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Nutraceutical Importance of Finger Millet (*Eleusine coracana*) for Improved Human Health

Kajal Srivastava • A. K. Sharma*

Department of Biological Sciences, CBSH, G. B. Pant University of Agriculture and Technology, Pantnagar – 263145, UK, India

Corresponding author: * **anilksharma_99@yahoo.com**

ABSTRACT

Diet is a major focus of public health strategy aimed at maintaining optimum health throughout life thus preventing early onset of chronic diseases as well as promoting healthier ageing. Studies on the different properties of foods have shown that consumption of certain foods may provide greater health benefits. One such group of healthy food is the nutraceutical, which can be any substance that is a food or component of a food that provides medical, health benefits, including the prevention and treatment of disease. They are often used in nutrient premixes or nutrient systems in food and pharmaceutical industries. Such foods items or food components that help in prevention or treatment of diseases are made from herbal/botanical raw materials. Finger millet (*Eleusine coracana*) is one of the oldest cereal grains in the Indian sub-continent having high nutraceutical value. It grows well in harsh environments and on poorly fertilized and dry soils where other crops give poor yield. It also grows well in hot climates with short rainfall periods and cool climates with warm summers. A multitude of small farmers grow finger millet with limited water resources and in many countries this crop is often referred as "poor people's crop". Finger millet as compared to the other crops is a very rich source of calcium; the calcium content is thirty times more than that of rice and wheat. It is not only a rich source of calcium but contains also other micronutrients essential for good health. It can replace or complement traditional crops and, with vertical integration into agriculture and manufacturing, it will also have impact on rural economic development.

Keywords: cereal, functional food, human welfare

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INTRODUCTION

In India, as in other developing countries, people are concentrating to better living and improved quality of life. It simply means that the nutrients must be provided in a sufficient amount or concentration to meet the development criteria. Studies on different properties of foods have shown that consumption of certain foods may provide better health benefits. One such group of healthy food is the nutraceutical. They can be derived from number of sources i.e. plants, animals, microorganisms etc. The term nutraceutical was originally coined by Dr. Stephen L. DeFelice, in 1995 founder and chairman of the Foundation of Innovation Medicine (FIM), Crawford, New Jersey. He defined it as a food or food components that provides health and medical benefits, including the prevention, treatment and cure of numerous diseases. Unlike pharmaceutical drugs, nutraceutical products are also widely available and monitored as dietary supplements in number of developing countries.

Nutrients help and support the life and include substances with established nutritional functions. The chief classes of nutrients are proteins, fats, carbohydrates, minerals and vitamins. Nutraceuticals are often used in nutrient premixes or nutrient systems in the food and pharmaceutical industries. Thus, nutraceuticals contain functional attributes of conventional food as well as new redesigned products and hence provide health benefits beyond basic nutrition. It can be any nontoxic food component that has scientifically proven health benefits. Nutraceuticals, foods or food products, are made from herbal/botanical raw materials and helps in prevention or treatment of disease. This research brings a revolution in the field of dietary products and therefore, numbers of industries are growing rapidly using these natural products. In near future nutraceutical crops can replace or complement traditional crops world wide and will also impact rural economic development. Consumers are turning massively to food supplements to improve well being where pharmaceuticals fail (Brower 2005).

Nutraceuticals is capturing the professional curiosity of nutritionist, health care professionals as well as food scien-

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tists. Its use is an attempt to accomplish desirable therapeutic outcomes with reduced side effects, over other therapeutic agents has met with great monetary success. Nutraceutical products were considered as alternative medicine from last many years (Watt and Breyer-Brandwijk 1962; Duke and Wain 1981). There are multiple different types of products that fall under the category of nutraceuticals and finger millet is just one of them. The use of finger millet as a dietary supplement is increasing in parallel with the research on its multitudinous effects on human health. It is one of the oldest foods known to humans and possibly the first cereal grain used for domestic purposes. In India, millets have been used as a staple food for thousands of years. Today millet ranks as the sixth most important grain in the world, sustains 1/3 of the world's population and is a significant part of the diet in northern China, Japan, Manchuria and various areas of the former Soviet Union, Africa, India, and Egypt (Upadhyaya *et al.* 2006; Dubey and Verma 2009). It is often considered to be a "poor men's cereal" as it does not require fertilizers input (Vietmeyer 1996). Indeed, it is one of the few special species that currently support the world's food supplies and have become a more mainstream supplement to the diet nowadays (Defelice 1995). It is highly nutritious and considered to be one of the least allergenic and most digestible grains. Ragi grain possesses excellent storage properties and is said to improve in quality with storage. However, number of studies showed that, they are highly valued as a reserve food in times of famine and can be stored without damage up to 50 years (Iyengar *et al.* 1945).

Exploitation of nutritional value of finger millet rich in nutrients assumes importance to provide food security, agricultural development, self-dependence and enhancement of economy of developing countries. Thus, it has been described as edible plant-based amylase inhibitors for modulation of carbohydrate breakdown and regulation of glycemic index of foods. It also provides a scientific rationale for the use of finger millet as a low cost nutrient useful in reducing the chronic pathologies (National Research Council 1996).

WHY FINGER MILLET?

In the era of functional foods, finger millet is an important subsistence and staple food in many regions of Asia (Garí 2001). It has the potential to improve nutrition, boost food security, foster rural development and support sustainable land maintenance (Oduori 2005). It can be grown extensively in the farming situations right from rainfed low hills to high hills. Millet is tiny in size caryopsis and round in shape with different colour of seed coats. The seed of the millet are an edible component and is a rich source of phytochemicals, dietary fibers, polyphenols, minerals and especially calcium (Hadimani and Malleshi 1993; Malleshi 2005) and cannot be ignored for enhancing the nutritional and therapeutic attributes of formulated foods. The soluble dietary fiber component may assist in regulation of blood glucose and lowering of serum cholesterol (Anderson 1980). It is especially valuable as it also contains the amino acid, methionine and many other macro and micronutrients (Schaafsma 2000), which is lacking in the diets of hundreds of millions of the poor who live on starchy staples meal. Herbal components are among the key ingredients of functional foods and contribute a good share in the functional food market. Finger millet has not been given due acceptance by the general population, the reason might be unawareness amongst the masses about its incredible nutritional and therapeutic values. It is specially recommended as wholesome food for diabetic patients. Regular consumption of finger millet is known to reduce the risk of *diabetes mellitus* (Gopalan 1981) and gastro-intestinal tract disorders (Tovey 1994) and these health beneficiary aspects of the millet could be attributed to its polyphenol contents. There are a number of health-promoting properties in finger millet which prove it to be a nutraceutical crop valued for food, nutritional, feed, cultural, long storability without spoilage, medicinal, malting purposes, and it has industrial and economic potential. Seetharam in 2008 named it as a "wonder grain" because of following advantages: 1. Grown all over the year; 2. Wide variety range; 3. Tolerant to abiotic stresses; 4. Long storage capacity; 5. High nutraceutical value.

NUTRACEUTICAL IMPORTANCE OF FINGER MILLET

Scarcity of protein rich food and food supplements are responsible for protein-energy malnutrition particularly among children and lactating women in the developing countries like India. World Health Organization (WHO) identified 4 major forms of malnutrition crippling globally (WHO 1985). This includes, vitamin-A deficiency, iron deficiency, iodine deficiency and protein energy malnutrition. Millets are a storehouse of nutrients and are a remedy for the malnutrition that affects a vast majority of our population. It has intensive multifunctional importance. Millet Network of India (Deccan Development Society, FIAN, India) confirmed in their study that, as compared to the other crops (rice and wheat) it is an exceptionally rich source of calcium chromium, zinc, copper and magnesium essential for good health. It is a rich source of non-available carbohydrates with low glycemic index, which is beneficial for prevention of diabetes and cardio-vascular diseases. It also helps in delaying ageing by reducing glycosylation of body proteins (Doraiswamy *et al.* 1969).

Finger millet is gaining renewed interest as an ingredient in the production of functional food. They are designed to allow person to eat enriched foods close to their natural state, rather than by taking dietary supplements manufactured in liquid or capsule form. Functional foods have been either enriched or fortified, a process called nutrification. This small millet also possesses high proportion of soluble viscous components, offering more suitability among cereal grains in the human diet. It is highly nutritious, non-glutinous non-acidic and is soothing and easy to digest. However, the seeds are also rich in phytochemicals, including phytic acid, which is believed to contribute to the lower cholesterol level of the blood, and phytate, and thus can reduce cancer risk. In fact, it is also considered to be one of the least allergenic and most digestible grains available and it is a warming grain so will help to heat the body in cold or rainy seasons and climates (Dubey and Verma 2009).

These grains reduce the severity of asthma and the frequency of migraine attacks because of its status as a good source of magnesium (Dubey and Verma 2009). It has been shown that it helps in lowering high blood pressure and reduces the risk of heart attack, especially in people with atherosclerosis or diabetic heart disease (Pradhan *et al.* 2010). They are also well balanced with essential amino acid composition along with Vitamin A, Vitamin B and phosphorous which helps in lowering high cholesterol level (Hegde *et al.* 2002).

The phosphorus provided by millet plays a vital role in the structural development of body cell and bones (**Fig. 1**). Moreover, it is an essential component of numerous other

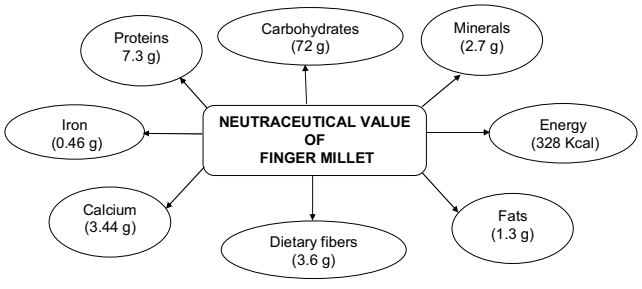

Fig. 1 Nutritive value of *ragi*/100 g. Source: International Crops Research Institute for the Semi-Arid Tropics, Patancheru, A.P.

life-critical compounds including adenosine triphosphate (ATP), the molecule that is the energy currency of the body. Phosphorus is an important component of nucleic acids (DNA and RNA), known as the building blocks of the genetic code. Furthermore, the metabolism of lipids (fats) relies on phosphorus, and it is also an important component of lipid-containing structures like cell membranes and nervous system.

Apart from being rich in the above mentioned nutrients, finger millet is also a good source of essential amino acids like arginine, lysine, methionine, lecithin etc. and performs a number of essential health promoting functions like (Glew *et al*. 2008):

1. Precursor for the synthesis of nitric oxide.
2. Stimulation of the release of growth hormone.
3. Improves immune function and reproductive ability.
4. Reduces healing time of injuries (particularly bone).
5. Quickens repair time of damaged tissue.
6. Reduces risk of heart disease and adipose tissue body fat.
7. Increases muscle mass and blood circulation.
8. Improve insulin sensitivity and helps in memory generation, etc.
9. Decrease blood pressure.
10. Alleviates male infertility, improving sperm production and motility.

Ragi diets brought improvement in all nutritional responses, i.e. height, weight, general nutritional status, apparent digestibility and N retention (Doraiswamy *et al.* 1969). The plant is also reported to be diaphoretic, diuretic, and vermifuge (Watt and Breyer-Brandwijk 1962) for catabolic diseases like measles, leprosy, liver disease, tuberculosis, pneumonia etc. Ragi is used as a traditional nutritional supplement, in many dry areas of country (Watt and Breyer-Brandwijk 1962; Duke and Wain 1981).

POLYPHENOLIC COMPOUNDS IN FINGER MILLET

The scientific information on the polyphenols in finger millet is scanty. Finger millet contains about 0.3-3% polyphenols and is well known for its health benefits such as hypoglycemic, hypocholestrolemic and anti-ulcerative characteristics, besides for its extremely good storage qualities (Pradhan *et al.* 2010). In general, it is presumed that the polyphenols of these small millets have major beneficial role as they posses antioxidant, antimicrobial and enzyme inhibitory activity (Chethan *et al.* 2008). Millets are also good source of polyphenols among cereals and is known to inhibit the activity of digestive enzymes such as amylase, glucosidase, pepsin, trypsin and lipases (Rohn *et al.* 2002). They play essential role in mediating amylase inhibition and therefore contribute to the management of type 2 diabetes, which is characterized by high blood glucose levels (Saito *et al.* 1998; Toeller 1994). They act as inhibitors of amylase and glucosidase and leads to a decrease in post-prandial hyperglycemia (Bailey 2001). However, very little information is available regarding variations among varieties with respect to the polyphenol contents (Chethan and Malleshi 2007). Chethan and his coworkers (2008) reported that polyphenols of millets exhibit the inhibitory activity on snake venom phospholipases A_2 (PLA_2). They also observe inhibitory potency in finger millet for cataract formation.

Ramachandra *et al.* (1977) analyzed 32 varieties of the millet comprising of both brown and white seed coat material from Indian and African sources and concluded that the white grain varieties contained lower percentage of polyphenols (0.04-0.09%) over brown grain varieties (0.08-3.47%). Later on, in 1982, Rao and Prabhavathi (1982) depicted 0.36% tannin in an unspecified variety of finger millet. Whereas, Shankara (1991) analyzed a large number of finger millet varieties (n = 85) from the Indian state of Karnataka and reported a wide variability in the total polyphenol contents assayed as chlorogenic acid (0.06-0.67%), tannic acid (0.03-0.57%) and catechin (0.03-2.37%) equivalents. Furthermore, Chethan and Malleshi (2007) analyzed five brown and two white varieties and reported 1.3-2.3% polyphenols as gallic acid equivalents in brown grained varieties and 0.3-0.5% in white grained varieties. The phenolics present in millets are heat stable but are pH sensitive. Mostly they are highly stable in acidic pH range (Chethan and Malleshi 2007). Polyphenols are also known to possess inhibitory activity on the digestive enzymes. Although, epidemically, the health benefits of the millet with respect to diabetes, cardio-vascular diseases and duodenal ulcer have been known, the roles of polyphenols towards these have not been investigated.

FINGER MILLET AS FOOD

Finger millet has been consumed as a staple food and is grown as a food crop in areas where rice is grown (Chethan and Malleshi 2007). Initial research on it has now created wide interest among the scientists to explore its nutraceutical properties (Seetharam and Halaswamy 2003). The whole grain is edible and the traditional foods were generally prepared from the whole meal. By virtue of its nutritive value, finger millet has industrial potential in the manufacture of baby and sick person's food formulations and breakfast cereals. Its grains contain high amount of calcium and iron having no parallel amongst cereals for these minerals (Gari 2001). This makes millet based processed food products like malt, biscuits, cakes etc. are known as power snacks, which are well suited for the growing children, females and aged people who need more calcium and iron in their diet (Vanderjagt *et al.* 2007). It is one of the least allergenic grain and easy to digest. It is usually converted into flour and a variety of preparations like cakes, pudding, porridge, bhakri, papad, etc. are made. Other than brewing, the malting process can be used in making cheap, digestible, liquid foods for infants and growing children (Malleshi 2003).

THERAPEUTIC AND MEDICINAL VALUE OF FINGER MILLET

Finger millet is considered as an ideal food for diabetic patients because of slow release of sugars to the body. High fiber content in grain checks constipation, high blood cholesterol formation and intestinal cancer (Usha 2004). Ragi has low glycemic index value. It reduced plasma cholesterol, total serum cholesterol and LDL cholesterol by 9% each and triglycerides by 15% and increased HDL cholesterol, thus showing a significant beneficial effect on the plasma profile (Enas *et al.* 2003). Besides, they are reported to improve aortic fragility and elasticity by attenuating elevation of blood pressure and they increase vaso-relaxation (Mizutani *et al.* 1999). The leaf juice has been given to women in childbirth, and the plant is reported to be diaphoretic, diuretic, and vermifuge (Watt and Breyer-Brandwijk 1962). Ragi is a folk remedy for leprosy, liver disease (Watt and Breyer-Brandwijk 1962), measles, pleurisy, pneumonia, and small pox (Duke and Wain 1981).

Further, several health beneficial properties, such as anti-inflammatory, antiviral, anticancer and platelet aggregation inhibitory activity has also been documented as therapeutic property of finger millet (Chethan and Malleshi 2007). It also possesses antimicrobial properties that enhance the body's defense mechanisms, and others may produce inhibitory effects for angiotensin-I-converting enzyme (ACE), leading to novel treatments for blood pressure conditions, heart failure, and diabetes (Mizutani et al. 1999). Antimicrobial activity on the intestinal microflora may be helpful towards identifying the pharmaco-nutritional characteristics of finger millet. Modern food biotechnology may also allow for the production of highly important products for those suffering life-altering food allergies. Inhibition of *Salmonella typhimurium* and *Escherichia coli* by fermented flour of finger millet (*Eleusine coracana*) was reported by Usha and co-workers (1998). Its medicinal properties are valued in Ayurvedic medicine and it is known as

a sattvic food, which means it is naturally balancing (Leder 2010).

PHYTOCHEMICAL AND ANTIOXIDANT PROPERTIES OF FINGER MILLET

Phytochemicals (pronounced fight-o-chemicals) is a term that means plant chemicals and there are over 900 phytochemicals found in foods items. Some of the common types of phytochemicals include carotenoids found in carrots and the yellow, red, and orange pigments of plants and ellagic acid found in berries. Phytochemicals properties of finger millet may help provide protection from diseases such as cancer, diabetes, heart disease, and hypertension (Kumari and Sumathi 2002; Hegde *et al.* 2002, 2004).

Antioxidants are compounds in fruits and vegetables that may be helpful in avoiding chronic disease. They act as a defense system against oxidative damage in our bodies and may be helpful in avoiding chronic diseases and the effects of aging (Sripriya *et al*. 1996). Some examples of antioxidants are Vitamins A, C, and E and beta-carotene. The antioxidant properties of millet's polyphenols have received the attention of many researchers. Sripriya *et al*. (1996) investigated the antioxidant properties of polyphenols extracted with methanol which was able to quench about 77% of hydroxyl radicals. According to them, the 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical quenching ability of finger millet was 94% whereas its fermented as well as germinated and also germinated and then fermented sample showed only 22, 25 and 10% quenching, respectively. This showed that processing the millet reduces its free radical quenching capacity. The major antioxidant principle reported is catechin (Sripriya *et al.* 1996).

ORGANIC NATURE OF FINGER MILLET

Finger millet is considered as annual crop and may be grown in a hot weather (from May to September), as well as cold season (from November and December) and matures 3-5 months after sowing, depending on variety, season and soil properties (Baker 2003). It is monocropped in India under irrigation or transplantation. However, it can be intercropped with cereals, castor bean (*Ricinus communis*), niger (*Hyoscyamus Niger*), groundnut (*Arachis hypogaea*), and pulses (Jena *et al.* 2000). It is typically a tropical crop and is well suited for dry farming, generally grown rainfed. Finger millet is very adaptable and thrives at higher elevations than most other tropical cereals. It can also be cultivated on soils ranging from rich loams to poor shallow upland soils. In India, it is grown on black cotton soils, but thrives on red lateritic loams. Also, it stands better even in water deficits conditions than most cereals crop (Baker 2003).

Millets constitute a unique neglected agro-biodiversity with enormous importance and potential in the agriculture and food security systems of millions of poor farmer's communities. It does not need chemical fertilizers for its growth and therefore, most of the farmers grow them using farmyard manure under purely eco-friendly conditions. Biofertilizers, vermicompost and growth promoters such as panchagavya, amrit pani; (organic growth promoters used to safeguard plants and soil micro-organisms and to increase plant production) are used to grow millets. Millets are also pest-free crops and hence do not require any pesticides and insecticides to grow (National Research Council 1996) and the resistance against mold and insects make it a viable emergency food (Burkill 1985). Thus, these are crops free from the use of synthetic fertilizers and are hence contamination free and valuable to consume. The plant is also productive and thrives in a variety of environments and conditions. Moreover, its seeds can be stored for years without insect damage, which makes them lifesavers for famine-prone areas.

CONCLUSION

Health is an important issue for all of us. Finger millet contains more fibre, minerals and vitamins, which are normally deficient in the Indian diet, and has eight times more calcium than other cereals. It also serves as a special food and traditional needs and earns cash for households. It is important to enhance the production and productivity of these millets as this is a low water consuming crop and can become the food of security for the people living in harsh and difficult terrains. However, these wonder grains suffer large neglect in science, agricultural programme, and policies, despite the increasing global awareness on plant genetic resource conservation and the concerns on local food security. As these traditional crops supplement wheat and rice meals, their production needs attention.

Accordingly, innovative and integrative efforts to strengthen the interface between millet biodiversity and food security are required, with a focus on empowering small farmers as privileged custodians and primary beneficiaries of such agricultural genetic diversity. Despite its valuable role and potential in the food security and nutrition of many poor farmers in Asia, it is a crop largely neglected. Its cultivation seems to be even declining in some countries. Utilization of these crops mainly as food for human consumption; straw is often a precious fodder for bovines. Being eco-friendly crops they are suitable for fragile and vulnerable ecosystems. Millet biodiversity constitutes the ecological heritage of millions of small-scale and traditional farmers and play a major role in their agricultural systems, food security, livelihood, and cultural identity. However, it is largely neglected and depreciated at the national and international levels. Adequate support from science, agricultural programme, and rural development policies is urgently required, so to launch ethno-ecological development modes throughout India.

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