid, syringic acid, ferulic acid, trans cinnamic acid- coumaric acid, caffeic acid, sinapic acid, quercetin and proanthocyanidins (condensed tannins). Phenolics present infinger millet grain particularly tannins in the outer layer of grains acts as a physical barrier to fungalinvasion and thus imparts resistance of grain to fungal attack.

Finger millet seed coat contains high poly phenolic content as compared to its whole flour extracts, and these seed coat based polyphenols show high antifungal and antibacterial activity as compared to the flour extracts. The good storagest ability of finger millet and its processed foods is attributed due to this phenolic contentgher than those reported for barley(Chandrasekara & . Shahidi2010).The free radicals formed due to the oxidation of microbial membranes and cell components forms irreversible complexation with nucleophillic amino acids leading to inactivation of enzymes are major biochemical benefits of polyphenols towards the antifungal activity. Besides, their functionality loss and also the interaction of polyphenolic compounds, especially tannins with biopolymers and with complex metal ions making them unavailable to micro-organisms are some of the mechanisms involved in the inhibitory effect of phenolic compounds on microorganisms. Flavonoids and tannins present in millet seed coat are multifunctional and they act as reducing agents (free radical terminators), metal chelators, and singlet oxygen quenchers. Finger millet being a potent source of antioxidants and this has high radical-scavenging activity higher than that of wheat, rice, and other millets. The brown or red variety of finger millet had higher activity (94%) using the DPPH method than the white variety (4%), which had lower activity. Carbohydrates present in finger millet are slowly digested and assimilated than those present in other cereals. Regular consumption of finger millet having high polyphenols and dietary fiber contents are known to reduce the risk of diabetes mellitus and gastrointestinal tract disorders, and this property is due to this high polyphenol and dietary fiber content. Finger millet is having high proportion of dietary fiber than many other cereals. Health benefits associated with finger millet are delayed nutrient absorption, increased faecal bulk, lowering of blood lipids, prevention of colon cancer, barrier to digestion, mobility of intestinal contents, increased faecal transit time and fermentability characteristics(Tharanathan & S. Mahadevamma.2003). Ragi also contains a functional fibre fraction known as RS, this escapes the enzymatic digestion, imparts beneficial effects by preventing several intestinal disorders (Annison et al1994) (Gee1992 et al). As it escapes digestion and provides fermentable carbohydrates for colonic bacteria. It also provide benefits such as the production of desirable metabolites, including short-chain fatty acids in the colon, especially butyrate, which seems to stabilize colonic cell proliferation as a preventive mechanism for colon cancer. Besides it's the rapeutic effects, resistant starch (RS) provides better appearance, texture, and mouth feel than conventional fibers (Martinez-Flores1999)

RAGI IN FOOD INDUSTRY

Composite Flour

Composite flour technology is initially referred to process of mixing wheat flour with cereal and legume flour for making bread and biscuits. However, the term can also be used with regard to mixing of non-wheat flours, roots and tubers or other raw materials (Dendy, 1992). Composite flour technology makes it possible to blend, mix or fortify one food material with others so that the resulting fortified mix has not only better nutritional quality but also the necessary attributes for consumer acceptance (Lupien, 1990).

Fortification of finger millet in chapattis not only improves the taste but also helpful in controlling glucose levels in diabetic patients very efficiently (Kang et al., 2008). The bulkiness of the fibers and the slower digestion rate makes us feel fuller on, fewer calories and therefore may help to prevent from eating excess calories. Its high fiber content is further helpful to the individuals having the problem of constipation (Cade et al., 2007).

Popping

Popping or puffing is a simple processing technique of cereals to prepare ready to eat products. Popped grain is crunchy, porous and a precooked product. Popped grains especially of finger millet posses a pleasant aroma and acceptable taste. This process improves the nutritional value by inactivating some of the anti- nutritional factors and thereby enhancing the protein and carbohydrate digestibility (Nirmala 2000)

For puffing, the whole finger millet grain is conditioned by mixing additional water so as to reach its moisture content in the range of 18-20% and tempered for about 4-6 hours under shed. The conditioned grains are puffed by agitation on the hot sand surface maintained at about 230 - 250 ˚C for short time following HTST (high temperature and short time) process. During this process, the sugars present in the aleurone layer react with amino acids of the millet causing Millard reaction and as a result, a pleasant and highly desired aroma is developed. Moreover, during this process, the vapor pressure of the grain increases and the moisture present in the grain turns into steam; gelatinization of the starch takes places and explodes.

Since during this process as grains are dehydrated to extremely low level of moisture content, nearly 3-5%, the shelf-life is enhanced. For mass production of puffing millet grains now day's modern air puffing machines have been developed. These machines have advantage that is no risk of sticking sand particles with the product in machine during popping or puffing. Puffed finger millet grains can be converted into powder by simple grinding which can further be enriched with additional ingredients.

Malting (Weaning Foods)

Malting of finger millet is a common technique in India and malted finger millet is considered superior to malted sorghum and malted maize. Studies have shown that finger millet develops higher amylase activity than sorghum and other millets (Malleshi and Desikachar, 1986; Senappa, 1988). Malleshi and Desikachar (1986) reported that finger millet malt has highly agreeable flavour with adequate starch hydrolyzing enzymes. Malting of finger millet improves its digestibility, sensory and nutritional quality as well as has pronounced effect in lowering the antinutrients. The inherent qualities of Finger millet make it superior compare to other cereals and also qualify for malting and preparation of malted foods. As it is resistant to fungal infection and elaboration of alpha and beta amylase during germination and during desirable aroma is developed during roasting/kilning makes it an ideal grain for malt foods. Mibithi et al. (2000) have also reported that the sulfur containing amino acids (methionine and cysteine) and lysine increased in finger millet during sprouting. Rao (1994) found that malting increased PER of brown and white varieties but the increase was significant for white varieties only. Contrary to this Malleshi and

Desikachar (1986) reported a significant improvement in protein efficiency ratio from 0.9 to 1.06 in brown finger millet varieties upon 48 h of sprouting. Losses in minerals have been reported due to malting and germination. Rao (1994) reported that total iron decreased in brown finger millet from 4.4 to 1.8 mg/100g and in white finger millet from 12.0 to 2.8 mg/100g. Similarly, Hemanalini et al. (1980) have reported that malted finger millet flour resulted in 32, 26 and 33% losses in calcium, phosphorous and iron. In order to make milk based beverage the malted weaning food is mixed with powdered sugar, milk powder or whole milk along with flavoring agents. This preparation is a good source of nutrition and suitable for all the age groups. Popularly this preparation is known as 'ragi malt' and can be used as health drink or energy drink.

Noodles

The changing food habits of children and teen aged groups have created a good market of noodles in India and abroad. The demand for millet noodles particularly the noodles made out of finger millet is growing due to awareness of its nutritional properties. Noodles are the pasta products also known as convenience foods prepared through cold extrusion system which become hard and brittle after drying. The cooking of these noodles is very convenient and requires few minutes. Noodles of different combinations are prepared such as noodles exclusively made of finger millet, finger millet and wheat in the ratio of 1:1 and finger millet blended with wheat and soy flour in the ratio of 5:4:1. In case of exclusive millet-based noodles, pretreatment to the millet flour is given to facilitate extrusion and smooth texture which should retain while drying and cooking. Generally, in the preparation of noodles, wheat flour is invariably used as an important member of blend because the presence of wheat gluten has an added advantage which not only helps in easy extrusion but also gives a smooth and fissure free texture to the noodles. Several other combinations of blends can be explored in the preparation of noodles keeping food values of ingredients and their availability in mind.

Roasting

Roasting and grinding processes render the grain digestible, without the loss of nutritious components (Krantz et al., 1983). The puffing and roasting are almost similar processes, but the volume expansion in puffing is higher (Srivastava et al., 1994). Roasting of cereals, pulses and oilseeds is a simpler and more commonly used household and village level technology which is reported to remove most anti nutritional or toxic effects such as trypsin inhibitor, hemagglutinin, gioterogenic agents, cyanogenic glycosides, alkaloids and saponins and increase storage life (Gopaldas et al., 1982; Huffman and Martin, 1994).

Bookwalter et al. (1987) reported inactivation of lipase in millet flours when roasted at 97ºC. Inactivation of lipase led to minimization of fat hydrolysis. Geervani et al. (1996) reported significantly higher NPU from roasted millets and legumes mix as compared to dehulled, boiled, malted and baked mixes. Weaning foods prepared by roasting of barnyard and finger millet increased iron bioavailability (Gahlawat and Sehgal, 1994).

Fermentation

Fermentation can be spontaneously initiated without the addition of microorganisms or controlled by the use of specific cultures of starters from previous batch of fermented products (Frazier and Westhoff, 1986). Changes that take place during fermentation include increase in amino nitrogen, the breakdown of proteins and destruction of any inhibitors that may be present (Davidek et al., 1990). Traditionally, finger millet is con-sumed in the form of thick porridge (mudde or dumpling), thin porridge (ambali), fried and baked pancake (roti, dosa) and beverages (chang/ jnard). Most of these involve fermentation step (Madhavi and Vaidehi, 1990; Hadimani and Malleshi, 1993; Gomez, 1993). Fermentation of finger millet using different cultures has been shown by Antony et al. (1996), Antony and Chandra (1999), and Mbithi et al. (2000). Lactic acid fermentation has been found to affect the amount of amino acids in cereals and legumes. Hamad and Fields (1979) observed that fermentation increased the lysine content in millets. Fermenting finger millet with lactobacillus salivaricus caused an increase in tryptophan and lysine by 17.8 and 7.1%, respectively. Also, the leucine to lysine ration, which is an indicator of pellagragenic character of protein, decreased significantly during fermentation (Mbithi et al., 2000)

Enhancement of biological value (BV), net protein utilization (NPU), thiamin, riboflavin and niacin contents has been shown in fermented finger millet (Aliya and Geervani, 1981; Rajyalakshmi and Geervani, 1990). Basappa et al. (1997) observed significant higher co-ncentrations of riboflavin (0.62 mg/100g), pantothenic acid (1.6 mg/100g), and niacin (4.2 mg/100g) in the fermented finger millet than in raw grains. They also observed that cyanocobalamin was synthesized during finger millet fermentation. Antony and Chandra (1998) reported that fermentation of finger millet flour using endogenous grain microflora showed a significant reduction of phytates by 20% and tannins by 52% and trypsin inhibitor activity by 32% at the end of 24 h. There was a simultaneous increase in mineral availability (calcium-20, phosphorous-26, iron-27 and zinc-26%).

Extrusion

Extrusion technology is another novel way of transforming ingredients into value added products. Extruded products prepared from different grains are very popular now days among the all age groups and their demand is growing, one such example is 'Kurkure', very popular among children. The change in life-style is also bringing a drastic change in the food habits, and the extruded foods being RTE products have become a good choice as snack foods. All the cereals containing good amount of starch can be extruded after making flour and conditioning to required condition. Finger millet flour or grits exhibit good extrusion characteristics. Extrusion cooking has ability to gelatinize and cook the product to the fullest extent and enables its uses as a RTE food. In extrusion cooking, the combined effects of shear along with heat and pressure are mainly responsible for the modification of starch properties. The flour/grit with 16-18% moisture content has ability to extrude in the barrel temperature range of 100-120˚C well with good expansion index with crunchy, porous and smooth surface texture. Like other preparations, the finger millet flour can be blended with other legume ingredient flours in appropriate proportion with further fortification of minerals and vitamins to design a balanced nutritional extruded food. Alternatively, the extrudates can be pulverized and blended with calculated amount of other pre-prepared/cooked ingredients to prepare supplementary food mix for infant babies and lactating mothers etc. A further value addition of extrudates so prepared from finger millets can be done by coating with sweet or savory to attract children.

Bakery Products

Incorporation of finger millet flour in the preparation of bakery products like biscuit, nankhatai, muffins and bread has been attempted and efforts are being made to standardize the recipe and product quality. The use of millets in bakery products will not only superior in terms of fiber content, micronutrients but also create a good potential for millets to enter in the bakery world for series of value added products. In a recent study, attempts have been made to improve the nutritional quality of cakes with respect to the minerals and fiber content by supplementing with malted finger millet flour (Desai et al., 2010). In recent years, finger millet has received attention and efforts are under way to provide it to the consumers inconvenient forms (Singh et al., 2012).

RAGI IN PREBIOTIC AND PROBIOTIC FOODS

Probiotics aid the existing flora, or helper populate the colon when bacteria levels are reduced by antibiotics, chemotherapy or disease.FAO/WHO stated that probiotics are "lives microorganisms which when administered inadequate amounts confer a health benefit on the host" though, this should also specify genus, species and strain level, as well as a safety assessment. Most of probiotic foods generate fatty acids, vitamins and other vital nutrients that improve the body's resistance against pathogens microorganisms (FAO/WHO, 2001; Abd El-Salam et al., 2012). Fermented foods are thus, important to human beings all over the world with between 20 to 40% of food supply being from fermented foods (Anukam and Reid, 2009). Lei and Michaelsen (2006) reported an interesting intervention study in Northern Ghana using spontaneously fermented millet product as a natural probiotic treatment for diarrhea in young children. Millet koko is an African spontaneously fermented millet porridge and drink, characterized by Lei and Jacobsen (2004) as a potential probiotic product as well as Mangisi, Kunu-zaki and Uji a thin, lactic acid-fermented porridge (Amadou et al., 2011a). Prebiotics are non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth and/or activity of one, or alimited number of bacteria in the colon (Laminu et al., 2011; Abd El-Salam et al., 2012). Food ingredients classified as prebiotics must not be hydrolyzed or absorbed in the upper gastro intestinal tract, need to be a selective substrate for one, or a limited number of colonic bacteria, must alter the microbiota in the colon to a healthier composition and should induce luminal, or systematic effects that are beneficial to the host health (Lei and Jacobsen, 2004). Cereals, in particular millet-based fermented foods and beverages, have been extensively studied and form a major part of the diet in most African countries (Rivera-Espinoza and Gallardo-Navarro, 2010). Malting induces important beneficial biochemical changes in the millet grain.

Fura is dough made from millet flour, it is hand molded into balls, placed inside a cooking pancontaining boiling water, and cooked for 30 min at atmospheric pressure then the balls are kneadedagain while still hot until a smooth, slightly elastic mass is obtained. Mangisi is a sweet-sour beverage made from naturally fermented millet mash. Moreover, unfermented millets foods and beverages such as Dambu a steamed granulated dumpling; Masvusvu a sweet beverage traditionally made from unfermented malted finger millet and Ragi roti, known as finger millet roti is anunleavened flatbread (Amadou et al., 2011a;Rivera-Espinoza and Gallardo-Navarro, 2010).

POTENTIAL HEALTH BENEFITS OF RAGI

Millet is more than just an interesting alternative to the more common grains. The grain is also rich in phytochemicals, including phytic acid, which is believed to lower cholesterol, and phytate, which is associated with reduced cancer risk (Coulibaly et al., 2011). These health benefits have been partly attributed to the wide variety of potential chemopreventive substances, called phytochemicals, including antioxidants present in high amounts in foods such as millets (Izadi et al., 2012).

Chandrasekara and Shahidi (2010) reported in their studies on free-radical quenching activity offinger millet (Eleusine coracana), that nonprocessed brown finger millet had the highestradical quenching activity than the processed one and postulated that tannins and phytic acid wereresponsible for the activity (Devi et al., 2011; Quesada et al., 2011; Kamara et al., 2012).

NUTRITIONAL INHIBITORS

Maximum utilization of the nutrient potential of the millet is limited by the presence of phytates, phenols, tannins and enzyme inhibitors. Tannins bind to both exogenous and endogenous proteins including enzymes of the digestive tract affecting utilization of proteins (Asquith and Butler, 1986). Among millets finger millets have been reported to contain high amounts of tannins ranging from 0.04 to 3.74% of catechin equivalents (Rao, 1994; Antony and Chandra, 1998; Antony and Chandra, 1999). Rao and Prabhavati (1982) have reported 360 mg/100g tannins in brown finger millet. They also found that 50% of the iron present in the diet might be bound to tannins. In vitro protein digestibility has been found to be negatively associated with tannin content of finger millet varieties (Ramachandra et al., 1977). Soaking, roasting, boiling, germination and fermentation have been found to reduce tannin content (Rao and Prabhavathi, 1982). Malting decreased the tannin content by 54% in brown finger millet (Rao, 1994).

Phytic acid, myo-inositol 1,2,3,4,5,6-hexakis (dihydrogenphosphate), is the main phosphorus store in mature seeds. Phytic acid has a strong binding capacity. It readily forms complexes with multivalent cations and proteins (Haug and Lantzsch, 1983). Phytate content in finger millet as observed by various authors has been found to be in range 0.679 to 0.693 g/100mg (Antony and Chandra, 1999). Finger millet has been found to contain 41% phytic phosphorus as percentage of total phosphorus (Deosthale, 2002). Rao (1994) reported phytate content to be 149 to 150 mg/100g in finger millet grains. The dietary phytic acid binds not only with the seed derived minerals but also with other endogenous minerals encountered in the digestive tract (Raboy, 2000). Agte and Joshi (1997) reported that for cereal based vegetarian meals, processing such as soaking cereal flour prior to heating can activate phytases and therefore favour zinc availability. Malting of the grain significantly reduced the phytin phosphorus content of finger millet (Rao and Deosthale, 1988; Malleshi and Desikachar, 1986; Deosthale, 2002). Rao (1994) reported that malting decreased the phytin phosphorus content by 58 to 65% in brown and white finger millet varieties, respectively. Mammiro et al. (2001) found that there was marked reduction in phytic acid content in finger millet during processing. Phytic acid decreased by 49.2 and 66.5% after germination and fermentation, respectively. Phytic acid decreased in finger millet by 84.7% when combinations of processing methods were used. The partial retention of phytates is beneficial for their contribution to health benefits such as antidiabetic, antioxidant and anticancer effects, which have been recently recognized (Graf et al., 1987; Thompson, 1993)

CONCLUSION

Millets are still the staple food for millions of poor in Asia and Africa. Like other cereals, Ragi millets are high in carbohydrate, energy and nutritious, making them useful components of dietary and nutritional balance in foods. Combination of millets with other sources of protein would compensate the deficiency of certain amino acids such as lysine. Successful improvement of these attributes would be a crucial key to expand the spectrum of applications of millet grains. Future trends should focus on the millet consumption in the developed countries that could help its industrial revolution.

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