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MILLETS AS A VALUE-ADDED PRODUCT: A REVIEW

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ABSTRACT

Millets play a crucial role as a staple crop worldwide, particularly impacting the economies of developing nations. Their resilience to drought and pests renders them highly advantageous. Millets are recognized for their high-energy content, making them valuable in combating malnutrition. Moreover, millet-based foods are viewed as promising sources of prebiotics and probiotics, offering potential health benefits. Across various cultures, millet grains are not only consumed as a dietary staple but also revered for their medicinal properties, contributing to overall well-being. Rich in phytochemicals, millets exhibit variability in types and quantities depending on species and processing methods, including dehulling, decortication, malting, fermentation, and thermal processing, which tend to reduce phenolic levels. Consequently, phytochemical concentrations in millet-based foods and beverages are generally lower compared to other cereal grains. Despite this, there is growing evidence supporting the functional and health-promoting effects of millet consumption, particularly in combating conditions like diabetes, obesity, and cardiovascular diseases, attributed to the actions of these phytochemicals and their impact on the immune system. However, direct confirmation of these health benefits is limited, as much of the research has focused on grains and extracts rather than finished food and beverage products. This review aims to compile available literature, both online and offline, regarding the nutritional significance and health-promoting properties of millets, presented in an easily accessible format. Given the nutritional profile and phytochemical content of millets, nutritionists and dieticians are urged to promote increased consumption of millets among the general public.

Introduction

India ranks among the world's top producers and consumers of millets. Millets include three major (Sorghum (*Jowar*), Pearl (*Bajra*), Finger (*Ragi*)) and six minor crops (Barnyard (*Sanwa*), Proso (*Chenna/Barri*), Foxtail (*Kakum*), Kodo, Brown Top and Little (*Kutki/Shavan*) (Anon., 2024a) Mandua and ragi are the most common names of Finger Millet (*Eleusine coracana* L.) in many parts of the India. India is the leading producer of small millets namely, finger millet (ragi), kodo millet (kodo), foxtail millet (kangni), barnyard millet (sawan), proso millet (cheema) and little millet (kutki) (Majumder *et al*., 2006). They have been cultivated for around 5000 years, notably in India. Small millets are a vital part of traditional cropping systems and play a big role in the national food basket's diversity, regional food security, and nutritional value. A considerable portion of the population that lives 0in the millet-growing areas which are thought to be the most impoverished groups benefits nutritionally from the increased fiber content of millets as well as the excellent quality of their protein and mineral composition (Desai *et al*., 2010). When it comes to nutrition, millets are best known for being an excellent provider of the mineral's phosphorus, magnesium, and manganese. Magnesium has been associated in studies to a lower incidence of heart attacks, while phosphorus is necessary for the synthesis of bodily tissue and energy metabolism. Millets are also a great source of phytochemicals, such as phytate, linked to a lower risk of cancer, and phytic acid (Shashi *et al*., 2007), which is thought to lower cholesterol. The dietary intake of millet and its

products is declining as a result of several factors, including the quick rate of urbanization, shifting consumer preferences, inadequate household structure, time and energy needed to prepare foods based on millets, processing methods, inadequate marketing facilities, relative scarcity of millets and their products, erratic supply, and comparisons of millet with other foods. For wheat, rice, and maize, the commercial processing methods of mechanical polishing or pearling are well established; for millet, these methods are unknown. Significant imports of wheat and rice, as well as some nations' subsidized production strategies for those commodities, have an impact on millets' yield. Millet may see significant demand if millet technologies are developed in millet industries in the future.

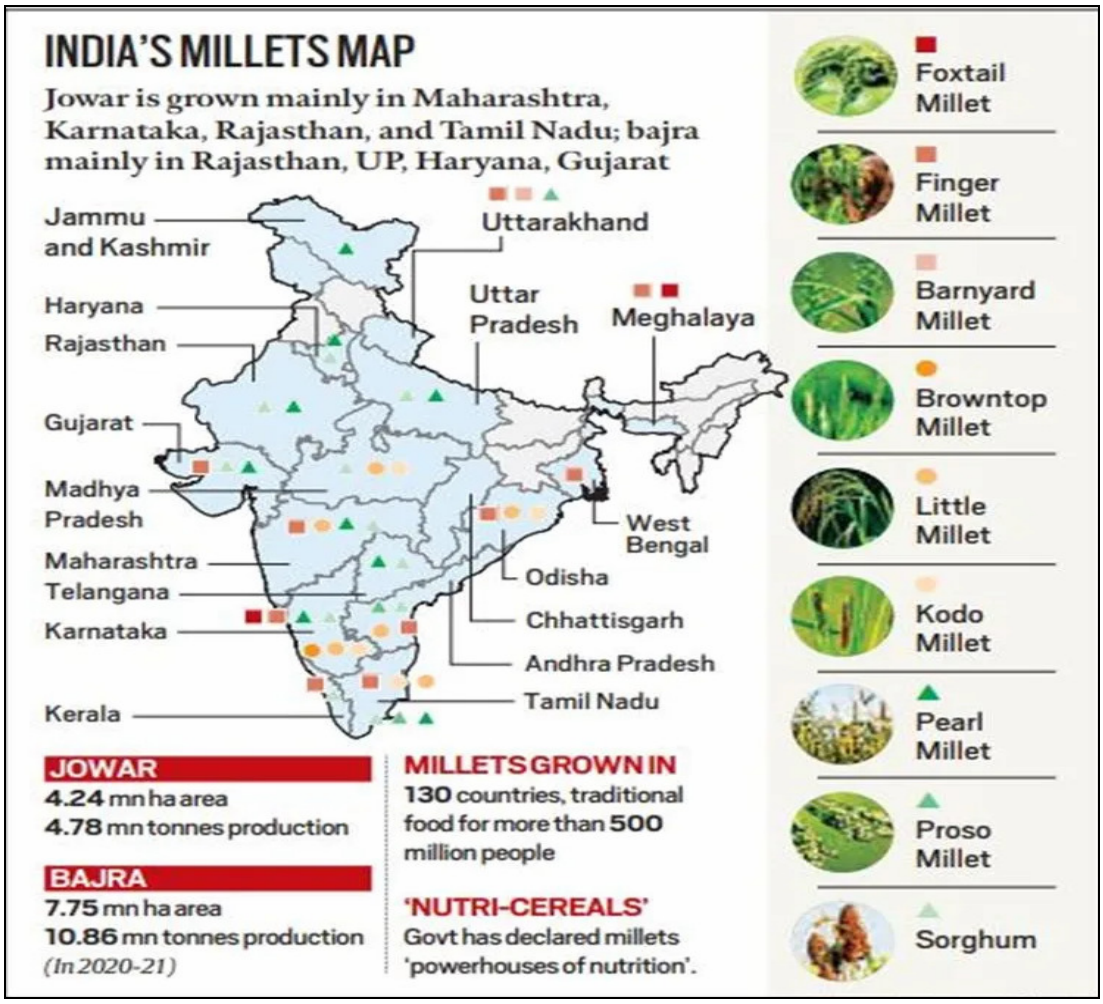

Fig. 1: Millet Map of India (*Source: Indian Express)*

Table 1: Major cultivating states of various millets

Millet Type	Major Cultivating States
Finger Millet (Ragi)	Karnataka, Tamil Nadu, Andhra Pradesh, Telangana
Pearl Millet (Bajra)	Rajasthan, Gujarat, Maharashtra, Haryana
Sorghum (Jowar)	Maharashtra, Karnataka, Andhra Pradesh, Telangana, Madhya Pradesh
Foxtail Millet (Kangni)	Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Odisha
Little Millet (Kutki)	Karnataka, Andhra Pradesh, Tamil Nadu, Telangana, Maharashtra

Significance of nutrition and its health advantages

The finger millet kernel is mostly made up of the endosperm, embryo, and seed coat (testa). Its five-layered seed coat is rich in nutritional fiber and antioxidants. Comparable to other millets and cereals, finger millet has similar amounts of carbohydrates

(81.5%), dietary fiber (18% to 20%), starch (65% to 75%), protein (9.8%), fat (1% to 1.7%), minerals (2.7%), and crude fiber (4.3%) (Saleh *et al*., 2013). Its protein content is fairly well balanced; in addition, it contains more lysine, valine, and threonine than other millets (Ravindran, 1991; Sripriya *et al*., 1997). Its mineral content and crude fiber content are particularly higher than those of rice (minerals 0.6%, fiber 0.2%) and wheat (minerals 1.5%, fiber 1.2%). Finger millet is a rich source of calcium (344 mg/100g), phosphorus (283 mg), iron (3.9 mg), vitamin B (1.71 mg), vitamin E (22 mg), and other micronutrients in addition to having proximate compositions. Its high nutritional profile provides a variety of medicinal effects. Postprandial hyperglycemia is controlled by inhibiting intestinal pancreatic amylase and α-glucosidase using the finger millet seed coat part.

As a result, by maintaining the appropriate blood glucose level, frequent consumption of finger millet as a staple food and whole meal-based product would aid in the administration of uncommon ailments of our body. Diabetic patients have reduced wound healing because of damage to nerve growth factor, and studies have demonstrated that finger millet extracts can improve this impairment by increasing the level of antioxidants and nerve growth factor synthesis (Chandra *et al*., 2016). Antioxidants are another name for tannin. Tannins neutralize pollutants, protecting our body from cell harm. Tannins have beneficial effects on the cardiovascular system, antibacterial, and anti-cancer properties. Phytate, a naturally occurring phosphorus molecule found in finger millet at 0.48%, prevents the intestines from absorbing zinc and calcium and renders them unusable (Doherty *et al*., 1982). Phytate binds strongly and can form complexes with multivalent cations and protein molecules.

The finger mill*et al*so contains saponins (0.36%) that have hemolytic properties. Both the central nervous system and the digestive system are impacted. Moreover, it results in cardiovascular disease (CVD). Protein absorption and digestibility are reduced by saponin. According to Kumar *et al*. (2016), saponins can help lower cholesterol and post-meal blood glucose levels in addition to possibly reducing the incidence of cancer. There is 0.27% of the anti-nutritional factor oxalate in finger millet. It interferes with the metabolism of magnesium and calcium (Oke, 1969), forms protein complexes that impede peptic digestion and stops the body from absorbing these minerals. Kidney stones might also result from it.

Table 2: Health benefits of using Millets in regular diet

Millets	Health benefits
Pearl Millet	Good for Insomnia
Kodo Millet	Good for Diabetics
Foxtail Millet	Good for Thyroid
Sorghum	Improves Digestive Health and Prevents Cancer
Barnyard Millet	Good for Weight Loss
Little Millet	An Indispensable Good Fat
Proso Millet	Balance Blood Sugar
Finger Millet	Good for Strengthen Bones
Horse Gram	Good for Asthma and Bronchitis

Nutritional Composition of millets:

The nutritional composition of millets varies slightly depending on the specific type of millet, but in general, they are considered highly nutritious grains. Here's a general overview of the nutritional composition of millets:

Carbohydrates: Millets are primarily composed of carbohydrates, making them a good source of energy. The type and amount of carbohydrates vary among different millet varieties.

Protein: Millets are relatively high in protein compared to other grains. They provide essential amino acids necessary for muscle building and repair.

Dietary Fiber: Millets are rich in dietary fiber, including both soluble and insoluble fiber. Fiber aids in digestion, promotes bowel regularity, and helps maintain a healthy weight.

Fat: Millets contain small amounts of fat, mostly unsaturated fats, which are beneficial for heart health when consumed in moderation.

Vitamins: Millets are a good source of various vitamins, including B vitamins such as thiamine (B1), riboflavin (B2), niacin (B3), and folate (B9). These vitamins play crucial roles in energy metabolism and overall health.

Minerals: Millets contain essential minerals like iron, calcium, magnesium, phosphorus, potassium, and zinc.

These minerals are important for bone health, muscle function, and overall wellbeing.

Antioxidants: Millets contain phytochemicals and antioxidants such as phenolic compounds, flavonoids, and carotenoids, which help protect cells from damage caused by free radicals and may reduce the risk of chronic diseases

When it comes to protein, vitamins, minerals, and energy, millets are just as nutritious as most cereals, if not more so. Table 1 lists the nutritional profile of various types of millets. According to the table, foxtail millet, pearl millet, and common millet have the highest protein content among the millets. According to Singh *et al*. (2012), millets are an excellent source of phytochemicals and minerals.

Table 3: Nutritional Information of Millets (Composition of small millets, wheat & rice (for 100 gms)

Millet	Protein	Carbs	Fat	Minerals	Fiber	Calcium	Phosphorus	Iron	Energy	Thiamin	Niacin
	(g)	(g)	(g)	(g)	(g)	(Mg)	(Mg)	(g)	(Kcal)	(Mg)	(Mg)
Finger	7.3	72	1.3	2.7	3.6	344	283	3.9	336	0.42	1.1
Sorghum	10.4	70.7	3.1	1.2	2	25	222	5.4	329	0.38	4.3
Pearl	11.8	67	4.8	2.2	2.3	43	–	11	363	0.38	2.8
Foxtail	12.3	60.2	4.3	4	6.7	31	290	2.8	351	0.59	3.2
Little	7.7	67	4.7	1.7	7.6	17	220	9.3	329	0.3	3.2
Kodo	8.3	65.9	1.4	2.6	5.2	35	188	1.7	353	0.15	2
Proso	12.5	70.4	1.1	1.9	5.2	8	206	2.9	354	0.41	4.5
Barnyard	6.2	65.5	4.8	3.7	13.6	22	280	18.6	300	0.33	4.2
Paddy Rice	6.8	78.2	0.5	0.6	1	33	160	1.8	362	0.41	4.3
Wheat	11.8	71.2	1.5	1.5	2	30	306	3.5	348	0.41	5.1

Processing of Millets

Generally speaking, the main step in processing grains and coarse cereals is to remove the offal, or portion that is unfit for human consumption. Offal is made up of the pericarp and occasionally the germ. The removal of offal is referred to as dehulling or decortication. The primary causes of millets' lower appeal among consumers of wheat and rice include their tough outer coat, a flavor that is similar to that of other grains, and the lack of processed millets that resemble rice and wheat. Numerous machinery are available for processing cereals, but no tried-and-true technique exists for turning colored millets into white products. For decortication, abrasive dehullers such as rice dehullers are occasionally employed. Decortication reduces total lysine and protein by 21 and 9%, respectively, but it also enhances the utilization of protein that remains, as noted by Pushpamma (1990). There was relatively little loss of minerals. Additionally, decoration increases nutrient availability and customer appeal. When cooked whole or decorated, millets can be consumed as a traditional grain or as a unique dish. They can also be ground into flour using conventional or industrial methods. However, it's necessary to look for other applications. Unlike wheat and rice flour, which can create an elastic, cohesive, and extended dough when mixed with water, millet flours cannot do so because they lack gluten. Because these qualities are lacking in millet flours, fortification is a way to employ millets to make processed foods that are ready to eat or serve.

Gluten free Value- added food products and beverages

Bread and biscuits (cookies)

Senegal has been making baguette-style bread with pearl millet for more than 30 years. About 85% wheat flour and 15% millet flour make up the flour's composition (Perten, 1984). The baguettes are rather smaller and darker than those made from 100% wheat flour, but they still have maintained their popularity. The absence of gluten requires a change in the bread making process to make bread from 100% non-wheat flour. Generally, a batter with some 100-150% water on a flour basis is used instead of a dough (Taylor *et al*., 2006). Hence, the process is more like cake making. Additionally, hydrocolloids, starch or gum, are normally included in the recipe in combination with the non-wheat flour (Satin, 1988). The added Gluten-free foods and beverages from millets 139 hydrocolloid seems have the same function as the absit in making injera. Around 1990, the Nigerian Federal Institute of Industrial Research carried out pioneering research into these batter breads and achieved notable success. Olatunji *et al*. (1992) made batter breads from 70% maize, sorghum or pearl millet flours, plus 30% cassava starch and the normal ingredients of yeast, salt, sugar, shortening and fungal alphaamylase. A batter was prepared using 80-100% water on a flour basis. The batter was fermented for 30 minutes, poured into baking pans, fermented for a further 20 minutes and then baked. Of the three cereal flours, pearl millet produced bread with the highest specific volume, 2.33

cm3/g. Unfortunately, however, the pearl millet gave the bread a grayish crumb color, which was judged unacceptable. With regard to making biscuits, the major problem when using non-wheat flours is that the biscuits tend to be fragile and crumble. When using pearl millet flour, Badi and Hoseney (1977) found that the only solution was to include wheat flour in the recipe. As the proportion of wheat flour was increased, the biscuits became progressively less fragile and of larger diameter. Interestingly, nearly 30 years later, Indrani *et al*. (2004) were granted a US patent for a process to make finger millet biscuits. The recipe comprises 50-60% finger millet flour and 7-10% wheat gluten powder, plus other ingredients.

Ready-to-eat food products

An excellent puffed Proso millet product is manufactured in the USA (Plate 6.2). This ready-to-eat breakfast cereal is produced by gun puffing. In gun puffing, whole grain is put into a pressure vessel (the gun) and live steam at about 1750kPa is injected. The vessel is heated up to 150°C for 1-2 minutes. A trip valve is released and the grain explodes out of the vessel. The rapid reduction in pressure causes the water in the grain to vaporize instantaneously, gelatinizing the starch and puffing up the grain. The puffing up of the grain also causes the bran to flake off. Research has also been carried out into producing ready-to-eat foxtail millet products by the use of various techniques (Ushakumari *et al*., 2004). It was found that roller drying gave the highest degree of starch gelatinization, followed by popping, flaking, and extrusion cooking. Beverages Malted finger millet powder, which is mixed with hot milk or water to make a beverage, is a popular commercial product in India (Malleshi and Hadimani, 1994). However, apparently, many of the products on the market contain less than 10% millet malt. This is due to problems with powder dispersability. Product development work is required to improve quality. In Nigeria, however, there is an excellent instant pearl millet beverage called kununtsayima, which contains pre-cooked pearl millet flour flavoured with tamarind oil. With regard to lager beer brewing with millets, this has not been researched extensively (Taylor *et al*., 2008). This is in contrast to the situation with sorghum where commercial sorghum lager beers are now being brewed in many countries. Probably the major reason for this difference is that millets are not generally available at sufficiently low cost to make them a competitive alternative for use in brewing. 140 Gluten-free cereal products and not withstanding this, the limited research that has been carried out suggests that millets represent useful brewing ingredients. For example, Nzelibe and obtained substantially higher extract (malt solubilization) when laboratory brewing with pearl millet and fonio malts rather than with sorghum malt.

Healthy food products

Probably the most important health-promoting aspect of millets as foods is that they generally contain substantial amounts of phenolics. Phenolics are notable for their antioxidant activity, which appears to be beneficial in terms of prevention of cardiovascular disease and cancer (Awika and Rooney, 2004). Unfortunately, research on the phenolic of millets is limited. However, it can be stated without doubt that all millets contain phenolic acids (Dykes and Rooney, 2006). In general, ferulic acid, p-coumaric acid, and cinnamic acids are the main types. It appears that the only millet flavonoids are flavones, which are responsible for grain pigmentation. With regard to tannin-type phenolics, it appears that finger millet is unique in that some varieties contain condensed tannins (Ramachandra *et al*., 1977). The antioxidant activity of the tannin-containing varieties is much higher than that of varieties without tannins, and similar to that of tannin sorghums (Siwela *et al*., 2007).

Millet-based Beverages

In addition to food products, millets are also used to make a variety of beverages. One popular example is millet-based milk alternatives, such as millet milk or millet-based dairy-free beverages. These beverages are made by blending millet grains with water and straining the mixture to create a smooth, creamy liquid. Millet-based beverages are suitable for those following a vegan or dairy-free diet and can be enjoyed on their own or used as a substitute for cow's milk in recipes and drinks. Additionally, millet grains can also be used to make traditional fermented beverages like millet beer or millet-based alcoholic drinks, which are popular in some cultures. These beverages are made through fermentation processes similar to those used in brewing beer or making wine.

Conclusions

The millets are more nutrient-dense than other cereals, there is no denying the potential for developing products that use and process millets to improve quality, nutrition, and overall health. Although it's not as popular among the populace as other cereals like rice and wheat, it can also be an option. Millets are less expensive but less practical to utilize because they are not widely consumed and are only used by the underprivileged and traditional people. There are several techniques and procedures for making products solely from millets and for combining millets with other ingredients; these techniques can be the same as

those for making wheat and rice or they can differ depending on the physical and chemical characteristics of the millets. Despite the millet's eating routine is particular and will likely remain such, it is nevertheless important to popularize it across a wider range. This can be achieved by creating specifically palatable meal designs that are well-liked by the common peoples.

References

Anonymous (2024a). A website https://blog.forumias.com/ millet-production-in-india/ is visited on date 05/01/2024.

Awika, J.M. and Rooney, L.W. (2004). Review: Sorghum phytochemicals and their potential impact on human health. *Phytochemistry,* 65, 1199-1221.

Badi, S.M. and Hoseney, R.C. (1977). Use of pearl millet and sorghum flours in bread and cookies. In: Dendy, D.A.V. ed. Proceedings of a Symposium on Sorghum and Millets for Human Food. London: Tropical Products Institute, pp. 37-39.

Chandra, D., Chandra, S., Sharma, A.K. (2016). Review of Finger millet (*Eleusine coracana* (L.) Gaertn): A power house of health benefiting nutrients. *Food Science and Human Wellness*; 5:149-155.

Desai, A.D., Kulkarni, S.S., Sahu, A.K., Ranveer, R.C. and Dandge, P.B. (2010). Effect of supplementation of malted ragi flour on the nutritional and sensorial quality characteristics of cake. *Adv. J. Food Sci. Tech*., 2(1): 67-71.

Doherty, J., Faubian, M., Roney, L.W. (1982). Semi-automated determination of phytate in Sorghum and Sorghum products. *Cereal Chemistry*, 59, 373-378.

Dykes, L. and Rooney, L.W. (2006). Review: Sorghum and millet phenols and antioxidants. *J. Cereal Sci*., 44, 236-251.

Indrani, D., Manohar, R.S., Rajiv, J. and Rao, G.V. (2004). Finger millet biscuit and a process for preparing the same. US Patent 2004/0191386 A1.

Kumar, S.I., Babu, C.G., Reddy, V.C., Swathi, B. (2016). Anti-Nutritional Factors in Finger Millet Journal of Nutrition and Food Science, 6.

Majumder, T.K., Premavalli, K.S. and Bawa, A.S. (2006). Effect of puffing on calcium and iron contents of ragi varieties and their utilization. *J. Food Sci. Tech*., 42(5):542-545.

Malleshi, N.G. and Hadimani, N.A. (1994). Nutritional and technological characteristics of small millets and preparation of value-added products from them. In: Riley, K.W., Gupta, S.C., Seetharman, A., and Mushonga, J.N. eds. Advances in Small Millets. New York: International Science Publisher, pp. 271-287.

Oke, O.L. (1969). Oxalic acid in plants and in nutritional world, Review of Nutrition and Dietetics; 10:263-303.

Olatunji, O., Koleoso, O.A. and Oniwinde, A.B. (1992). Recent experience on the milling of sorghum, millet, and maize for making nonwheat bread, cake, and sausage in Nigeria. In: Gomez, M. I., House, L. R., Rooney, L. W., and Dendy, D. A. V. eds. Utilization of Sorghum and Millets. Patancheru, India: ICRISAT, pp. 83-88

Perten, H. (1984). Industrial processing of millet and sorghum. In: Dendy, D.A.V. ed. Symposium: The Processing of Sorghum and Millets: Criteria for Quality of Grains and Products for Human Food. Vienna: International Association for Cereal Science and Technology, pp. 52-55.

Pushpamma, P., Ejeta, G., Mertz, E.T., Rooney, L.W., Schaffert, R. and Yohe, J. (1990). Importance of sorghum as food in Asia., Proceedings of International Conference an Sorghum Nutritional Quality, 26, 229-241.

Ramachandra, G., Virupaksha, T.K. and Shadaksharaswamy, M. (1977). Relationship between tannin levels and in vitro protein digestibility in finger millet (*Eleusine coracana* Gaertn.). *J. Agric. Food Chem*. 25, 1101-1104.

Ravindran, G. (1991). Studies on millets: proximate composition, mineral composition, phytate and oxalate content. *Food Chemistry*. 39, 99–107.

Saleh, A.S., Zhang, Q., Chen, J., Shen, Q. Millet grains (2013). Nutritional quality, processing, and potential health benefits. Comprehensive reviews in Food Science and Food Safety; 12:281-295.

Satin, M. (1988). Bread without wheat: Novel ways of making bread from cassava and sorghum could reduce the Third World's dependence on imported wheat for white bread. New Sci. 28 April, 56-59.

Shashi, B.K., Sharan, S., Hittalamani, S., Shankar, A.G. and Nagarathna, T.K. (2007). Micronutrient composition, antimicronutirent factors and bioaccessibility of iron in different finger millet (*Eleucine coracana*) genotype. Karnataka *J. Agric. Sci.,* 20(3), 583-585.

Singh, P. and Raghuvanshi, R.S. (2012). Finger millet for food and nutritional security. *African Journal of Food Science;* 6:77-84.

Siwela, M., Taylor, J.R.N., De Milliano, W.A.J. and Duodu, K.G. (2007). Occurrence and location of tannins in finger millet grain and antioxidant activity of different grain types. *Cereal Chem*. 84, 169-174.

Sripriya, G., Antony, U. and Chandra, T.S. (1997). Changes in carbohydrate, free amino acids, organic acids, phytate and HCl extractability of minerals during germination and fermentation of finger millet (*Eleusine coracana*). *Food Chemistry*. 58, 345–50.

Taylor, J.R.N., Schober, T.J. and Bean, S.R. (2006). Review: Novel and non-food uses for sorghum and millet. *J. Cereal Sci*., 44, 252-271.

Taylor, J.R. and Emmambux, M.N. (2008). Gluten-free foods and beverages from millets. In *Gluten-free cereal products and beverages* (pp. 119-V). Academic Press.

Ushakumari, S.R., Latha, S. and Malleshi, N.G. (2004). The functional properties of popped, flaked, extruded and roller-dried foxtail millet (Setariaitalica). *Int. J. Food Sci. Technol*., 39, 907-915.