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Nutritional Significance and Utilization of Millet grains in the preparation of value-added products- A Review

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Abstract

Millet is an underutilized species holding great genetic diversity and consumed by the people of low socio-economic status. Despite their nutritional superiority, utilization of millets is restricted due to non-availability of refined and processed millets in ready to eat form. Therefore, it is necessary to optimize a processed composite millet powder for the development of convenience food with application of processing and drying methods. Its essential to formulate the composite millet powder for producing the value-added products namely pasta and extrudates. The present study emphasis on the formulation of value-added products with different processing and drying methods. Successful utilization of millets with added functionality in value added food sector will open new dimensions to the food industries

Key words: Millets, composite millet powder, value added products.

INTRODUCTION

Worldwide, billions of people are experiencing food insecurity and malnutrition. Over the past decade, climate change, population growth and an economic slowdown have impacted food security. Globally, many countries are facing the challenge of both undernutrition and overnutrition. Millet is one of the indigenous foods known to humans and has been widely used in India as a staple food for thousands of years. Millets, or nutri-cereals, have the potential to play a crucial role in the fight against food insecurity and malnutrition. Millet, a versatile grain, is a highly nutritious, non-glutinous and non-acid-forming food. It contains a high amount of macro as well as micronutrients and is rich in phytochemicals, including lignans, phenolic acids and phytosterols. The nutrient content and digestibility of millets are significantly influenced by the processing techniques. Though several snack foods of different cereals, including wheat, rice, barley etc., are being prepared and marketed to the public using varying types of traditional processing techniques, snack foods prepared by incorporating processed millets would probably be an effective way to motivate the preparation of gluten-free, ready-to-eat snack foods. This review article highlights the nutritional significance and utilisation of millet grains in the preparation of value-added products.

1.1. NUTRITIONAL SIGNIFICANCE OF MILLET GRAINS

Nutritional properties of food play a vital role in maintaining the overall physical well-being of human health because the nutritional properties act as a sustainable force for health and development, which helps to maximise the human genetic potential of the body, thereby solving problems such as food insecurity, malnutrition, and dietary quality. Among the cereals, millets are referred to as poor man's cereals and are minor grains. They are also found to be higher in their nutritional properties when compared to other major cereal crops such as wheat and rice (Singh and Raghuvanshi, 2012; Parameswaran and Sadasivan, 1994). Millet grains such as finger millet, pearl millet, kodo millet, foxtail millet and little millet are unique among the minor cereal grains since they are superior in nutritional qualities and possess several health benefits with nutraceutical potential for human health (Malleshi and Hadimani *et al*., 1993). Millets are a good source of carbohydrates (67.0 g/100 g), protein (7.7–12 g/100 g), and fat (4.5-7.6 g/100 g), and they also contain a higher proportion of vitamins and minerals. The seed coat fractions contained a comparatively higher level of fat, protein, calcium, phosphorus, and iron. The dietary fibre was the highest in the seed coat, followed by whole powder (Malleshi and Hadimani *et al*., 1993; Mbithi--Mwikya *et al*., 2000).

Among vitamins, the B- group vitamins were found to be important sources of millets and they possess a higher amount of ash, iron, phosphorus, dietary fibre, and amino acids was higher than rice or wheat (FAO 1995; Ganapati *et al*., 2008). The presence of natural antioxidants like vitamin C, tocopherol, carotenoids, and polyphenols helps to prevent free radical damage in the body (Sri Devi *et al*., 2008). which play a major role in the body's immune system. The total lipid content in the foxtail, proso and finger millet ranges from 5.2 to 11.0% whereas in the little, kodo and barnyard millets it ranges from 5.1 to 8.3%. Hence, the overall qualities of all millets, which possess good protein and carbohydrate and have immense nutritional properties promote human health. Recommendation of combined millets in the form of ready-to-eat, ready- to-cook, health mix and other supplementary products would be highly beneficial.

Finger millet is a wealthy source of macronutrients and micronutrients. The nutritional properties of finger millet revealed that it contains a higher amount of carbohydrate (81.5%), protein (9.8%), crude fibre (4.37%) and minerals (2.7%), which is comparable to other cereals and millet. The seed coat of the finger millet fraction contains 13.1% protein, 3.3% fat, 5.6% ash and 43.8% dietary fibre and these values were significantly higher than those for the whole meal millet. In addition, it contains 1.25% calcium, where 50% of the calcium content of the whole grain is concentrated in the seed coat (Kurien *et al*., 1959). The crude fibre and mineral content were obviously found to be higher than wheat (1.2% fibres, 1.5% minerals). The finger millet has a high content of dietary fibre (19.1g), calcium (334g), phytate (209mg). tannins (360g), iron (2.4-6.4mg), beta-caroteine (42µg) and total minerals (2.7%). Protein is comparatively better in finger millet; it contains more lysine, threonine, and valine than other millet and it is a good source of methionine, an essential amino acid. It also contains many micronutrients like calcium, iron, phosphorus, sodium, zinc and potassium. The calcium content is superior to all cereals and the iodine content is said to be the highest among all the food grains (Upadhya *et al*., 2006; Duke 1979; Gopalan *et al*., 2000; Gopalan *et al*., 2004).

The nutritional composition of pearl millet indicates that it is a good source of energy and protein. On a dry-weight basis, it contains 7.4% protein, 6.3% fat, 2.8% fibre and 2.2% ash. Linoleic acid (44.8%), oleic acid (23.2%) and palmitic acid (22.3%) are the prevailing fatty acids in millet oil followed by stearic acid (4.0%) and linolenic acid (2.9%). The results are associated with Kamara *et al.,* (2009), who found that pearl millet contains 12.3% crude protein, 3.3% minerals and 72% carbohydrates which include the main components such as starch, protein, lipid, vitamins and minerals. It is the cheapest source of energy, protein, iron and zinc when compared to other cereals and pulses. The essential amino acid profile of pearl millet contains about 40% of lysine and methionine and it contains 30% of threonine when compared to proteins present in corn (Burton *et al*., 1972; FAO/WHO, 1995; Gopalan *et al*., 2000; Klopfenstein and Hosney *et al*., 1995).

Foxtail millet holds nearly 15% protein, 70–80% carbohydrates, and a fair amount of fibre, methionine, lecithin, vitamin E and B-complex vitamins, which include niacin, thiamin and riboflavin. It also contains a good amount of chromium with an account of 0.03mg per 100g (Bahadursingh *et al.*, 2011). In foxtail millet 79% of the edible portion indicates the presence of a high amount of fibre; it typically contains higher quantities of essential amino acids (methionine and cysteine) and it is superior in fat content to maize, rice, and sorghum (Gopalan *et al.*, 1987; Kamara *et al.*, 2009).

When compared to other major cereals, the nutritional composition of little millet and kodo millet is 65–72% carbohydrate, 8–9% protein, 1-2% fat, 2-3% minerals and 9 % fiber. The little millet contains 4.79g/100g of fat (Nirmala kumari *et al*., 2010; Ramanathan *et al*., 1957). Starch content account of 79 % that favours extrusion process in developing the expanded snack (Geervani *et al*., 1989).

The physical properties of cereals and millets are essential for the formulation of the products, which plays a vital role in the final output of the product. The physical properties of millet grains and other cereals, along with millets, were studied to analyse the functionality of millets and their products. Studying the functional properties like bulk density, swelling power, water absorption capacity, foam capacity, foam stability and oil absorption capacity of millets would have helped to enhance the quality as well as shelf life of the food products prepared from millet grains.

Combinations of different millets are being introduced for the development of products using different processing methods to retain and enrich the nutritional properties of products. During processing, changes in protein are usually observed, usually by physical, chemical, and biological means such as fermentation or enzymatic treatment, as well as changes in structure and consequently in physicochemical and functional properties (Amadou *et al*., 2011b; Saldivar, 2003).

1.2. HEALTH BENEFITS OF MILLETS

Food provides not only essential nutrients for life but also other bioactive compounds for health promotion and the prevention of diseases. Regular consumption of plant foods helps to reduce the risk of chronic degenerative diseases and biological ageing. Recent research indicates that the nutritional guidance of grains and grain products based on a food guide pyramid emphasises the importance of the consumption of grains and grain products as part of a normal diet for optimal health (USDA 2000, 2005; Singh and Sharma, 2009). The epidemiological evidence from recent research showed that plant foods protect against several degenerative diseases, including metabolic syndrome and Parkinson's disease (Gupta *et al*., 2012). Millets have been traditionally accepted as functional and nutraceutical foods for more than four decades since they provide dietary fibre, protein, energy, minerals, vitamins, and other necessary benefits for human health. It has several potential health benefits, such as preventing cancer and cardiovascular diseases, reducing the incidence of tumours, lowering blood pressure, delaying gastric emptying, etc. The consumption of whole millets has health-promoting effects that are equal to or even greater than those of fruits and vegetables and it has the potential to protect against insulin resistance, heart diseases, diabetes, ischemic stroke, obesity, breast cancer, childhood asthma and premature death (Cade *et al*., 2007). Among the millets, the minor millets possess several health benefits which could be attributed to their low carbohydrate content, low digestibility and water-soluble gum content, as they improve the glucose metabolism by slowly releasing sugar into the blood and also diminish the absorption of glucose. The dietary fibre and resistant starch present in minor millets have been endorsed to exhibit hypoglycemic and hypolipidemic effects, and they also contain phytochemicals like phenolics, tannins, phytates, microminerals, etc. that help to prevent hyperglycemia and oxidative stress (Anderson *et al.*, 1991; Ranhotra *et al.*, 1991; Srivastava *et al*., 1998).

Millets are good sources of minerals, especially magnesium and phosphorus. Intake of magnesium helps reduce the effects of migraines and lowers high blood pressure. The phosphorus present in millets is also an essential component of adenosine triphosphate (ATP), which acts as a precursor to energy in the body. Niacin helps to reduce the high cholesterol levels in the body (Guigliano *et al*., 2011; Badau *et al*., 2005; Liang *et al*., 2010; Devi *et al*., 2011; Shashi *et al*., 2007).

In recent scenarios, the changes in the utilisation pattern of processed products and the awareness of consumers about the health benefits associated with regular intake of millet foods have led to the important applications that the finger millet possesses, such as antibiotics, anti-inflammatory agents, and its functional components such as slowly digestible starch and resistant starch. It has a high proportion of complex carbohydrates in the form of non-starchy polysaccharides and dietary fibre in grains, which helps reduce cholesterol and regulate glucose in the bloodstream during digestion. It was found to be a good source of micronutrients, which helps to lessen the wide spread of micronutrient malnutrition among the vulnerable segments in developing countries (Wadikar *et al*., 2007; Shobana and Malleshi, 2007; Subba Rao and Muralikrishna, 2002; Samantray, 1989). The presence of tannin and phytic acid is responsible for the highest free radical quenching activity in non-processed brown finger millet compared to processed finger millet (Devi *et al*., 2011; Quesada *et al*., 2011; Kamara *et al*., 2012; Chandrasekhar and Shahidi, 2010; Wisker *et al.*, 1985; Gopalan *et al.*, 1981; Kang *et al.*, 2008). It reduced the levels of total serum cholesterol (LDL) by 9%, triglycerides by 15%, and HDL by 15%. The soluble dietary fibre in finger millet is an important fraction in foods because it traps fatty substances in the gastro-intestinal tract, reduces cholesterol levels in the blood, and lowers the risk of heart disease (Kurup *et al.*, 1993).

Pearl millet provides a low-cost solution to combating malnutrition due to micronutrient deficiency. Pearl millet provides an additional health-related advantage because of its higher level of insoluble dietary fibre and more balanced amino acid profile. Kodo millet has a therapeutic effect on lowering postprandial blood glucose response, possibly due to the lowering of viscous soluble fibre. Among the millets, kodo millet contains natural antioxidants and high-soluble dietary fibre for maintaining low blood glucose and inhibiting LDL cholesterol oxidation, which play a vital role in the prevention of atherosclerosis and related heart diseases. Soluble fibre present in kodo millet has gelling properties that could delay intestinal absorption (Sharma, 2003; Jenkkins *et al*., 1986).

The protein present in the proso millet could show a therapeutic effect in type 2 diabetes. The presence of polyphenols and dietary fibre in proso millet is gluten-free, and it can be used for the development of products for celiac patients. The starch present in millet is resistant starch, which escapes from digestion in the small intestine and helps in lowering caloric density and low glycemic response (Choi *et al*., 2005; Park *et al*., 2008; Hegde *et al*., 2005).

Foxtail millet has a good nutritional profile when compared to cereals such as rice and wheat in terms of protein, fibre, minerals, and vitamins, which has a potential role as a lower-gastrointestinal food. It is found to be highly nutritious, easy to digest, non-glutinous, and not an acid-forming food. Millet is considered to be one of the least allergenic and most digestible grains, and it helps to give heat to the body in cold or rainy seasons; hence, it is called a worming grain. Antioxidants and polyphenols in foxtail millet appear to be beneficial for preventing CVD, cancer, and obesity-related disorders. Pawar *et al.* (2006) found that foxtail millet contains a higher amount of bioactive compounds, which possess many health benefits, mainly in the treatment of improving cholesterol metabolism (Zhou *et al.*, 2009; Anu *et al.*, 2010). Anju *et al.* (2006) formulated biscuits prepared from foxtail millet powder that showed a significant decrease in serum glucose, serum lipids, and glycosylated haemoglobin in type 2 diabetes.

1.3. UTILIZATION OF MILLET GRAINS IN THE PREPARATION OF VALUE-ADDED PRODUCTS

In the forthcoming review of the present section, some of the value-added products and possibilities of utilising different varieties of millet as one of the basic ingredients are discussed below. Millet can be used in a variety of ways and is a great substitute for other grains, such as rice and other starchy grains. Since the seed coat of millets was normally dark in color, had a cherry texture, and had nasty odours, the food products prepared from that millet had an effect on their acceptability. Hence, to increase the consumption of millets, they were further processed to remove the seed coat, which improved the acceptability of the products.

These products are either in practice or have been demonstrated as avenues for enhanced consumption of millets among consumers since millets are nutritionally superior when compared to rice or wheat. The presence of required nutrients in millets is suitable to produce food products like snack foods, baby foods, and dietary foods (Bahadur *et al*., 2011). In the traditional preparation, the millets were consumed in the form of thick porridge (mudde or dumpling), thin fermented porridge (ambali), fried or baked pancakes (roti,dosa), and beverages. Finger millets are fermented naturally for the preparation of a product using the traditional method called 'Ambali'. Malleshi and Hadimani, 1991). The pulverised millet powder and whole meal are used to prepare traditional foods such as unleaded pancakes, stiff porridge or dumplings, and thin porridge

Generally, the millets were used for the preparation of pudding, porridge, and roti. In emerging trends, millets are used as a raw material for industrial purposes such as the production of biscuits and confectionery, beverages, weaning foods, and beers (Laminu *et al*., 2011; Anukam and Reid, 2009). Hence, malted and fermented millet powder is usually used in the preparation of weaning foods, instant mixes, and beverages in pharmaceutical products. (Gomez *et* al., 1993; Rao *et al.*, 2001). The most popular weaning food blends prepared from fermented pearl millet and cowpea in 70:30 and 60:40 ratios were found to have resulted in lowering the levels of phytic acids, and the increased *in vitro* protein digestibility of the weaning food blends was found to promote growth in children. (Laminu *et al*., 2011). To improve the utilisation of millets among consumers, modern methods of preparation were developed for the incorporation of millet powder in wheat flour with different ratios for the development of bread, biscuits, and other snacks, which helps to improve the nutritive value of the foods (Mridula *et al.,* 2007; Akeredolu *et al*., 2005). Soft biscuits and cookies are developed using sorghum, maize, and wheat composites. (Akeredolu *et al*., 2005; Hama *et al*., 2011; Laminu *et al*., 2011).

In recent days, extrusion technology has become popular among food industries and consumers. This method satisfies not only consumer demand but also helps to meet the necessary requirements for people suffering from wheat tolerances such as celiac disease (Sabanins and Tzia, 2009; Faller *et al*., 1999). Due to economic and nutritional considerations, it is desirable to replace wheat flour with other locally available non-gluten flours to develop a product. Some of the alternative cereals, like barley, sorghum, millet, and amaranth, as well as grains like flaxseed and quinoa, are used for extrusion processes (Plahar *et al*., 2003; Arya, 1990). Ready-to-eat extruded breakfast cereal products were prepared by using millet, amaranth, and buckwheat as replacements for wheat and maize flour. The result shows that there was an alteration in the physical and nutritional quality of the extruded breakfast cereal. The pasta is a well-known ancient and versatile dish for both nutritive and gastronomic reasons. It was found to be consumed at large by people all over the world. This has a significant quality of complex carbohydrates, protein, B-vitamin, and iron and is low in sodium, amino acids, and total fats. (Antognelli, 1980; Breman *et al*., 2012.). Pasta prepared from millets had rich sources of carbohydrates (74.77%) and a low glycemic index. (Monge *et al*., 1990). The inclusion of pseudo-céréals showed a significant reduction in readily digestible carbohydrates and slowly digestible carbohydrates when compared to the control products.

The composite flour containing finger millet and wheat flour in the ratios of 60:40 and 70:30 (w/w) was used in the formulation of biscuits, and the quality characteristics were evaluated for the dough and biscuits. The results indicated that the biscuit prepared from composite flour in the ratio of 60:40 was found to be the best. The effect of replacing wheat flour with different percents from 0% to 100% was studied, in which 100% finger millet flour was replaced for the development of muffins. The muffin prepared from the combination of 60% finger millet flour was found to be significantly increased in volume and in quality characteristics. (Rajiv *et al*., 2011; Saha *et al*., 2011). In addition, as a new technology, the incorporation of finger millet powder with refined wheat flour in a different proportion (30%–50%) was used for the preparation of noodles for diabetic patients. The results of the sensory evaluation showed that 30% of finger millet-incorporated noodles were found to be acceptable, and they were evaluated for glycemic response. The results revealed that finger millet-incorporated noodles had a significantly lower glycemic index when compared to control noodles (Shukla and Srivastava, 2011).

Pearl millet flour was used for the formulation of cookies, which did not spread during baking, had poor top grain character, and looked dense and compact. Fermented foods like rabadi, which used pearl millet, had a shelf life of 7 days. Another combination of pearl millet, finger, and decorticated soybean blends was used for extrudates, which was carried out by a linear programming (LP) model since it was used to minimise the total cost of the finished product. Ready-to-eat desserts like kheer were formulated using pearl millet flour, and they were reported to be acceptable among consumers (Abdel Rahaman *et al.,* 2005; Balasubramanian *et al*., 2012; Singh *et al*., 2000; Badi *et al*., 1976; Modha and Pal *et al*., 2011; Jha *et al.,* 2011). Popped pearl millet, rich in fibre, carbohydrates, and energy, is used for developing weaning foods or food supplements (Bhaskaran *et al*., 1990). Pearl millet was used to prepare the flakes, which are rich in fibre and an ideal snack for the obese and calorie consumers (Hadimani and Malleshi, 1993).

The foxtail millet and barnyard millet were used to prepare biscuits, from which sensory analysis was carried out, and they were found to be acceptable among the diabetic subjects. Bread was prepared using millet-based composite flours using barnyard millet and wheat composite flours with a proportion of 61.8 g/100 g of barnyard millet, 31.4 g/100 g of wheat, and 6.8 g/100 g of gluten. The results of the sensory analysis were found to be acceptable among consumers (Anju *et al.,* 2010; Singh *et al*., 2012). Weaning foods and thinner gruel with low viscosity were prepared using millet flours such as kodo millet and barnyard millet, as well as other flours, namely wheat flour and soy flour, for the preparation of products, and it was found to increase the level of syneresis that may improve the resistant starch content on storage (Vijayakumar and Mohanakumar, 2009).

One of the most traditional and highly popular cereal-based products is pasta. It was highly acceptable among consumers because of its convenience, nutritional quality, and palatability, and it became one of the most popular foods with high acceptability scores among the population groups. In order to increase the acceptability of products, they can be readily incorporated with new ingredients in large-scale utilisation by the industry for the production of pasta (Cubadda *et al*., 2007; Goni and Valentine-Gamazo, 2003).

In the food industry, extrusion technology has been commercially stable for a long time. The convectional ingredients used for extrusion processing are starch-based food materials like corn, rice, and semolina. The extrusion process involves a high-temperature, short-time process, simultaneous thermal and pressure treatment, and also mechanical shearing. As a result, the extrudates underwent several changes, such as the gelatinization of starch, the denaturation of protein, and even complete cooking for the final product. For popular breakfast cereals in commercialised industry, the extrudates were developed using corn and oatmeal (Sefa-Dedeh *et al*., 2003; Rossen and Miller, 1973). The commonly used ingredients for the development of extrudate products are corn flour, which is rich in carbohydrates and fibres but relatively low in protein content. In the large-scale industry, extruded products usually contain a high-quality protein mix that is formulated using local ingredients. In the present scenario, the food processing industry has the challenge of developing convenience foods such as breakfast cereals and snacks with high nutritional value. Popular extrudate products that are consumed worldwide are spaghetti, macaroni, vermicelli, and noodles. The main ingredient for the preparation of pasta is durum wheat (Frame, 1994; Muhungu *et al*., 1999; Warren *et al*., 1983).

Extrusion plays a vital role in modern technology. Extrusion cooking had a significant effect on the development of the products. Extruded products not only enhance the acceptability of the products but also help to improve their appearance, taste, and texture. The effect of extrusion on their nutritive value has had limited studies (Castello *et al*., 1998; Noguchi *et al*., 1982). The extruded products, developed from rice flour or starch, were found to be low in protein and have low biological value as they have a lower content of amino acids. So in order to improve the nutritional contents of the extruded products, the fortification was carried out with cereals, high-protein foods, and lysine foods to improve the amino acid content (Baskaran and Bhattacharya, 2004). The products prepared using millet and legume flour blends are being carried out in India to form nutritionally balanced foods that can be used as supplementary food products for malnourished children. Soy-fortified millet-based products were prepared from sorghum blended with soy, millet, and rice. (Seth *et al*., 2012; NRC, 1996). Malleshi *et al.* (1996) reported that millet grits and flour are used to prepare ready-to eat products. Soya or protein-rich ingredients, namely legumes or groundnuts, are blended with pearl millet for extrusion. Extrusion cooking has the potential to inactivate anti-nutritional factors such as lysine inhibitors and urease activity, reduce the growth of the fungal pathogen Fusarium, and increase the shelf life of the product as well. The extruded products were prepared to improve the nutritive value of developed supplementary foods with the addition of soy to corn extruded products, which serves as a tool to produce healthy foods.

CONCLUSION

The international year of millets was celebrated in 2023 recognizing their importance by the government. Millet is considered as ancient crops with a long history of cultivation, its play a crucial role in providing a diverse culture throughout worldwide. Millet grains are considered as a nutritional powerhouse which helps in varies health benefits. These wholesome grains are valuable source of essential nutrients, including fibre, minerals, and antioxidants, contributing to improve digestion, bone health and disease prevention. It considered as a low glycaemic index foods which are an ideal option for maintaining the stable blood sugar levels and managing diabetes. Additionally, their gluten free nature makes the millets suitable for individuals with celiac disease and supports a healthy gut. Incorporation of millet and millet products as a regular part of our diet can helps to lead the overall well-being and a healthy lifestyle.

REFERENCE

[1] Akeredulu,I.A., Addo, A.A. and Akeredolu. 2005. Clinical evaluation of pearl millet technology Conophor weaning mix as supplementary food for Nigerian children. *Brazil Archeology Biology*, 48(4):531-536.

[2] Amadou,I., Guo-Wei., Yong-Hui,S., Gbadamosi,O.S., Kamara and Sun,J., 2011b.Optimized *Lactobacillus Plantarum* LP6 solid-state fermentation and proteolytic hydrolysis improve some nutritional attributes of soyabean protein meal. *Journal of Food Biochemistry,* 35(6):1686-1694.

[3] Anderson, J.W., Hamilton, C.C., Horn, J.L., Spencer, D.B., Dillon, D.W. and Zeigler, J.A., 1991. Metabolic effects of insoluble oat fiber in lean men with Type II diabetes. *Cereal Chemistry,* 68: 291-294.

[4] Anju, T. and Sarita, S. 2010. Suitability of foxtail millet (Setaria italica) and barnyard millet (Echinochloa frumentacea) for development of low glycemic index biscuits. *Malaya Journal of Nutrition*, *16*(3), 361-368.

[5] Anju, T. and Sarita, S. 2010. Suitability of foxtail millet (Setaria italica) and barnyard millet (Echinochloa frumentacea) for development of low glycemic index biscuits. *Malaya Journal of Nutrition*, *16*(3), 361-368.

[6] Antognelli, C. 1980. The manufacture of pasta as a food ingredient: *A Review Journal Food Technology,* 15: 125-145.

[7] Anu., Sehgal, S. and Kawatra, A. 2010. Use of pearl millet and green gram flours in biscuits and their sensory and nutritional quality. *Journal Food Science Technology,* 44(5):536-538.

[8] Arya, S.S. 1990. Grain based snack and convenience foods. *Indian Food Packer*, 44(5): 17-38.

[9] Badau, M.H., Nkama, I and Jideani, I.A. 2005. Phytic acid content and hydrochloric acid extractability of minerals in pearl millet as affected by germination time and cultivar. *Food Chemistry,* 92(3):425-435.

[10] Badi, S.M., Hoseney, R.C and Finlay, P.C.1976. Pearl millet II partial characterization of starch and use of millet flour in bread making. *Cereal Chemistry,* 53:718-724.

[11] Bahadur Singh Hathan, B.L. and Prassan. 2011. World academy of science. *Engineering* and *Technology,* 60.

[12] Balasubramanian, S., Yadav, D.N., Kaur, J. and Anand, T. 2012. Development and shelf-life evaluation of pearl millet based upma dry mix. *Journal of Food Science and Technology, 49(5):572-579*

[13] Baskaran, K., Ahamath, B. K., Shanmugasundaram, K. R. and Shanmugasundaram, E. R. B. 1990. Antidiabetic effect of a leaf extract from Gymnema sylvestre in non-insulin-dependent diabetes mellitus patients. *Journal of Ethnopharmacology*, *30*(3), 295-305.

[14] Baskaran, V. and Bhallacharaya. S. 2004.Nutritional status of the protein of corn-soy based extruded products evaluated by rat bioassay. *Plant Foods Human Nutrition*, 59:101-104.

[15] Brennan, C.S. and Tudorica, C.M. (2007). Fresh pasta quality as affected by enrichment of nonstarch polysaccharides. *Journal of Food Science,* 72: 659-665.

[16] Cade, J.E., Berley. and Greenwood, D.C. 2007. Dietary fibre and risk of breast cancer in the UK women's cohort study. *International Journal of Epidemiological*, 36:431-438.

[17] Castelo, M.M., Kalta, S.K., Summer, S.S., Hanna, M.A. and Butterman, L.B. 1998. Extrusion Cooking reduces recoverability of fumornism B from extruded corn grits. *Journal of Food Science,* 63: 698-698.

[18] Chandrasekara, A and Shahidi, F. 2010. Content of insoluble bound phenolics in millets and their contribution of antioxidant capacity. *Journal of Agriculture Food Chemistry*, 58: 6706-6714.

[19] Choi,Y.Y., Osada,K., Ito,Y., Nagasawa,T., Choi. and Nishi Zawa, N. 2005. Effect of dietary protein of Korean foxtail millet on plasma adiponectin, HDL-Cholesterol, and insulin levels in genetically type 2 diabetic mice. *Bioscience Biotechnology Biochemistry,* 69:31-37.

[20] Cubadda, R.E., Carcea, M., Marconi, E. and Trivisonno, M.C. 2007. Influence of gluten protein and drying temperature on the cooking of durum wheat pasta. *Cereal Chemistry,* 84 (1):48-55.

[21] Devi,P.B., Vijayabharathi, Sathyabama, S., Malleshi,N.G. and Priyadarishini.V.B. 2011. Health benefits of finger millet (*Eleusine coracana L.*) polyphenols and dietary fiber: A Review. *Journal of Food Science Technology, 1-20.*

[22] Faller, J.Y., Klein, B.P. and Faller, J.F. 1999. Acceptability of extruded corn snacks as affected by inclusion of soy protein. *Journal of Food Science,* 64:185-188.

[23]Ganapathi.S., Nirmala kumari.A. and Raveendran.T.S. 2008. Centre for plant breeding and genetics. *World Journal of Agricultural Sciences*, 4(4): 483- 486.

[24] Geervani, P and Eggum, B.O. 1989 Nutrient composition and protein quality of minor millets. *Plant Foods Human Nutrition*. 39:201-208.

[25] Goni,Isabel, and Valentin –G amazo, Carmen. 2003. Chickpea flour ingredient slows glycemic responses to pasta in healthy volunteers. *Food Chemistry,* 81(4): 511-515.

[26] Gopalan, C., Ramasastri, B.V. and Balasubramanian, S.C., 2000. Nutritive value of Indian foods. National Institute of Nutrition, ICMR, Hyderabad. 59-67.

[27] Guigliano, R.P. 2011. Niacin at 56 years of age time for an early retirement. *The New England Journal Medicine,* 360: 2318-2320.

[28] Gupta, N., Srivastava, A.K. and Pandey, V.N.2012. Biodiversity and nutraceutial quality of some Indian millets, prodceedings of the national Academy of Sciences, India section B: Biological Science.

[29] Hadimani, N.A. and Malleshi, N.G. 1993. Studies on milling physicochemical properties, nutrient composition and dietary fiber contents of millets. *Journal of Food Science Technology,* 30: 193-198.

[30] Hama, F., Icard-Verniere, C., Guyot, J.P., Picq, C., Diawara, B. and Mouquet-Rivier `C. 2011. Changes in micro and macronutrient composition of pearl millet and white sorghum during in-field versus laboratory decortication. *Journal Cereal Science,* 54: 425–33.

[31] Hegde,P.S. and Chandra, T.S. 2005. ESR spectroscopic study reveals higher free radical quenching potential in kodo millet (*Paspalum scrobiculatum*) compared to other millets. *Food Chemistry,* 92: 177-82.

[32] Jha, A., Tripathi, A.D., Alam, T. and Yadav, R. 2011. Process optimization for manufacture of pearl millet based dairy dessert by response surface methodology. *Journal of Food Science and Technology,* Doi:10.1007/s13197-011-0347-7.

[33] Kamara, M.T., Amadou, I. and Zhou, H.M. 2012. Antioxidant activity of fractionated foxtail millet protein hydrolysate. *International Food Research Journal,* 19: 59-66.

[34] Kamara, M.T., Zhou, H. M., Zhu, K. X., Amadou, I. and Tarawalie. F. 2009. Comparative study of chemical composition and physicochemical properties of two varieties of defatted foxtail millet flour grown in China. *American Journal Food Technology,* 4(3): 255–267.

[35] Kang, R.K., Jain, R and Mridula, D., 2008. Impact of indigenous fiber rich premix supplementation on blood glucose levels in diabetics. *American Journal of Food Technology*, 3 (1): 50-55.

[36] Kurup, P.G., Krishnamurthy, S. 1993. Glycemic response and lipemic index of rice, ragi and tapioca as compared to wheat diet inhuman. *Indian Journal Experimental Biology,* 31: 291–293.

[37] Laminu, H.H., Modu, S. and Numan, A.I. 2011. Production in vitro protein digestibility, phytate content and acceptability of weaning foods prepared from pearl millet (*Pennisetum typhoideum*) and cowpea (*Vigna unguiculata*). *International Journal Nutrition Metabolism,* 3(9): 109-113.

[38] Laminu, H.H., Modu, S. and Numan, A.I. 2011. Production in vitro protein digestibility, phytate content and acceptability of weaning foods prepared from pearl millet (*Pennisetum typhoideum*) and cowpea (*Vigna unguiculata*). *International Journal Nutrition Metabolism,* 3(9): 109-113.

[39] Liang, S., Yang, G. and Ma, Y. 2010. Chemical characteristics and fatty acid profile of foxtail millet bran oil. *Journal of American Oil Chemistry Society,* 87: 63-67.

[40] Malleshi, N.G., Hadimani, N.A., Chinnaswamy, R. and Klopfenstein, C.F. 1996. Physical and nutritional qualities of extruded weaning foods containing sorghum, pearl millet or finger millet blended with mung beans and non-fat dried milk. *Plant Foods of Human Nutrition,* 49:181-189.

[41] Malleshi, N.G., Hadimani, N.A., Riley, K.W., Gupta, S.C., Seetharam, A. and Mushonga, J.N., 1993.Nutritional and technological characteristics of small millets and preparation of value added products from them. In Advances in Small Millets, Oxford and IBH publishing: New Delhi. 270-281.

[42] Malleshi, N.G., Hadimani, N.A., Riley, K.W., Gupta, S.C., Seetharam, A. and Mushonga, J.N., 1993.Nutritional and technological characteristics of small millets and preparation of value added products from them. In Advances in Small Millets, Oxford and IBH publishing: New Delhi. 270-281.

[43] Mbithi- Mwikya, S., Van camp, J., Yiru, Y. and Huyghebaert, A. 2000. Nutrient and anti-nutrient changes in finger millet during sprouting. *Lebensm-wiss-u-technology,* 33: 9-14.

[44] Modha, M. and Pal, D. 2011.Optimization of rabadi-like fermented milk beverage using pearl millet. *Journal of Food Science Technology*, 48: 190-196.

[45] Monge, L., Cortassa, G., Fiachi, F., Mussino, G. and Carta, Q. 1990. Calycoinsulinaemic response digestion and intestinal absorption of the starch contained in 2 types of spaghetti. *Diabetes, Nutrition and Metabolis,*.3: 239 -246.

[46] Mridula, D., Gupta, R.K. and Maikantan, M.R. 2007. Effect of incorporating sorghum powder to wheat powder on quality of biscuits fortified with deflate soy powder. *Africa Journal of Food Technology,* 2: 428-434.

[47] Muhungu, S. M., Diaz-Mercado, S. Li. J., Schwenk, M., Singletary, K. and Faller, J. (1999). Stability of isoflavones during extrusion processing of corn/soy mixture. *Journal of Agriculture and Food Chemistry,* 47(1): 279–284.

[48] Nirmala kumari.A., Saline, K and Veerabathiran.P. 2010. Department of millets, Electronic. *Journal of Plant Breeding Genetics,* (2): 148-155.

[49] Noguchi, A., Mosso, K., Aymard, C., Jeunink, J., and Cheflet, J.C. 1982. Millard reaction during extrusion cooking of protein enriched biscuits. *Rebens Wiss Technology,* 15: 105-110.

[50] Park,K.O., Ito.Y., Nagasawa.T., Choi,M.R. and Nishizawa. N. 2008. Effects of dietary Korean proso millet protein on plasma adinopectin, HDL-Cholesterol, insulin levels and gene expression in obese type 2 diabetic mice. *Bioscience Biotechnology Biochemistry,* 72(11): 2918-2925.

[51] Pawar, V.D and Machewad, G.M. 2006. Processing of foxtail millet for improved nutrient availability. *Journal of Food Processing Preservation*. 30:269–79.

[52] Plahar, W.A., Onumaokezie, B. and Cryato, C.K. 2003. Development of a high protein weaning food by extrusion cooking using peanuts maize and soybeans. *Plant Food of Human Nutrition,* 58:1-12.

[53] Rajiv,J., Soumya,C., Indrani, D. and Rao,G.V. 2011.Effect of replacement of wheat flour with finger millet flour (*Eleusine corcana*) on the batter microscopy, rheology and quality characteristics of muffin. *Journal of Texture studies*.42:478-89.

[54] Ranhotra, G.S., Gelroth, J.A., Astroth, K. and Eisenbraun, G.J.1991 Effect of resistant starch on intestinal responses in rats. *Cereal Chemistry*. 68 (2): 130-132.

[55] Rossen, J. and Miller, R. C. 1973. Food Extrusion. *Journal of Food Technology,* 27(8): 46–53.

[56] Sabanins, D. and Tzia, C. 2009. Effect of rice, corn and soy flour addition on characteristics of bread produced from different wheat cultivars. *Food Bioprocess Technology, (22-45).*

[57] Saha, S., Gupta, A., Singh, S.R.K., Bharti, N, Singh, K.P, Mahajan, V. and Gupta, H.S. 2011. Compositional and varietal influence of finger millet flour on rheological properties of dough and quality of biscuit. *LWT—Food Science Technology,* 44(3): 616–21.

[58] Saldivar, S. 2003. Cereals: Dietary importance .In: B.Carllero, L.Trugo and P.Finglas(Eds). Encyclopedia of Food Science and Nutrition, Reino unido: Academic Press, Agosto, London.1027-1033.

[59] Samantray, G.T., Misra, P.K. and Patnaik, K.K. 1989. Mineral composition of ragi. Indian of Journal of Nutrition and Dietetics, 26: 113-116.

[60] Sefa-Dedeh S., Cornelius, B. and Afoakwa, E.O. 2003. Application of response surface methodology to study the quality characteristics of cowpea-fortified nixtamalized maize. *Journal of Food Technology*, 4: 109 -119.

[61] Seth, D. and Rajamanickum, G. 2012. Development of extruded snacks using soy, sorghum, millet and rice blend-A responses surface methodology approach, *International Journal of Food Science and Technology,* 47(7): 1526-1531.

[62] Sharma, A. and Kapoor, A. 2003. Levels of anti-nutritional factors in pearl millet as affected by processing treatment and various types of fermentation. *Plant Foods Human and Nutrition,* 49: 241-252.

[63] Shobana S, Malleshi, N.G. 2007 Preparation and functional properties of decorticated finger millet (*Eleusine coracana*). *Journal of Food Engineering*. 79:529–538.

[64] Singh, K.P., Mishra, A. and Mishra, H.N. 2012. Fuzzy analysis of sensory attributes of bread prepared from millet-based composite flours. *LWT—Food Science Technology,* 48: 276–82.

[65] Singh, P. and Raghuvanshi, R.S. 2012. Finger millet for food and nutritional security. *African Journal of Food Science*. 6(4): 77-84.

[66] Singh, P.P and Sharma,P. 2009.Antioxidant basket :do not mix apples and oranges. *Indian Journal of Clinical Biochemistry,* 24(3): 211-214.

[67] Sridevi., Nirmala, Y. and Basarkar, D.W. 2008. Antioxidant contents of whole grain cereals of North Karanatka. *Karnatka Journal of Agricultural Science*, (21): 602-603.

[68] Srivastava, S and Batra, A.1998. Popping qualities of minor millets and their relationship with grain physical properties. *Journal Food Science and Technology,* 35(3): 265-267.

[69] Subba Rao, M. V. S. S. T. and Muralikrishna, G. (2002). Evaluation of the antioxidant properties of free and bound phenolic acids from native and malted finger millet (Ragi, Eleusine coracana Indaf-15). *Journal of Agricultural and Food Chemistry*, *50*(4), 889-892.

[70] Upadhya ,H., Gowda, C.L.L., Pundir, R.P.S., Reddy, G.V. and Singh. S. 2006. Development of core sub set of finger millet germplasm using geographical origin and data on 14 quantitative traits. *Journal of plant science,* 53: 679-685.

[71] USDA, 2005. Nutrition and your health: Dietary guidelines for Americans: US department of Agricultural. Department of Health and Human services, Washington, DC.

[72] Vijayakumar, P.T. and Mohankumar, J.B. 2009. Formulation and characterization of millet flour blend incorporated composite flour. *International Journal of Agricultural Science,*1(2): 46-54.

[73] Wadikar, D.D., Prevalli, R.S., Satyanarayanswamy, Y.S. and Bawa, A.S. 2007. Lipid profile in finger millet. *Journal of Food Science Technology,* 44(1): 79-81.

[74] Warren, A.B., 1983, Protein fortification of cookies, crakers and snacks bars: uses and needs. *Cereal of food world,* 28: 441-445

[75] Wisker, E., Feldheim, W., Pomeranz, X. and Meuser, F., 1985. Dietary fibre in cereals. *Advance Cereal Science Technology,* 7: 169-238.