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Finger millet (Ragi, *Eleusine coracana* L.). A review of health benefits, processing and product developments

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ABSTRACT

Globally, use of millets has been confined only to traditional or rural level consumers in developing countries; still have remained underutilized due to a lack of innovative millet processing technologies (Naik *et al.,* 2014) . Functional foods are a growing trend in the food market, the additional health benefits and prevention of nutrition-related diseases are attractive for consumers that are seeking a healthy lifestyle and improvement of their eating habits. Ragi is rich in carbohydrates and is a good source of other macro and micronutrients hence attempt should be taken to market to provide easy–to-handle, ready-to cook or ready-to-eat and safe products at a commercial scale. The main objective of this review is to present the nutritional importance, the various processing methods and different forms of ragi products available in market

Key Words : Anti-diabetic, Malting, Decortication

INTRODUCTION

Ragi (Finger Millet; *Eleusine coracana*) is in use since time immemorial, and a large number of its traditional food preparations are in practice in the rural areas. It contains important amino acids *viz.,* isoleucine, leucine, methionine and phenylalanine which are deficient in other starchy meals. It is comparable to rice with regards to protein (6-8%) and fat (1-2%) and is superior to rice and wheat with respect to minerals and micronutrient contents (Verma and Patel, 2013). Ragi has gained importance because of its slowly digestible and resistant starch (Wadikar *et al*., 2007) and has low glycemic index which makes it suitable for diabetic patients (Pradhan *et al.*, 2010) additional benefits are its antioxidant and antibacterial functions. It is an extremely nutritious food and could be enjoyed in different forms and preparations like i) Weaning food products, (ii) Health food products, (iii) Pasta food products, (iv) Fermented food products, (v) Baked food products, (vi) Fried food products and (vii) Household food products. Processing methods like soaking, cooking, roasting, germination, milling, fermentation, malting, popping, puffing, cooking and decortication are done in ragi (Hadimani and Malleshi, 1993)

Health benefits of ragi:

Anti-diabetic:

Pradhan *et al*. (2010) reported that ragi is a humble grain with low glycemic index which makes it more suitable for diabetic patients. The phenolic content of brown Ragi was 96% higher than the white variety. Consumption of Ragi based diets resulted in significantly lower plasma glucose levels, mean peak rise, and area under curve which might have been due to the higher fiber content of Ragi compared to rice and wheat. Millets helps to lower blood glucose levels and improves insulin response (Lakshmi and Sumathi, 2002).

Antioxidant:

Sripriya *et al*. (1996) reported that DPPH radical quenching with 50 ìl of the extracts brown Ragi quenched

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94% whereas the white Ragi quenched only 4%. Hedge *et al*. (2005) reported that significant increase in protein and collagen and decrease in lipid peroxides occurred when aqueous paste of finger millet flour was applied topically on the excision wound (rat model) once daily for 16 days. Rajasekaran *et al*. (2004) reported that Ragi feeding improved the antioxidant status on skin which hastened the dermal wound healingprocess.

Antibacterial:

Varsha *et al*. (2009) evaluated the antioxidant and antimicrobial properties of Ragi polyphenols and their results indicated that potential exists to utilize ragi seed coat as an alternative natural antioxidant and food preservative. Ilango and Antony (2014) assessed the microbiological quality-total bacterial count (TBC), lactic acid bacteria (LAB) count, yeast-mould count (YMC), coliforms at 35°C and pathogens. And found no *Staphylococcus* sp. and *Listeria* sp.

Other effects

Shobana *et al*. (2010) reported the blood glucose lowering, cholesterol lowering, and nephro- protective properties of Ragi. Whole grains like millet may have health promoting effects equal to or even in higher amount than fruits and vegetables and have a protective effect against insulin resistance, heart diseases, diabetes, ischemic stroke, obesity, breast cancer, childhood asthma and premature death (Cade *et al*., 2007). Chethan (2008) worked upon the extraction of seed polyphenols from Ragi and their nutraceutical potential and reported that the millet polyphenols inhibit the millet malt amylases and aldose reductase from cataracted human eye lenses. Green ragi is recommended for conditions of blood pressure, liver disorders, and asthma and heart weakness and also to lactating mothers in condition of lack of milk production (Archana, 2014).

Commercially available finger millet (Ragi) processed ragi food products in the markets of South India:

Globally, use of millets has been confined only to traditional / rural level consumers in developing countries; limited especially to the areas of their cultivation, and still have remained underutilized. This is due to a lack of innovative millet processing technologies to provide easy–to-handle, ready-to cook or ready-to-eat and safe products at a commercial scale that can be used to feed large population in urban areas. The processed ragi food products which are available in the market are.

(i) Weaning foods products: are malts made of ragi flour adding different ingredients to enhance its quality and flavour. Ragi malt rich in iron and calcium is the popular poor man's health drink in rural part of south India due to its nutritional value and affordability. Malting of finger millet improves its digestibility, sensory and nutritional quality as well as pronounced effect in lowering the anti-nutrients (Kulkarni *et al.,* 2012). The malted weaning food is mixed with powdered sugar, milk powder or whole milk along with flavouring agents to make as milk-based beverage.

(ii) Health foods products: are beverages made of ragi adding different ingredients. The fermented ragi flour are extensively used in preparation of instant mixtures and pharmaceutical products (Rao and Muralikrishna (2001). These beverages/mixtures are rich in calcium, iron, fibre, fatty acids and enriched with vitamins and minerals. Ragi contains an amino acid called Tryptophan, which lowers appetite and helps in keeping weight in control (Verma and Patel, 2013).

(iii)Pasta food products: The studies made by various researchers and the Institutions reveals that the ragi flour can also be used for making enriched vermicelli/ noodles. The pasta foods made of ragi flour are ideal foods for diabetic patients. Use of green banana and sprouted finger millets flour as natural ingredients will improve the nutritional quality of the pasta foods in terms of antioxidants and hypoglycemic activity Muralikrishnan and Prabhasankar (2010)

(iv) Fermented food products: Ragi flour serve as a good raw material for making fermented food products such as instant dosa-mix and idly-dosa mix. The fermented food products made of ragi flour are rich in calcium, iron, fibre, energy and protein. Sprouting of finger millet grain or the malted grains are used for making fermented foods depending on the taste and choice (Verma and Patel, 2013). The rate of available iron, manganese, calcium and mineral are higher in finger millet after fermentation. Fermentation is more effective than malting in reducing anti- nutritional factors such as phytic acid that decreases the dietary availability in finger millet (Makokha *et al*., 2002). Ragi could be used along with barley malt in equal proportions as an adjunct in brewing (Venkatanarayana *et al.,*1979).

(v) Baked food products: The findings of the research of various Institutions shows that ragi flour also

serves as a good raw material for making various bakery products. Bread, biscuits, rusk, cake, mixture etc. using ragi flour as base material and adding ingredients as required by each product to enhance its quality and flavour. Incorporation of finger millet 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. Attempts have been made to improve the nutritional quality of cakes with respect to the minerals and fibre content by supplementing with malted finger millet flour (Desai *et al* ., 2010). Incorporating finger millet into bread or noodle is proved better in replacing percentage of wheat flour (Veenu Verma & Patel 2013). Ragi biscuits prepared by Selvaraj *et al.,* (2002) were observed to have a good shelf life.

vi) Fried food products: The findings of the research of various Institutions shows that ragi flour also serves as a good base material for making various fried food products. Fried food products such as papad, chakkali, nipattu, muruku, sandige, ragi pakoda (finger millet fritters), ragi vada, etc. using ragi flour as base material and adding ingredients as required by each product to enhance its quality and flavour and are readily available in the outlets .

Processing of ragi:

Soaking:

Soaking is a process of adding distilled water to grains until the grains are fully steeped in water and left for an overnight period at an ambient temperature of 30 to 60° C. The washed grains are then dried in a hot air oven at 60° C for 90 min before milling to flour (Banusha and Vasantharuba, 2013). Soaking thus reduces the availability of anti-nutritional compounds such as phytic acid which increases the bioavailability of minerals like zinc (Saleh *et al*., 2013).

Cooking:

Cooking is a processing method that involves boiling grains in water until the grain becomes soft. Grueling helps to reduce the microbial load and improves the desirable sensory quality of the cooked grain (Khamgaonkar *et al*., 2013). It was observed that the consumption of these whole grain products will increase the average daily antioxidant intake. Pressure cooking of soaked ragi or parboiling treatment considerably improved the technological characteristics of ragi as also its suitability for various food preparations. (Desikachar, 1972).

Germination:

It is a traditional process where the whole unhusked grains are soaked for 2-24 h and then spread on a damp cloth for up to 24-48 h or incubated at 30 °C for 48 h (Shimray *et al.*, 2012). Germination has been used for centuries to soften the kernel structure and improve the nutritional composition and concentration of carbohydrates, minerals, vitamins and essential amino acids, thus increasing the functional properties of the grains (Mbithi-Mwikya *et al*., 2000; Chove and Mamiro, 2010; Pushparaj and Urooj, 2011).

Malting:

Malting is a combined process of steeping, germination, drying, toasting, grinding and sieving in order to achieve high nutritional quality, better starch digestibility, sensory properties and reduced ant nutritional activities Malting improves the fibre, crude fat, vitamin B, C and mineral content in the grains, while anti nutritional activities of tannins and phytic acid in brown millet are decreased significantly the other benefits of malting such as vitamin-C is elaborated, phosphorus availability is increased and lysine and tryptophan are synthesized (Desai *et al*., 2010). Among millets, ragi is the most suitable from the standpoint of product quality and enzyme release during malting (Rao *et al*., 1981) an added advantage of malting of ragi is in the production of an agreeable odour developed during the kilning of germinated grain (Malleshi and Desikachar, 1981).

Milling or grinding:

It is the most common traditional processing method that converts dried and moistened cereal grains into flour by using wooden or stoned mortar and pestle (Young, 1999). Finger millet grain requires dehulling and debranning before consumption because grain contains large portions of husk and bran. During milling process, about 10% of water is added to the grain in order to facilitate the removal of fibrous husk. Milling is mostly done to remove the fibrous coarse bran or the seed coat of the grains. Furthermore, removal of some phytochemicals such as phytates and tannin during milling improves the bioavailability of iron (Singh and Raghuvanshi, 2012). Finger millet flours prepared in different type of cereal pulverizes differ in the digestible

starch content and also in some of their physico-chemical properties.

Fermentation:

Fermentation is a processing method widely used on grains whereby the raw material becomes the medium of growth for the microorganism. Finger millet may be fermented at room temperature for 24 to 72 h depending on the product or beverages intended to be produced.. Fermentation also provides health benefits by reducing ant nutritional compounds such as trypsin, amylase inhibitor, phytic acid and tannins in cereal grains (Rasane *et al*., 2015). Commercial cultures can also be successfully used to produce a composite fermented beverage from finger millet and skim milk (Mugocha *et al*., 2000). Various microbial types like *Saccharomyces diastaticus, Saccharomyces cerevisiae, Lactobacillus brevis,* and *Lactobacillus fermentum* used for fermentation of millet grains and their food products. In addition, protein efficiency ratio, feed efficiency ratio, apparent protein digestibility, true protein digestibility, net protein utilization, net protein retention, protein retention efficiency, and utilizable protein values in the case of pure-culture-fermented pearl millet flour were higher than in the control (Khetarpaul and Chauhan, 1991).

Roasting:

It is a simple traditional technology commonly practiced in households and rural areas. Roasting is similar to puffing process but differs in the volume expansion which is higher in puffing. During roasting, the anti-nutritional or toxic effect such as saponins, alkaloids, glycosides, gioterogenic agents, tryptin inhibitor and hemagglutinin are removed. Roasting improves the nutritional quality and increases the shelf-life of the roasted grains .Processed foods obtained as a result of roasting of grains include weaning foods which increases the bioavailability of iron (Singh and Raghuvanshi, 2012; Thapliyal and Singh, 2015)

Popping and puffing:

Popping or puffing is one of the traditional food processing methods used for the preparation of expanded cereals and grain legumes to prepare ready-to-eat products (Ushakumari *et al*., 2004).

It was observed that flattening the grains to the desired shape and moisture content were critical factors for obtaining millet with maximum expansion ratio. Popping and Puffing enhances appearance, colour, taste and aroma of the processed raw materials (Verma and Patel, 2013; Saleh *et al*., 2013)

Finger millet popped products have been reported to improve the pleasant aroma, acceptable taste and quality of grains by inactivating destructive bacteria (Thapliyal and Singh, 2015). Puffing on its part, increases the digestibility and solubility of starch due to gelatinization. Puffing also increases the dietary fibre of the final products and decreases ant nutritional factors (Choudhury *et al*., 2011; Sarkar *et al*., 2015).

Extrusion:

Extrusion of foods is an emerging technology for the food industries to process and market a large number of products of varying size, shape, texture and taste. Extrusion cooking combines the heating of food products with the act of extrusion to create a cooked food product with a desired shape. It results in gelatinization of starchy components, denaturation of proteins, shaping and restructuring of tactile components, the shaping of end product and exothermic expansion of extrudate (Rao, 1982). Rajwat *et al.* (1999) studied the effect of extrusion cooking variables on ant nutritional components and *in vitro* protein digestibility. They found that extrusion at temperature 85^0 C with moisture of 23 % was most effective in reducing the anti-nutritional factors and elevating its protein digestibility. Malleshi *et al.* (1989) reported the production of good quality vermicelli extruded from blends of ragi and wheat flour.

Decortication:

This is a very recent process developed for finger millet. It is also known as debranning. This method is used for debranning of all cereals, but it is not effective for finger millet owing to its seed coat intactly attached to fragile endosperm. However hydrothermal processing is used to decorticate finger millet this involves (hydration, steaming and drying) which hardens the endosperm of grain and enables it to withstand mechanical impact. The decorticated finger millet could be cooked as such as rice is cooked (Gull *et al*., 2016).

Summary and conclusion:

Functional foods are a growing trend in the food market, the additional health benefits and prevention of nutrition-related diseases are attractive for consumers that are seeking a healthy lifestyle and improvement of

their eating habits. Ragi is rich in carbohydrates and is a good source of macro and micronutrients .Knowing about the health benefits, processing technology and products available in market help to develop easy–to-handle, ready-to cook or ready-to-eat and safe products at a commercial scale.

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