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Finger Millet: A Potential Commodity for Nutritional Security and Entrepreneurship Development – A Perspective

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Abstract

Finger millet (*Eleusine coracana* L.), one of the small millets, is known for several health benefits and some of the health benefits are attributed to its polyphenol and dietary fiber contents. It is an important staple food in India for people of low income groups. Finger millet is comparable to rice with regard to protein (6-8%) and fat (1-2%) and is superior to rice and wheat with respect to mineral and micro-nutrients. It is a major source of dietary carbohydrates for a large section of the society specially the people residing in the tribal and forest belts. Nutritionally, its importance is well recognised because of its high content of calcium (344 mg/100 g), dietary fiber (22 g/100 g) and phenolic compounds (0.3 – 3%). Finger millet is also recognised for its health beneficial effects, such as anti-diabetic, antioxidant and antimicrobial properties. However, its utilization in the daily dietary at present is confined to the areas where it is grown only. Unavailability of products to the taste of urban mass is the main reason capping the utilization. Processing the finger millet using traditional as well as modern techniques for the development of value added products would be the possible solution to enhance the consumption of this important commodity. Establishment of enterprises using finger millet at production catchment and its vicinity will further support the nutritional security and generate employment for livelihood. The aim of this paper is to describe the recent advances developed in the area of utilization of finger millet for the preparation of value added products.

Keywords

Finger millet
Ragi
Value addition
Value added products

INTRODUCTION

Finger millet is important millet grown extensively in various regions of India and Africa constituting as a staple food for a large section of the population in these countries. Millets are small-seeded with different varieties such as pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracana*), kodo millet (*Paspalum setaceum*), proso millet (*Penicum miliaceum*), foxtail millet (*Setaria italic*), little millet (*Panicum sumatrense*), and barnyard millet (*Echinochloa utilis*). They are known as coarse cereals beside maize, sorghum, oats and barley. The world total production of millet grains at last count was 762712 MT and the top producer was India with an annual production of 334500 MT (43.85%) (FAO, 2012). Finger millet is known as *ragi* and *mandia* in the Bastar region of Chhattisgarh and offers both nutritional and livelihood security for human beings and also feed security for diverse livestock populations in dryland regions of rural India (Pradhan *et al.*, 2010). Millets are not placed as a single important commodity in the North American and European food basket at the present time, but their importance as an ingredient in multigrain and gluten-free-cereal products has been highlighted. In many Asian and African areas, millets serve as a major food component and various traditional foods and beverages, such as bread (fermented or non-fermented), porridges, and snack foods are made of millets, specifically among the no affluent segments in their respective societies (Chandrasekara and Shahidi, 2011). In addition to their nutritive value, several potential health benefits such as preventing cancer and cardiovascular diseases, reducing tumor incidence, lowering blood pressure, risk of heart disease, cholesterol and rate of fat absorption, delaying gastric emptying, and supplying gastrointestinal bulk have been reported for millet (Truswell, 2002; Gupta *et al.*, 2012). Millet grains, before consumption and for preparing of food, are usually processed by commonly used traditional processing techniques including decorticating, malting, fermentation, roasting, flaking, and grinding to improve their edible, nutritional, and sensory properties. However, negative changes in these properties during processing are not avoidable because industrial methods for processing of millets

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are not as well developed as the methods used for processing of wheat and rice (FAO, 2012). Therefore, with value added strategies and appropriate processing technologies, millet grains especially the finger millet can find a place in the preparation of several value added and health food products, which may then result in high demand from large urban population and non-traditional millet users (Mal *et al*., 2010). The aim of this paper is to describe some basic information about finger millet, the processing requirement and some useful avenues for its value addition and food uses.

NUTRITIVE VALUE

Nutritional quality of food is a key element in maintaining human overall physical well-being because nutritional well being is a sustainable force for health and development and maximization of the genetic potential. Therefore, for solving the problem of deep rooted food insecurity and malnutrition, dietary quality should be taken into consideration (Singh and Raghuvanshi 2012). In addition to easy cultivation practices, millets are found to have high nutritive value and well comparable with the major cereals wheat and rice. Further the millet proteins are good sources of essential amino acids except few such as lysine and threonine. Finger millet is rich sources of phytochemicals and micronutrients (Mal *et al*., 2010). Finger millet is known to have several potential health benefits and some of the health benefits are attributed to its polyphenol contents (Chethan and Malleshi 2007). It has a carbohydrate content of 81.5%, protein 9.8%, crude fiber 4.3%, and mineral 2.7% that is comparable to other cereals and millets. Its crude fiber and mineral contents are significantly higher than those of wheat (1.2% fiber, 1.5% minerals) and rice (0.2% fiber, 0.6% minerals); its protein is relatively better balanced; it contains more lysine, threonine, and valine than other millets (Ravindra 1991; Sripriya *et al*., 1997). In addition, black finger millet contains 8.71 mg/g dry weight fatty acid and 8.47 g/g dry weight protein (Glew *et al*., 2008). Thus, the presence of all the required nutrients in finger millet make it suitable for large-scale utilization in the manufacture of food products such as baby foods, snack foods, and dietary food and, increasingly, more millets products have entered into the daily lives of people, including millet porridge, millet wine and millet nutrition powder from both grain and flour form (Subramanian and Vishwanthan, 2007).

It is worth mentioning that no other cereal comes close to finger millet when it comes to calcium content. The natural fat content in it is lower than all other cereals which is in unsaturated form, a good choice for people trying to lose weight. Further, it contains an amino acid known as Tryptophan which reduces the appetite. The average nutritional composition of finger millets along with other cereals is being reproduced in Table 1 for easy look of the readers (Malleshi, 2007).

Table 1: Nutritional composition of finger millet compared to other cereals (g/100 g)

Food grain	Proteins	Carbohydrates	Fat	Dietary fibre	Minerals	Calcium (mg)	Phosphorus (mg)
Finger millet	7.3	72.0	1.3	18.8	2.7	344	283
Wheat	11.8	71.2	1.5	12.9	1.5	41	306
Rice	6.8	78.2	0.5	5.2	0.6	10	160
Barley	11.5	69.6	1.3	22.3	1.2	26	215
Maize	11.1	66.2	3.6	10.5	1.5	20	348
Sorghum	10.4	72.6	1.9	12.0	1.6	25	222
Oats	11.6	69.8	5.2	20.0	2.9	94	385

PROCESSING AND VALUE ADDITION

Related to improvement of nutritional characteristics, sensory properties and convenience in preparation to transform into edible and acceptable foods, there are some processing operations essentially required in the manufacturing of food products.

Similar to other cereal grains finger millet is also required to undergo certain basic steps of primary processing operations, such as cleaning, grading and separation wherein removal of unwanted materials like, stones, soil particles, stalks, chaffs, grains of other crops etc. These operations are also important for adding value to the produce from the point of view of getting better returns from their sale. The finger millet grain is essentially covered with an outer thin pericarp known as glume which needs to be removed from the kernel prior to further processing as it is non-edible tissue. Glume is separated by giving mild abrasive action with the help of hand or foot pounding operation. This is also possible with the help of hullers used for dehusking of paddy. Specially designed *ragi* polishers are also available for this purpose in southern part of India. Pre-cleaning operations are accomplished by using cleaners and destoners used for other cereals after making suitable modification/retrofitting.

MILLING

The most common primary processing of finger millet is to convert the grain in the form of flour which is achieved by pulverizing or milling. Different types of conventional and modern equipments/machines are available for milling the finger millet grains into flour. Some of them are; conventional stone mills, burr mills (steel or emery type), hammer mills, ball mills etc. Since the whole meal is used for different preparations, the fineness of the flour or the machine by which it is prepared does not arise. On demand of the recipe the coarser flour is separated by sieving the whole meal. Till date, no scientific definition about the millet flour for traditional preparations like chapatti (*roti*), mudde of Karnataka, *pez* of Bastar *etc.* has been established. However, finer flour is preferred for making chapatti whereas comparatively coarser flour is suitable for *mudde* and *pez* making depending upon the cooking methods. *Mudde* is a typical preparation of Karnataka and very often prepared during social functions. *Ambli* is another traditional preparation but it is something like thin porridge and not the stiff like *mudde*. *Pez* is a typical traditional preparation of Bastar in the form of thin porridge or gruel like cooking; it also contains few cooked rice grains. Coarser flour helps in lump formation during *mudde* preparation and that of finer flour absorbs more water due to higher surface area and facilitates flattering for chapatti making. It is worth mentioning here that fortified mix has not only better nutritional quality but also the necessary attributes for consumer acceptance.

Looking to the growing demand of ready-to-eat and ready-to-cook products, there is a need exists to prepare the millet flour suitable for different traditional food products. Fortified ready mixes for the conventional preparation of popular traditional foods combining finger millet (*ragi*) as one of the ingredients are available in the market which further encourages for milling of *ragi* into flour.

VALUE ADDED PRODUCTS

In the foregoing paragraphs, some of the examples of value added products and possibilities of utilizing finger millet as one of the basic ingredients are discussed. Finger millet can be used in a variety of ways and is a great substitute for other grains such as rice and other starchy grains. These products are either in practice or have been demonstrated/ tested as avenue for enhanced consumption of finger millet. However, not much scientific studies have been carried out about their preparation and meaningful popularization on large scale.

(i) Multi-grain flour / Composite flour

The concept of multi-grain flour/composite flour is not new to the mankind. Mixing of two-three types of grains or grain and pulses has been in practice since long ago depending upon the availability of such commodities locally or the food habits, but in such cases, the understanding of nutritional security is not necessarily linked. Multi-grain flour by combining wheat and finger millet in the ratio of 7:3 (wheat:finger millet) is one of the simple semi-finished products suitable for making chapatti (*roti*), as no Indian meal is complete without Indian style bread or *roti*.

In the proposed blend, though the gluten content is reduced significantly the making of chapatti while flattering is not affected. However, the colour of the chapatti turns to slightly dark. Fortification of finger millet in chapattis not only improves the taste but also helpful in controlling glucose levels in diabetic patients very efficiently. The bulkiness of the fibres and the slower digestion rate makes us feel fuller on, fewer calories and therefore may help to prevent from eating excess calories. Its high fiber content is further helpful to the individuals having the problem of constipation.

(ii) Papad

Addition of finger millet as one of basic ingredient to the tune of 15-20% (w/w) along with other essential ingredients such as black or green gram, rice and spices has become a tradition in millet growing areas of South India. According to a report, addition of finger millet up to 60% in papad is possible and practised in some parts of Karnataka (Begum, 2007).

Papad from finger millet flour is also prepared in which it is used as base material mixed with spices and salt. Flour is first cooked in water till it is gelatinized and dough is prepared. Thin sheet from the dough is prepared by rolling it and cutting into desired shapes and sizes followed by drying of these papad pieces to desired moisture content of 7-8% (db). Since the pericarp is not separated out

from the starch, it gives a little dark colour to the papad which again upon frying or roasting turns to lighter with good consumer acceptability.

(iii) Puffing or popping

Puffing or popping is one of the traditional food processing method used for the preparation of expanded cereals and grain legumes to prepare ready-to-eat products. Popping improves the nutritional value by inactivating some of the anti-nutritional factors (enzymes and enzyme inhibitors) and thereby enhancing the protein and carbohydrate digestibility; it also enhances the appearance, colour, taste and aroma of the processed raw material (Mangala et al., 1999). The flour can be used for different types of Ready-to-Eat food preparations depending upon the taste and likings.

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

Further, during this process, the vapour pressure of the grain increases and the moisture present in the grain turns into steam; gelatinization of the starch takes places and explodes. Since during popping or puffing grains are dehydrated to the extremely low level of moisture content, nearly 3-5%, the shelf-life is enhanced. Now days modern air puffing machines have been developed which can be used for mass production of puffed or popped millet grains. In addition to this, there will be no risk of sticking sand particles with the product in machine popping or puffing.

(iv) Puffed finger millet mix

Puffed finger millet grains can be converted into powder by simple grinding which can further be enriched with additional ingredients. Various combination of ingredients can be taken and mix well, this nutritious mix so prepared forms ready-to-eat (RTE) food. The selection and combination of the ingredients is done based on the requirement of the target groups like children, pregnant and lactating mothers etc. The ingredients are selected in such a way that no further cooking requires and hygienically packed in suitable packaging materials. The following table give an example of such mix, similar other combination of ingredients can be selected which should be nutritious as well as acceptable to the target group. The mix contains higher amount of protein, energy, calcium and iron with higher bioavailability.

Table 2: Example of a RTE mix

Ingredients	Per 100 g
Puffed finger millet flour	33
Sugar powder	30
Defatted soy flour	10
Dried coconut powder	25
Cardamom or other spice as per taste	02

(v) Malting – Weaning food

Germination or malting of cereal grains may result in some biochemical changes and produce malt with improved nutritional quality that can be used in various traditional recipes. Traditionally the millet malt is utilized for infant feeding purpose and also to prepare beverages either with milk or luke warm water with the addition of sugar since pretty old times. Finger millet being good malting characteristics, its malting is popular in the area of cultivation particularly in Karnataka and part of Tamil Nadu. Malting of finger millet improves its digestibility, sensory and nutritional quality as well as pronounced effect in lowering the anti-nutrients (Desai *et al.*, 2010). Finger millet has some of the inherent qualities which make it superior compare to other cereals and also qualify for malting and preparation of malted foods. It is resistant to fungal infection and elaboration of alpha and beta amylase during germination and during roasting/ kilning a desirable aroma as well as is developed which makes it an ideal grain for malt foods. In addition to these, finger millet is a good source of sulphur amino acids and calcium. The changes in nutrition contains of grains after germination can be attributed to utilization by growing sprouts. It has also been reported that the bio-accessibility of minerals such as calcium, iron and zinc are increased in finger millets (Suma and Urooj, 2011).

The sprouted grains should be dried to a final moisture content of nearly 10-12% and subsequently the separation of roots and shoots is done which can be accomplished by various traditional and modern methods by giving a mild rubbing or abrasion action to the grain mass. These grains (malted) are then roasted uniformly at 70 - 80˚C either by conventional roasting pan or heaters. Uniform heating and roasting helps in developing characteristic aroma and desirable quality of the product. The malt so obtained is pulverized to convert it into ready-to-eat (RTE) form. The pulverization can be accomplished by any size reduction facilities suitable to convert into fine flour. The pulverized malt is then subjected to sieving through the fine sieve to separate the husk and fine malt flour is obtained.

The malted weaning food is mixed with powdered sugar, milk powder or whole milk along with flavouring agents to make as milk based beverage. This preparation is a good source of nutrition and suitable for all the age groups. This preparation is popularly known as '*ragi malt*' and can be used as health drink or energy drink. Now-a-days about 5% *ragi* malt is invariably blended with the energy food to improve its texture and mouth feel.

(vi) Noodles – Vermicelli

The changing food habits of children and teen aged groups have created a good market of noodles in India and abroad. The demand for millet noodles particularly the noodles made out of finger millet is growing due to awareness about its nutritional properties. Noodles are the pasta products also known as convenience foods prepared through cold extrusion system which become hard and brittle after drying. The cooking of these noodles is very convenient and requires few minutes (2 minutes), they are cooked with water, some vegetable pieces, spices etc. also added and served hot. Noodles of different combinations are prepared such as noodles exclusively made of finger millet, finger millet and wheat in the ratio of 1:1 and finger millet blended with wheat and soy flour in the ratio of 5:4:1. In case of exclusive millet based noodles, pre-treatment to the millet flour is given to facilitate extrusion and smooth texture which should retain while drying and cooking. Generally, in the preparation of noodles, wheat flour is invariably used as an important member of blend because the presence of wheat gluten has an added advantage which not only helps in easy extrusion but also gives a smooth and fissure free texture to the noodles. Several other combinations of blends can be explored in the preparation of noodles keeping food values of ingredients and their availability in mind.

(vii) Extruded products

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

(viii) Bakery products

Incorporation of finger millet flour in the preparation of bakery products like biscuit, nan-khatai, muffins and bread has been attempted and efforts are being made to standardize the recipe and product quality. The use of millets in bakery products will not only superior in terms of fibre content, micronutrients but also create a good potential for millets to enter in the bakery world for

series of value added products. In a recent study attempts have been made to improve the nutritional quality of cakes with respect to the mineral contents and fibre content by supplementing with malted finger millet flour (Desai *et al.*, 2010).

(ix) Fermented foods

Fermented foods are common ethnic foods in many parts of India and are popular as well. Traditionally, finger millet is consumed in the form of thick porridge (*mudde* or dumpling), thin porridge (*ambali*), fried and baked pancake (*roti, dosa*) and beverages (*chang/jnard*). Most of these involve fermentation steps (Madhavi and Vaidehi, 1990; Hadimani and Malleshi, 1993). Dosa and Idli mixes containing 30% finger millet are available in the markets. Incorporation of finger millet not only brings nutritionally improvement but also improves the taste. The incorporation of sprouted finger millet could be an innovative approach for preparation of such products which can further improve the quality of the food.

CONCLUSION

Increased nutritional awareness challenges in food industries in developing new food products especially with the characteristics of health foods. Finger millet is well comparable and even superior to many cereals in terms of mineral and micronutrient contents. Its major use as food has remained only in the area where it is cultivated and to the traditional preparations. Finger millet has good potential of providing nutritional security to the consumers. Its consumption in urban area can be increased through its proper processing and value addition. With the advancement of post harvest processing and value addition technologies, it has become possible to process and prepare value added products which are acceptable by both rural and urban consumers. This will not only help in increasing the profitability of its cultivators but will also help in providing income and employment opportunities in rural area. Thus, the finger millet has a vast potential for upcoming entrepreneurs and to create a sustainable health food chain.

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