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# Millet's anti-nutrients and their therapeutic effects

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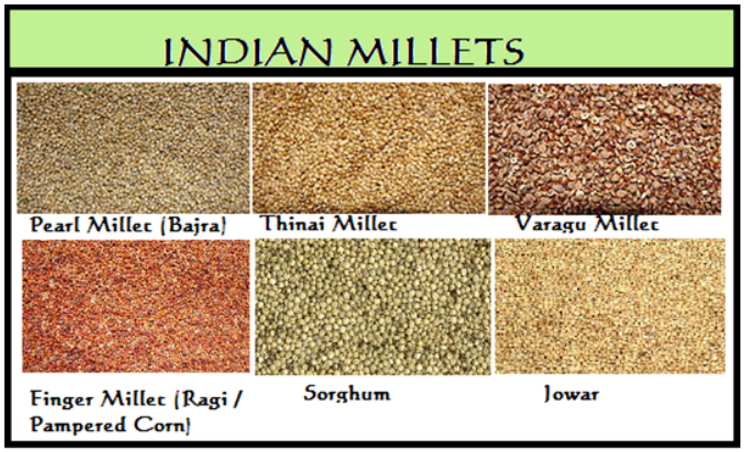
**Abstract**
Millet is used as animal and bird feed but limited consumption by people in rural areas at household level due to lack of knowledge. To avoid malnutrition and certain chronic diseases, make improvement of the nutritive value of food and diet is best approaches with low-cost and locally available food formulations. For successful improvement of these attributes would be a crucial key to expand the spectrum of applications of millets. Millets have been found to have high nutritive values and are comparable to other major cereals like wheat and rice. Millets have uniqueness because of its richness in carbohydrate, protein, calcium, iron, dietary fibre, antioxidants and anti-nutrients. Millets can be used as nutraceutical and to produce healthier food for nourishing. Millet contains tannins, phytates, polyphenols, trypsin inhibitors and dietary fiber which considered as "anti-nutrients. Polyphenols considered as "life span essential" due to their role in maintaining body functions and health throughout end phase of the life. These have no known direct role in nutrition but have some health friendly properties like anti-oestrogenic, anti-mutagenic, anti-carcinogenic, antiviral effects, anti-inflammatory, platelet aggregation inhibitory activity that might be potential benefit in minimizing and preventing the incidence of diseases. Millet's food can contributed to anti-oxidant activity, which play important role in health, aging and metabolic diseases. This study showed that millets are used as "food medicine".

**Keywords:** Anti-nutrients, nutraceutical, polyphenols, condensed tannin, dietary fibre, celiac disease

## Introduction
Millets are small seeded and minor cereals of the grass family (*Poaceae*) and are characterized by their ability to survive in less fertile soil, resistance to pests and diseases, drought-resistant, short growing season [13] and cultivated round the year. Millet is considered as first domesticated cereal [44]. National Nutrition Monitoring Bureau [35], has reported that the consumption of millets was higher in the states of Gujarat (pearl millet, maize), Karnataka (finger millet), Maharastra (sorghum) but negligible in the states of Kerala, Orissa, West Bengal and Tamil Nadu where rice is the most consumed cereal. Cereals are being consumed as main staple by Indians that constitute 70-80% of the total energy intake [22]. Recent study by NNMB on dietary profile of urban Indians (from the Chennai Urban Rural Epidemiology Study (CURES)) revealed that only 2% of the total calories (6.7 g/d) were contributed by the millets [37].
India is the largest producer of pearl millet. Millets contain many health-promoting components such as good protein, carbohydrate, fat, dietary fibre, vitamins and minerals as well as antioxidant and phytochemicals [5]. Millets are easily available and are cheap in cost. Major cultivator of finger millet is India with 15870 $km^2$ cultivated area. The state of Karnataka is the largest producer of finger millet which is known as "ragi" in this region, pertaining 58% of total production of India [23]. Pearl millet can be grown in that area where other cereal like wheat, maize etc. would not survive. Present time pearl millet is grown on 260,000 $km^2$ of area around the world which accounting 50% of total millets production of worldwide [59]. Millet has many nutritious and medical functions [58].
The aim of this study is to introduce the millets as a nutritious food, fulfillment of the nutritional need of global population and to find ways to utilize the millets effectively, nutritionally and to alleviate the problems of malnutrition and other health problems. This study would like to emphasize on nutraceutical properties of millets and the application of millets as alternative of cereals potentially healthy to elaborate therapeutic food products such as gluten free diet, protein and energy rich diet, diet for diabetes, CVD, etc. This study will show that millets are used as "food medicine". Millet is source of antioxidants such as phenolic acids and glycated flavonoids. Millet foods are also characterized to be potential prebiotic and can enhance the viability of probiotics with potential health benefits.




**Source:** http://ww.thealternative.in/lifestyle/fretting, [62]

**Nutrient profile**

Millets are rich source of energy; the major nutrients of millets are 60-70% carbohydrates, 7-11% proteins, 1.5-5% fat, and 2-7% crude fibre, minerals and vitamins. Millets have high content of iron and phosphorus. Pearl millet is significantly rich in soluble and insoluble dietary fibers, resistant starch, minerals and antioxidants [38]. It contains about 92.5% dry matter, 2.8% crude fiber, 63.2% starch, 2.1% ash, 7.8% crude fat and 13.6% crude protein [1]. In addition, finger millet has high calcium content (350mg/ 100g). Millets are rich in several bioactive phytochemicals that have commendable effect in prevention and in delaying the occurrence of non-communicable diseases (NCDs) [44].

**Nutritional Composition of Different Millets**

| Crops | Protein(g) | Fat(g) | Fiber(g) | CHO(g) | Minerals(g) | Iron(mg) | Calcium(mg) |
|---|---|---|---|---|---|---|---|
| Rice raw milled | 6.8 | 0.5 | 0.2 | 78.2 | 0.6 | 0.7 | 10 |
| Wheat | 11.8 | 1.5 | 1.2 | 71.2 | 1.5 | 5.3 | 41 |
| Sorghum | 10.4 | 1.9 | 1.6 | 72.6 | 1.6 | 4.1 | 25 |
| Maize | 11.1 | 3.6 | 2.7 | 66.2 | 1.5 | 2.3 | 10 |
| Foxtail millet | 12.3 | 4.3 | 8.0 | 60.9 | 3.3 | 2.8 | 31 |
| Pearl millet | 11.6 | 5.0 | 1.2 | 67.5 | 2.3 | 8.0 | 42 |
| Finger millet | 7.3 | 1.3 | 3.6 | 72.0 | 2.7 | 3.9 | 344 |
| Kodo millet | 11.0 | 3.6 | 10.0 | 66.6 | 1.9 | 0.5 | 27 |
| Little millet | 7.7 | | 7.6 | | 1.5 | 9.3 | 27 |
| Proso millet | 12.5 | 4.2 | 2.2 | 73.0 | 1.9 | 0.8 | 14 |
| Barnyard millet | 12.2 | 3.85 | 10.1 | 55.8 | 3.2 | 1.4 | 24 |

**Source:** http://ww.slideshare.net/poshadri/cereals-millet-processing, [61]

**Anti-nutrients**

Millet contains tannins (0.61), phytates (0.48%), polyphenols, trypsin inhibitors and dietary fiber which considered as "anti-nutrients" because of their metal chelating and enzyme inhibitor activities which termed as nutraceuticals [53]. The seed coat of the millet is excellent source of phytochemicals such as polyphenols (0.2-3.0%) and dietary fiber [24, 40].

Now a days, polyphenols considered as "life span essential" due to their role in maintaining body functions and health throughout end phase of the life [8]. Millet polyphenols is a complex mixture of cinnamic acid derivatives and benzoic acid perform enzyme inhibitory and anti-cataractogenic activities [13]. Main polyphenols such as phenolic acid and tannins are present in cereals whilst flavonoids are present in small quantities [41]. These compounds have no known direct role in nutrition but have some health friendly properties like anti-nutrients [50]. anti-oestrogenic, anti-mutagenic, anti-carcinogenic, antiviral effects, anti-inflammatory, platelet aggregation inhibitory activity that might be potential benefit in minimizing and preventing the incidence of diseases [19]. The pigment testa in the red colored is identifying to have much tannin content which is located in the said tissue of the grain. [49] Total polyphenol contents founded in wide range (0.19-3.37%) among 85 Indian finger millet varieties [45].

Phenolic compounds are more concentrated in bran layers that to losses during the separation of seed coat in milling process [54]. Phenolic compounds (both free and bound forms) are present in very good amount in finger millet [47]. Insoluble-bound phenolic fraction forms except finger millets are found of hydroxycinnamic acids and their derivatives (HCAS) which include chlorogenic, caffeic, and trans-cinnamic, p-coumaric, and sinapic, trans-ferulic and cis-ferulic acids [44]. These ferulates contained comparatively more antioxidant activity [9]. It studied that ferulic, p-coumaric, and cinnamic acids are major phenolic acids present in millets [33]. The millet phenolics are pH sensitive but heat stable and are highly unstable under alkaline conditions [11]. Fractionated polyphenols which is extracted by HPLC (high performance liquid chromatography) showed that the analytics were derivatives of flavonoid compound (quercetin), benzoic acid, which is accounted apprx. 85% of the total phenolic compounds (gallic acid, p-hydroxybenzoic acid and proto-catechuic acid) and cinnamic acid (syringic acid, ferulic acid, p-coumaric acid and trans-cinnamic acid) revealed [12]. The seed coat of millet extracted by direct infusion electrospray ionization mass spectrometry, the total phenolic compounds showed that presence of naringenin luteolin glycoside, kaempferol, apigenin, phloroglucinol, (+)-catechin/(-)-epicatechin, trans-feruloyl-malic acid, daidzein, dimer of prodelphinidin (epi-gallocatechins; 2GC), catechin gallates,

trimers and tetramers of catechin [47].

Several flavonoids are present in millets such as orientin, isoorientin, vitexin, isovitexin, saponarin, violanthin, lucenin-1 and tricin (antitumour and anti-leukemic properties) founded in finger millet's leaves and glucosylvitexin, glucosylorientin, goitrogenic and vitexin isolated from pearl millet grains [44]. Finger millet contained proanthocyanidins, which are also known as condensed tannins [16].

Finger millet's carbohydrates (72%) is main constituent and the non-starchy polysaccharides (NSP) which accounts to 15-20% of seed matter known as an unavailable carbohydrate [14]. It is observed that higher fiber foods are barrier to digestion, delayed nutrient absorption, increasing faecal bulk, mobility of intestinal contents, increased faecal transit time and fermentability properties, lowering of blood lipids and prevention of colon cancer [52]. The resistant starch (RS) complements the health benefits of the millet, also contributes towards dietary fibre. Residual starch (RS) is a functional fibre fraction, also present in ragi [46]. RS escapes the enzymatic digestion imparts beneficial effects by preventing several intestinal disorders [3, 20]. Millet oil could be a good source of natural oil like linoleic acid and tocopherols [2].

**Therapeutic effect**

Nutrients like vitamins, minerals, essential fatty acids and fiber were believed to be responsible for health benefits but recent research suggests that some bioactive substances combined with nutrients such as oligosaccharides, lipids, antioxidants (phenolic acids, avenanthramide, flavonoids), hormonally active compounds (lignans, phytosterols) and anti-nutrients (such as phytic acid, tannins etc.) gives more positive health effects [17]. Millets act as functional food as well as nutraceuticals. The cases of obesity and diabetes are increasing very fast globally. Food containing complex carbohydrates with high fiber and health beneficial phytochemicals has been in demand to combat above health issues [48]. Wholegrain cereals food formulations is increasing worldwide because they are rich sources of phytochemicals and dietary fiber which offer positive effects on health [26]. Phytates, polyphenols and tannins of millet's foods can contributed to anti-oxidant activity that play important role in health, aging and metabolic disease [6].

**Health Benefits of Millets**

1. Alkalizing
2. Easily digestible
3. Healthy colon
4. Lower cholesterol
5. Lots of fiber
6. Low GI
7. Reduce migraines
8. Reduce heart-attack
9. Calming mood food
10. High in protein

Source: http://www.eathealthylivefit.com/page/7/, [60]

Incorporation of finger millets into the diets has preventive potential from chronic disease [28]. It is noticed that improvement in children on level of hemoglobin after feeding finger millet-based food [51]. Millets are staple food substitutes for celiac patients because they have gluten-free properties. Celiac disease is a syndrome characterized by damage to the mucosa of the small intestine, which caused by ingestion of certain proteins such as gliadins [27] and glutenins [56] of wheat gluten, that are not tolerated by celiac patient [18].

It is suggested that phenolic antioxidants in millets can contribute in health protective properties against diet-related chronic disease [25]. Procyanidins, which are high-molecular weight polyphenols, accounted biologically active and when present in good amount may give negative effect on nutritional value and biological availability of proteins and minerals [10]. Several studies demonstrated their anti-inflammatory, antiviral, antibacterial and antioxidant properties. Condensed tannins are more potential anti-oxidant [13].

It is reported that millet-consuming population has lower incidence of diabetes [29]. The effect of consumption of finger millet on hyperglycemia in NIDDM (non-insulin dependent diabetes mellitus) men and noticed lower the glycemic response in whole finger millet based roti and dosa and germinated finger millet roti [31]. It is compared and analyzed that supplemented with ragi food for a month showed higher reduction of glucose in fasting and post prandial condition than other millets [21]. Finger millet based diet response to lower glycemic effect due to the presence of antinutritional factors which reduce starch digestibility and absorption [30]. Finger millet seed coat phenolics and dietary fiber content [12] act as inhibitors decreasing the postprandial hyperglycemia by blocking the action of enzymes (amylase, alpha-glucosidase) needed for hydrolysis of complex carbohydrates [47]. Polyphenols act as inhibitors that inhibit the activity of digestive enzymes like amylase, glucosidase, lipases, pepsin, and trypsin [42]. Finger millet reduced the risk of gastrointestinal tract disorders [55].

It is founded that phenolic content and flavonoids of finger millet inhibit oxidation of microbial membranes and microbial enzymes leading to inhibitory activities of proliferation of bacterial cells such as *E. coli, B. cereus, Listeria monocytogenes, Staphylococcus aureus, Streptococcus pyogenes, Serratiamarcescens, Proteus mirabilis, Pseudomonas aeruginosa, Klebsiella pneumonia and Yersinia enterocolitica* [4]. Plant phenolics showed minimizing the intensity of several diseases and growth of an assortment of fungal genera [6]. Finger millet's phenolics including tannins may be resistance to fungal infection in grains [43]. Protein extracts of pearl millets were highly effective to inhibit the growth of pathogenic fungi such as *Rhizoctonia solani, Macrophomina phaseolina* and *Fusarium oxysporum* [36]. It is founded that millet's polyphenols content showed antibacterial and antifungal activity [57].

Phenolic acids such as ferulic, caffeic, protocatechuic acids and p-coumaric possessed antifungal effect [15]. It is founded that millet's flavones (such as kaempferol, quercetin, apigenin and luteolin) contributed to antiproliferative activities [32]. Antioxidants acted as lipid stabilizers and as suppressors of oxidation process that causes ageing and cancer [34]. Antioxidant such as phenolic acids and their derivatives, tannins, flavonoids, present in millet seed coat are multifunctional and can act as metal chelators, reducing agents (free radical terminators), singlet oxygen quenchers [50]. Castelluccio reported that ferulic acid is very strong antioxidant, free radical scavenging and anti-inflammatory activity [7]. It is observed that the effect of millet's antioxidant properties on oxidative stress and glycemic status in alloxan-induced rats. The alloxan induced rats showed more reduction of blood glucose and cholesterol after fed with finger millet. The level of lipid peroxides, enzymatic (glutathione, vitamin E and C) and non-enzymatic antioxidants (superoxide dismutase, glutathione peroxidase, glutathione reductase and catalase)

were reduced in diabetic animals and restored to normal levels in the millet-fed groups [25]. The effect of finger millet's antioxidant on dermal wound healing process in diabetic rat with oxidative stress-mediated modulation of inflammation is analyzed. Effect of finger millet fed diabetic animals controlled the glucose levels and enhance the antioxidants status, this hastened the dermal wound healing process due to the phenolic antioxidants which is present in finger millet protected the insulin-producing cells from alloxan-mediated cell damage partially encourage the healing process [39].

## Conclusion

Generally, millet is staple food for animals and birds. But, millet has huge potential for nourishment of population with benefit of low cost availability and easy cultivation. Millet has wide range of nutrients, anti-nutrients and antioxidants making them useful components of dietary and nutritional balance in foods. Millet's anti-nutrients (such as polyphenols, phenolic compounds, tannins, flavonoids) are not directly related to nourishing to the body but important role in health to curing of diseases such as diabetes, cardiovascular disease, cataract, cancer, inflammation, gastrointestinal problems etc. Millet has specialty among cereal because it is alkaline-forming and gluten-free. Millet is best option for celiac patient, depends on gluten-free diet.

## References


1. Ali MAM, El Tinay AH, Abdalla AH. Effect of fermentation on the *in vitro* protein digestibility of pearl millet. Food Chem. 2003; 80(1):51-4.
2. Amadou I, Amza T, Yong-Hui S, Guo-Wei L. Chemical analysis and antioxidant properties of foxtail millet bran extracts. Songklanakarin J Sci Technol. 2011c; 33(5):509-515.
3. Annison G, Topping DP. Nutritional role of resistant starch: chemical structure and physiological function. Annu Rev Nutr. 1994; 14:297-320.
4. Banerjee S, Sanjay K, Chethan S, Malleshi NG. Finger millet (*Eleusine coracana*) polyphenols: Investigation of their antioxidant capacity and antimicrobial activity. African Journal of Food Science. 2012; 6:362-374.
5. Bhattacharjee R, Khairwal IS, Bramel PJ, Reddy KN. Establishment of a pearl millet [*Pennisetum glaucum* (L.) R. Br.] core collection based on geographical distribution and quantitative traits. Euphytica. 2007; 155:35-45.
6. Bravo L. Polyphenols: chemistry, dietary sources, metabolism and nutritional significance. Nutr. Rev. 1998; 56:317-333.
7. Castelluccio C, Paganga G, Melikian N, Bolwett GP, Pridham J, Sampson J *et al*. Antioxidant potential of intermediates in phenylpropanoid metabolism in higher plants. EEBS Lett. 1995; 368:188-192.
8. Chandrasekara A, & Shahidi F. Content of insoluble bound phenolics in millets and their contribution to antioxidant capacity. J Agric Food Chem. 2010; 58:6706-6714.
9. Chandrasekara A, Shahidi F. Determination of antioxidant activity in free and hydrolysed fractions of millet grains and characterization of their phenolic profiles by HPLC-DAD-ESI-MS$^n$. Journal of Functional Foods. 2011a; 3:144-158.
10. Chavan UD, Shahidi F, Naczk M. Extraction of condensed tannins from beach pea (*Lathyrus maritmus* L.) as affected by different solvents, 2001.
11. Chethan S, Malleshi NG. Finger millet polyphenols: optimization of extraction and the effect of pH on their stability. Food Chem. 2007a; 105:862-870.
12. Chethan S, Sreerama YN, Malleshi NG. Mode of inhibition of finger millet malt amylases by the millet phenolics. Food Chem. 2008b; 111:187-191.
13. Devi PB, Vijayabharathi R, Sathyabama S, Malleshi NG, Priyadarisini VB. Health benefits of finger millet (*Eleusine coracana* L.) polyphenols and dietary fiber: a review. J Food Sci Technol. 2011; doi: 10.1007/s13197-011-0584-9.
14. DeVries JW, Prosky L, Li B, Cho S. A historic prospective on defining dietary fibre. Cereal foods world. 1999; 44:367-369.
15. Dragland S, Senoo H, Wake K, Holte K, Blomhoff R. Several culinary and medicinal herbs are important sources of dietary antioxidants. Journal of Nutrition. 2003; 133:1286-1290.
16. Dykes L, Rooney LM. Sorghum and millet phenols and antioxidants. J Cereal Sci. 2006; 44:236-251.
17. Edge MS, Jones JM, Marquart L. A new life for whole grains. J Am Diet Assoc. 2005; 105(12):1856-60.
18. Fasano A, Catassi C. Current approaches to diagnosis and treatment of celiac disease: An evolving spectrum. Gastroenterology. 2001; 120:636-651.
19. Ferguson LR. Role of plant polyphenols in genomic stability. Mutat Res. 2001; 475:89-111.
20. Gee JM, Johnson IT, Lind L. Physiological properties of resistant starch. Eur J Clin Nutr. 1992; 46:S125-S131.
21. Geetha C, Parvathi EP. Hypoglycaemic effect of millet incorporated breakfast on selected non-insulin dependent diabetic patients. Indian J Nutr Diet. 1990; 27:316-320.
22. Gopalan C, Rama Sastri BV, Balasubramani an SC. Nutritive value of Indian foods. Hyderabad, India: National Institute of Nutrition, Indian Council of Medical Research, 2009.
23. Govt of India - Ministry of Agriculture Report on Ragi harvest. Marketable surplus and post-harvest losses of ragi in India, 2002.
24. Hadimani NA, Malleshi NG. Studies on milling, physicochemical properties, nutrient composite on and dietary fiber content of millets. J Food Sci Technol. 1993; 30:17-20.
25. Hegde PS, Rajasekaran NS, Chandra TS. Effects of the antioxidant properties of millet species on oxidative stress and glycemic status in alloxan-induced rats. Nutr Res. 2005; 25:1109-1120.
26. Jones JM, Engleson J. Whole grains: benefits and challenges. Ann Rev Food Sci Technol. 2010; 1:19-40.
27. Kagnoff MF, Austin RK, Johnson HC, Bernardin JE, Dietler MD, Kasarda DD. Celiac sprue: correlation with murine T cell responses to wheat gliadin components. Journal of Immunology. 1982; 129:2693-2697.
28. Kannan S. Finger millet in nutrition transition: An infant weaning food ingredient with chronic disease preventive potential. British Journal of Nutrition. 2010; 104:1733-1734.
29. Kim JS, Hyun TK, Kim MJ. The inhibitory effects of ethanol extracts from sorghum, foxtail millet and proso millet on apha-glucosidase and a-amylase activities. Food Chem. 2011; 124:1647-51.
30. Kumari PL, Sumathi S. Effect of consumption of finger millet on hyperglycemia in non-insulin dependent diabetes mellitus (NIDDM) subjects. Plant Foods Hum Nutri.

2002; 57:205-13.
31. Lakshmi Kumari P, Sumathy S. Effect of consumption of finger millet on hyperglycemia in non-insulin dependent diabetes mellitus (NIDDM) subjects. Plant Foods Hum Nutr. 2002; 57:205-213.
32. Manthey JA, Guthrie N. Antiproliferative activities of citrus flavonoids against six human cancer cell lines. Journal of Agricultural and Food Chemistry. 2002; 50:5837-5843.
33. McDonough CM, Rooney LW. The millets. In K Kulp& JG Ponte (Eds.), Handbook of Cereal Science and Technology NY: Marcel Dekker Inc. 2000, 177-201.
34. Namikii M. Antioxidants/antimutagens in food. Crit Rev Food Sci Nutr. 1990; 29:273-300.
35. NNMB. Diet and nutritional status of rural population and prevalence of hypertension among adults in rural areas. NNMB Technical Report 24. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India. 2006.
36. Radhajeyalakshmi R, Yamunarani K, Seetharaman K, Velazhahan R. Existence of thaumatin-like proteins (TLPs) in seeds of cereals. Acta Phytopathol Entomol Hungarica. 2003; 38(3-4):251-7.
37. Radhika G, Sathya RM, Ganesan A, Saroja R, Vijayalakshmi P, Sudha A *et al*. Dietary profile of urban adults population in south India in the context of chronic disease epidemiology (CURES-68). Journal of Public Health Nutrition. 2011; 14(4):591-598.
38. Ragaee S, Abdel-Aal EM, Noaman M. Antioxidant activity and nutrient composition of selected cereals for food use. Food Chem. 2006; 98(1):32-8.
39. Rajasekaran NS, Nithya M, Rose C, Chandra TS. The effect of finger millet feeding on the early responses during the process of wound healing in diabetic rats. Biochim Biophys Acta. 2004; 1689:190-201.
40. Ramachandra G, Virupaksha TK, Shadaksharaswamy M. Relationship between tannin levels and *in vitro* protein digestibility in finger millet (*Eleusine coracana* Gaertn). J Agric Food Chem. 1977; 25:1101-1104.
41. Rao MVSSTS, Muralikrishna G. Evaluation of the antioxidant properties of free and bound phenolic acids from native and malted finger millet (ragi, *Eleusine coracana* Indaf-15). J Agric Food Chem. 2002; 50:889-892.
42. Rohn S, Rawel HM, Kroll J. Inhibitory effects of plant phenols on the activity of selected enzymes. J Agric. Food Chem. 2002; 50:3566-3571.
43. Seetharam A, Ravikumar RL. Blast resistance in finger millet- its inheritance and and biochemical nature. In: Riely KW, Gupta SC, Seetharamn A, Mushonga JN. (eds) Advances in small millets. International Science Publisher, New York. 1994, 449-465.
44. Shahidi F, Chandrasekara A. Millets grain phenolics and their role in disease risk reduction and health promotion: A review. Journal of Functional Foods. 2013; 5:570-581.
45. Shankara P. Investigations on pre-harvest and post-harvest aspects of finger millet. Ph. D. thesis, University of Mysore, India, 1991.
46. Shobana S, Malleshi NG. Preparation and functional properties of decorticated finger millet (*Eleusine coracana*). J Food Eng. 2007; 79:529-538.
47. Shobana S, Sreerama YN, Malleshi NG. Composition and enzyme inhibitory properties of finger millet (*Eleusine coracana* L.) seed coat phenolics: mode of inhibition of alpha-glucosidase and pancreatic amylase. Food Chem. 2009; 115:1268-1273.
48. Shobana S, Usha Kumari SR, Malleshi NG, Ali SZ. Glycemic response of rice, wheat and finger millet based diabetic food formulations in normoglycemic subjects. Int J Food Sci Nutr. 2007; 58(5):363-372.
49. Siwela M, Taylor JRN, de Milliano WAJ, Duodu KG. Occurrence and location of tannins in finger millet grains and antioxidant activity of different grain types. Cereal Chem. 2007; 84:169-174.
50. Sripriya G, Chandrasekharan K, Murty VS, Chandra TS. ESR spectroscopic studies on free redical quenching action of finger millet (*Eleusine coracana*). Food Chem. 1996; 57(4):537-540.
51. Tatala S, Ndossi G, Ash D, Mamiro P. Effect of germination of finger millet of nutritional value of foods and effect of food supplement on nutrition and anaemia status in Tanzanian children. Tanzania Health Research Bulletin. 2007; 9(2):77-86.
52. Tharanathan RN, Mahadevamma S. Grain legumes-a boon to human nutrition. Trends Food Sci. Technol. 2003; 14:507-518.
53. Thompson LU. Potential health benefits and problems associated with antinutrients with foods. Food Res Int. 1993; 26:131-149.
54. Tian S, Nakamura K, Kayahara H. Analysis of phenolic compounds in white rice, brown rice and germinated brown rice. Journal of Agricultural and Food Chemistry. 2004; 52:4808-4813.
55. Tovey FI. Diet and duodenal ulcer. J Gastroenterol Hepatol. 1994; 9:177-185.
56. Van de Wal Y, Kooy YMC, Van Veelen P, Vader W, August SA, Drijfhout JW *et al*. Glutenin is involved in the gluten-driven mucosal T cell response. European Journal of Immunoligy. 1999; 29:3133-3139.
57. Xu W, Wei L, Qu W, Liang Z, Wang J, Peng X *et al*. A novel antifungal peptide from foxtail millet seeds. J Sci Food Agri. 2011; 91:1630-1637.
58. Yang X, Wan Z, Perry L, Lu H, Wang Q, Hao C Li J, Xie F, Yu J, Cui T, Wang T, Li M & Ge Q H. Early millet use in northern China. Proc Nat Acad Sci. USA. 2012, 1-5.
59. http://cgiar.org
60. http://eathealthylivefit.com/page/7/
61. http://slideshare.net/poshadri/cereals-millet-processing
62. http://thealternative.in/lifestyle/fretting