PRODUCTION AND UTILIZATION OF SMALL MILLETS IN INDIA

A. Seetharam and K.T. Krishne Gowda
Project Coordination Cell, AICSMIP, ICAR
UAS, GKVK, Bangalore – 560 065

Small millets have their origin chiefly in Asia and Africa (Table 1). The most important domestication areas are East Asia, Indian sub-continent and the regions from Southern margin of Sahara to the Ethiopian high lands of Africa. Different kinds of millets were domesticated in these two continents. For eg., sorghum, pearl millet and finger millet represent African millets; while foxtail millet, common millet, Japanese barnyard millet and Indian barnyard Millet originated in Eurasia. Some small millets are grown only in specific regions though they have a long history of cultivation. For eg: kodo millet and little millet are cultivated in India. On the other hand finger millet, foxtail millet, common millet and barnyard millet have much wider distribution in Asia, Africa and Europe. It is evident from the above that small millets as a group are quite important in areas of their production as dry land crops and for mountain or hill agriculture providing staple food for the people of the region. These crops with much longer history of cultivation than major food grains were rated highly in the past, playing an important role in our traditional food culture and farming systems.

Table 1: Small millets and their place of domestication

Name of crop	Scientific name	Chromosome Number	Place of domestication
Finger millet	*Eleusine coracana* (L.) Gaertn.	2n =36 (4x)	East Africa
Foxtail millet	*Setaria italica (L.)* P. Beauv.	2n =18 (2x)	Central Asia-India
Common millet	*Panicum miliaceum* L.	2n =36 (4x)	Central Asia-India
Indian barnyard millet	*Echinochloa frumentacea* Link	2n =54 (6x)	India
Japanese barnyard millet	*Echinochloa utilis* Ohwiet Yabuno	2n =54 (6x)	East Asia
Little millet	*Panicum sumentranse* Roth	2n =36 (4x)	India
Kodo millet	*Paspalum scrobiculatum* L.	2n =40 (4x)	India

Characteristics of small millets

They being component of traditional agricultural systems are grown with low inputs and accompanied less productivity. There is a trend to replace them with commercial crops such as maize or rice or oilseeds in more productive systems. This is true in many countries of South Asia resulting in decline of acreage. It must be recognized that there are situations in which major cereals do have advantage and difficult to arrest the area decline under millets. Nevertheless, small millets have a number of merits as a consequence of unique traits possessed by them and this should make their cultivation attractive even to the improved agricultural systems. Some of the unique features possessed by small millets are:

1) They can grow well even in areas where soil, climate and other conditions are less favourable for crop growth. They are fast maturing which is so important to fit them into more intensive cropping systems as a catch or relay crop.

2) Their grains are small and yields are stable. The grains store well for long periods ensuring food supply in years of crop failure and in lean seasons.

3) In view of small grain size they often require less cooking time which could be an important factor for women who is required to look after many farm related responsibilities.

4) Many method of using millets have been established as materials of traditional staple foods. There are also ways of processing millet into novel preparations as well. This can be a factor in increasing market demand for them. Millets are used as materials for making local drinks too. This application is closely related to the farm practices, dietary culture and agricultural rituals of rural communities.

5) Small millet grains in general have excellent nutritious properties with high levels of essential minerals such as iron, calcium, zinc, dietary fibre, quality protein, nutraceuticals etc. Finger millet is especially known for its excellent malting qualities which should make it an important ingredient for the preparation of several noval, high value foods.

6) These crops often have dual use and grown for grain and quality fodder / straw and both are equally important in mixed farming.

Small millet production systems in India

In most parts of India, small millet is grown with limited attention and inputs for local consumption. The marketing avenues are extremely limited in areas where millet

is the main food crop. Live stock is an important component of most millet production systems and millet crop residues contribute significantly to fodder supplies.

In Indian sub continent, millet cropping systems tend to be extensive with limited application of improved technologies except in parts of South India where intensive cultivation practices are followed in finger millet production. But for these exceptions, these crops are grown without irrigation or manures on light, marginal well drained soils that are poor in native soil fertility. Because of these reasons the millet yield tend to be lower with significant year to year and location to location variation.

Small millets distribution and production constraints

Small millets area in India is around 3.0 million ha producing around 3.0 million tonnes of food grain. The bulk of small millet production in India is of finger millet (80%) and the remaining from kodo millet, little millet, foxtail millet, barnyard millet and proso millet in that order. Small millets in India are grown in Karnataka, Andhra Pradesh, Maharashtra, Tamil Nadu, Orissa, Jharkhand, Chhattisgarh, Madhya Pradesh and Uttarkhand. They being the components of traditional farming system one could see well evolved cropping systems. Mixed cropping of small millets with as many as nine crops (Navadhanya) is not uncommon even today in several parts of India. The intercrops grown especially with finger millet are - sorghum (fodder), pearl millet, cowpea, field bean, niger, pigeonpea, mustard, soybean, and horsegram. Rotation with several grain legumes like green gram/black gram/rice bean/soybean/ground nut/ horse gram is practiced in different regions.

Small millet production suffers from a number of constraints. Poor soil fertility, low and erratic rainfall, diseases like blast, *Helminthosporium* blight and *Cercospora* leaf spot (on finger millet); grain and head smuts (in small millets) and shoot fly and stem borer among pests are the major causes. The population pressures along with replacement of millet by other cash crops have pushed millets into more marginal lands resulting in stagnation of yield levels and production. Lack of marketing avenues and lower prices has tended to keep the use of cash inputs especially fertilizers and pesticides as well as level of crop management at a minimum.

India has well organized research network on small millets operated at the National level through the All India Coordinated Small Millets Improvement Project. Sustained efforts have been going on during the last two decades resulting in the development

and release of varieties suitable to various regions and also production technology for higher yields. The genetic resources conservation activities are also have receiving good attention.

Utilization

Grain morphology

Small millet grains show considerable diversity in physical and morphological features. They differ in colour, shape, size as well as in certain nutritional features. The basic grain structure is more or less similar in all millet grains - with pericarp, germ and endosperm as principal anatomical components. (Table 2). Finger millet possess a very thin layer of pericarp and fairly thick/thin bran as seed coat similar to wheat. Foxtail millet, proso millet, kodo millet, barnyard millet and little millet possess husk and brain similar to rice. So, they require dehusking and debraning prior to utilization.

Endosperm forms the largest component of millet grain which is the major storage tissue. It is composed of an aleurone layer and peripheral corneous and floury zones. The aleurone layer consisting of single layer of cells laying just below seed coat or testa is rich in minerals, B-complex, vitamins and oil. The peripheral endosperm contain starch granules and protein. The proportion of corneous and floury endosperm determine the texture of millet and millets vary widely for the kernel texture from floury to corneous types. Finger millet grain is soft textured and were floury in nature. On the other hand other small millet grains contain less floury endosperm and is of a hard corneous texture.

Table 2 : Structural feature of kernels of small millets

Grain	Type	Shape	Nature of seed coat	Colour
Finger millet	Utricle	Globose	Thin pericarp and bran	White, red, copper brown, violet
Proso millet	Utricle	Oval	Husk and bran	Grey, brown, golden yellow, straw white
Foxtail millet	Utricle	Oval	Husk and bran	Red, black, white, yellow
kodo millet	Utricle	Spherical	Husk and bran	Grey brown, brown, dark brown
Barnyard millet	Utricle	Oval	Husk and bran	Straw white, dull white
Little millet	Utricle	Oval	Husk and bran	Grey, straw white

Nutritional composition of grains

Like other cereal grains, millets are predominantly starchy. The protein content is more or less equal and comparable to that of wheat, rice and maize (Table 3). Finger millet has a slightly lower protein content but is in fact nutritionally superior because the protein quality is generally as good as or better than other cereals. Finger millet contains the lowest fat. Barnyard millet has the lowest carbohydrate content and energy value.

One of the characteristic features of the grain composition of millet is their high ash content (mineral composition). They are relatively rich in iron and phosphorus. Finger millet has the highest calcium content among all the food grains. High fibre content and lower digestibility of nutrients are the other characteristic feature of millet grains which influence their consumer acceptability. The whole grains are important sources of B-complex vitamins which is mainly present in the outer bran layer of the grain. Millets do not contain vitamin 'A'. However certain yellow endosperm varieties contains some amount of 'β' carotene, a precursor of vitamin 'A'.

Considerable variation in grain composition of these millets has been reported. Genetic factors play a major part in determining grain composition and thus screening of germplasm will be useful in identifying nutritionally superior varieties. Environmental factors also have a role in deciding nutrient make up of the grain. Often an inverse relationship has been observed between grain yield and protein content. Grain colour also has same relationship with nutrient composition especially protein content. The millet protein has well balanced amino acid profile and good source of methionine, cysteine and lysine. These essential amino acids are of special benefits to those who depend on plant food for their protein nourishment.

The millet grain contains about 65 - 70% carbohydrate, a high proportion of which is in the form of non starchy polysaccharides and dietary fibre. Millet grains are also rich in important vitamins *viz.,* thiamine, riboflavin, folin and niacin.

Millet grains are known for good shelf life. The grains dried to 10 -12 % moisture stored in farm houses show less store pest damage. There are reports of finger millet kept for more than two decades without spoilage. The other small millets also store well when whole grains are kept without dehusking. The millet flour and their products also show good shelf life.

Traditional foods from millets

Millet is a high energy nutritious whole some food especially recommended for children, convalescents and the elderly. Several traditional food preparations are made from millet which differs between different regions of a country.

Milled small millets (other than ragi) is similar to rice in several cooking properties and used in making several kinds of food items. The cooking style of millets in India is given in Table 4. In India many different kinds of traditional foods are made and they form the staple diet for many rural and urban households. Ragi is eaten in the form of mudde (dumpling or stiff porridge) and / or roti. Many other traditional foods are made from popped ragi flour mixed with sugar / jaggery / ghee / milk / butter milk and salt. In several rural households a vast variety of traditional snacks are made from ragi and other small millets.

However, very little information about the food uses of millets has been documented. There is an urgent need for collection and dissemination of detailed information about the traditional uses and processing methods of small millets.

Millet processing for value addition- scope and opportunities

The millet grains offer many opportunities for diversified utilization and in adding value. With proper processing, it is possible to make many different kinds of food products by adopting appropriate milling, popping and other technologies.

Milled millet can be produced today at cottage level as well as in large scale processing. Milled millet can be further processed towards various food uses such as flakes, quick food cereals, ready to eat snacks, supplementary foods, extrusion cooking, malt based products, weaning foods and more importantly health foods. Finger millet flour is easy to make since the endosperm and bran are pulverized freely and in such flour, fibre content is normally higher. However, it is possible to reduce fibre content by adopting simple sieving methods. Millets are well adaptable to a wide range of ecological and unfavourable agro-climatic conditions. There is a great potential for their enhanced production, especially in the arid regions. Development of suitable technologies for their diversified uses and preparation of value-added foods from millet shall encourage their production, widespread utilization and thereby improve their economy.

Table 3: Nutrient composition of small millets and other cereals

(per 100 g edible portion; 12 per cent moisture)

Food	Protein (g)	Fat (g)	Ash (g)	Crude fibre (g)	Carbo-hydrate (g)	Energy (kcal)	Ca (mg)	Fe (mg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)
Rice (brown)	7.9	2.7	1.3	1.0	76.0	362	33	1.8	0.41	0.04	4.3
Wheat	11.6	2.0	1.6	2.0	71.0	348	30	3.5	0.41	0.1	5.1
Maize	9.2	4.6	1.2	2.8	73.0	358	26	2.7	0.38	0.2	3.6
Sorghum	10.4	3.1	1.6	2.0	70.7	329	25	5.4	0.38	0.15	4.3
Pearl millet	11.8	4.8	2.2	2.3	67.0	363	42	11.0	0.38	0.21	2.8
Finger millet	7.7	1.5	2.6	3.6	72.6	336	350	3.9	0.42	0.19	1.1
Foxtail millet	11.2	4.0	3.3	6.7	63.2	351	31	2.8	0.59	0.11	3.2
Common millet	12.5	3.5	3.1	5.2	63.8	354	8	2.9	0.41	0.28	4.5
Little millet	9.7	5.2	5.4	7.6	60.9	329	17	9.3	0.3	0.09	3.2
Barnyard millet	11.0	3.9	4.5	13.6	55.0	300	22	18.6	0.33	0.10	4.2
Kodo millet	9.8	3.6	3.3	5.2	66.6	353	35	1.7	0.15	0.09	2.0

* N X 6.25

Source: Hulse, Laing and Pearson, 1980; United States National Research Council/National Academy of Sciences, 1982; USDA/HNIS,1984.

Table 4: Cooking styles of small millets in India

Crop	Bhat (rice like)	Kheer (sweetened thin porridge)	Traditional food items				Shavige (noodles)	Hurihittu (popped grain flour)	Sattu	Pappad (deep fried or roasted)	Halwa (cooked sweet product)	Malted beverage	Fermented beverages
			Roti/Chapati (unleavened bread)	Gruel (thin porridge)	Mudde (stiff porridge)	Dosa (fermented pancake)							
	1	2	3	4	5	6	7	8	9	10	11	12	13
Finger millet			O	O	O	Δ	Δ	Δ		Δ	Δ	O	O
Proso millet	O	Δ	Δ	Δ					O				
Barnyard millet	O	O	Δ	Δ							Δ		
Foxtail millet	O	O	Δ	O	Δ	Δ			O		Δ		
Kodo millet	O			O									
Little millet	O	Δ		O		Δ			O		Δ		

O : Frequent
Δ : Seldom

NUTRITIONAL AND TECHNOLOGICAL FEATURES OF RAGI (FINGER MILLET) AND PROCESSING FOR VALUE ADDITION

N. G. Malleshi
Department of Grain Science and Technology
Central Food Technological Research Institute, Mysore - 570 020

Introduction

Finger millet (*Eleusine coracana*), popularly known as ragi in India is one of the important minor cereals cultivated in many South Asian and African countries. It is one of the oldest food crops and referred to as "Artta-Kandaka" in the ancient Sanskrit literature, which means "Dancing Grain". It is comparable to rice as regards protein (6 - 8%) and fat (1-2%) content; but superior to rice, wheat and other cereals with respect to mineral and micronutrient contents (Table 1). Ragi protein is a good source of sulphur containing amino acids and contains slightly higher levels of lysine than maize and sorghum (Table 2). The millet forms a major source of dietary carbohydrates for a large segment of population in the area of its cultivation and the carbohydrates comprise of free sugars (1-2%), starch (75-80%) and non-starch polysaccharides (NSP) (15-20%). Glucose, fructose, maltose and sucrose; the main constituents of free sugars are generally present in the bran tissue and contribute towards development of aroma to the millet products. The NSP largely consists of cellulose, hemicellulose and pectinase materials forming a major component of its dietary fibre. The cellulose contributes towards the major part of insoluble fibre whereas the hemicellulose forms soluble fibre. The dietary fibre exerts several physiological benefits such as scavenging of toxic components, ease of bowel movement and removal of low density lipoproteins. Thus, it helps in lowering the cholesterol formation and also contributes towards slow digestibility of its carbohydrates or in other words imparts the hypoglycemic and hypocholesterolemic qualities to the millet. The millet starch is made up of amylose and amylopectin, normally present in the ratio of 25:75, which is comparable to the Indian rice and other cereals. There are no reports of very low or very high amylose millet cultivars till date. The starch granules in the millet are generally of diamond shaped and 3-15 μm diameter. Most granules are compacted in the cells and compound in nature (Fig. 1). The millet starch is of slow digestibility and is known for its intrinsic hypoglycemic characteristics.

Finger millet grain contains very low amount of lipids, but provide some of the essential fatty acids. The lipid constituents are known to be beneficial for the gastro-intestinal health, with special reference to minimizing the onset of duodenal ulcer. The lower lipid content also contribute for the extremely good shelf life of millet flour and foods.

Ragi grain is exceptionally rich in calcium (300 - 400 mg%), which is approximately 10 times more than what is present in most cereals including rice and wheat. It is also a good source of many other micronutrients such as iron, magnesium, zinc, chromium, iodine and thiamine (Table 3). Because of high mineral contents, the millet food is considered as cool food, and this probably helps in maintaining the acid base balance in the human system. As a result the persons on consumption of millet food withstand dehydration and tolerate thirst better than persons consuming other foods.

Table 1: Nutrient composition of finger millet compared to other cereals (gram per 100g)

Food grain	Proteins	Carbo hydrates	Fat	Dietary fibre	Minerals	Calcium (mg)	Phos-phorus (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

Table 2: Essential amino acid contents of finger millet in comparison to other cereals

Food grain	Ileu-sine	Leu-sine	Lysine	Methi-onine	Cys-tine	Phenyl alaine	Threo-nine	Trypto-phan	Valine
Finger millet	4.4	9.5	2.9	3.1	2.2	5.2	3.8	1.6	6.6
Wheat	3.3	6.7	2.8	1.5	2.2	4.5	2.8	1.5	4.4
Rice (milled)	3.8	8.2	3.8	2.3	1.4	5.2	4.1	1.4	5.5
Barley	3.5	9.8	2.6	1.6	1.6	5.1	3.5	1.4	5.8
Maize	3.7	12.5	2.7	1.9	1.6	4.9	3.6	0.7	4.9
Sorghum	3.9	13.3	2.0	1.4	1.4	4.9	3.1	1.1	5.0
Oats	3.8	7.3	3.8	1.8	3.3	4.9	3.3	3.6	5.1
Pearl millet	4.1	9.6	3.4	2.5	1.8	4.8	3.1	2.0	5.5

Table 3: Mineral and vitamin contents of finger millet (mg/100 g)

Minerals	Content	Minerals	Content
Phosphorous	283	Nickel	0.02
Iron	3.9	Lead	0.6
Copper	1.0	Rubidium	0.2
Magnesium	173	Sulfur	122
Manganese	1.7	Tin	0.006
Molybdenum	0.01	Strontium	3.3
Aluminum	0.4	Titanium	0.03
Barium	2.2	Vanadium	0.04
Beryllium	< 0.05	Lithium	0.2
Bismuth	< 0.05	Zinc	1.5
Boron	0.05	Carotene	0.04
Cobalt	0.01	Riboflavin	0.19
Chromium	0.02	Niacin	1.1
Gallium	< 0.01	Choline	16.9
Potassium	300.0	Folic acid	18.3

Physical features

The seed coat and the endosperm form the main botanical component of the millet kernel. The embryo in the millet is hardly noticeable and accounts to about 2% of the seed whereas, the endosperm and the seed coat account to about 84 and 14% of the seed matter respectively. The entire kernel is edible and there are no reports of any kind of toxic or such other adversities reported on the millet consumption in any part of the world.

The seed coat of finger millet is generally copper brown in colour and contains large proportion of phytochemicals and pigments. However, different grades of brown and white coloured varieties of the millet are also cultivated. Polyphenols are the important phytochemicals having the neutraceutical qualities. The polyphenols are known to slow down the carbohydrate digestibility, regulate the intestinal microflora and minimize the gastrointestinal tract related disorders such as duodenal ulcer. The preliminary investigations on the millet polyphenols towards inhibiting the growth of *Helicobacter pylori* (known to be associated with gastrointestinal ulcer) have been highly promising. The millet polyphenols are complex in nature unlike other vegetable polyphenols; sparingly soluble in water, but can be extracted effectively in acidic methanol solvent system. Out of the large number of phenolics present in the millet, galic acid forms the major phenolics of the seed coat where as the ferulic acid forms the major phenolic of the endosperm cell walls. A considerable portion of the millet polyphenols and phytate are concentrated in the seed coat.

Traditional foods

Finger millet is normally consumed in the form of flour-based foods such as roti (unleavened pancake), mudde (stiff porridge/dumpling) and ambli (thin porridge) and each of these foods have their characteristics features (Fig. 2). For preparing roti, the flour is mixed with hot water to partially gelatinize the starch, kneaded into a dough, flattened and baked on hot pan by contact heat. During baking, the product develops characteristic aroma and swells, forming two distinct layers similar to wheat chapathi. The product normally turns leathery and chewy when left for a few hours after preparation. Normally, the roti is consumed along with vegetables, dhals and such other adjuncts. On the other hand, for preparation of mudde, initially a small quantity (2% w/v) flour is mixed with water, the slurry is heated to boiling and to that predetermined quantity of flour is added and left in the form of heap. Heating is continued to partially

steam the flour for a few minutes and then mixed well to a smooth consistency. Then it is shaped in to a ball of about 150 g each. Steaming the flour reduces its stickness and improves the hand and mouth feel. Very often in the social functions, the mudde balls are stacked in bamboo baskets for serving (Fig. 3). The eating pattern of mudde is distinctly different compared to other foods, as a small piece (5g) of mudde is rolled in sambar or sauce and swallowed without chewing. This offers advantage with respect to slow digestibility because the mudde does not undergo partial digestion by the salivary amylase in the mouth. In addition, it has been reported that an amylase inhibitor present in finger millet retains its activity even after the preparation of mudde, which partially inhibits the amyloglucosidase activity in the digestive tract leading to slow digestion of its carbohydrates. These factors contribute to the sustaining power of mudde for a longer time after its intake compared to other foods.

The thin porridge of millet is normally a mild fermented product (Fig. 4). For its preparation, the millet flour is mixed with water along with a small quantity of buttermilk and the contents are left overnight for mild fermentation. This improves the bioavailability of minerals and imparts feeble sour taste. The millet porridge or ambali is consumed in the summer season because of its soothing effect.

Processing and products

Milling

The finger millet grain invariably needs processing for food preparation. The most commonly practiced primary processing is pulverization or milling for preparation of flour. However, prior to milling, grain is cleaned free of foreign materials such as stones, stalks, chaffs, glumes and other grains. Generally the finger millet grain is covered by a outer glume or thin pericarp, which is a non-edible tissue and needs to be removed from the kernel prior to pulverisation. Now a days, the grain can be pre-cleaned using destoners and deglumed in abrasive mills such as rice huller or ragi polishers to separate the outer pericarp. The clean deglumed millet with attractive lustrous appearance fetches higher price in the market.

Grain is generally pulverized in stone, iron or emery coated disc mills and generally the whole meal is used for food preparation. Rarely, some consumers separate out a small portion of seed coat as coarse material by sieving. As on date, the scientific information on the quality criteria of millet flour suitable for roti and mudde are not well

defined, but normally finer flour containing about 10% of damaged starch is more suitable for roti where as sightly coarse flour is desired for mudde. The damaged starch in the flour absorbs more water during dough preparation and facilitates its flattening for roti making. On the other hand, the slight grittiness of the flour prevents lump formation during mudde preparation.

Since, there is growing demand for ready-to-cook products, a need has arisen to undertake R&D activities on preparation of the millet flour especially suitable for these conventional food products. Idli (Fig. 5) and dosa (Fig. 6) which are conventionally prepared from rice can also be prepared using the millet as base. The texture of these products are nearly comparable to rice. In view of the special nutritional features, now a days even ready mixes for idli and dosa from ragi are prepared and marketed.

To prepare refined flour with very low levels of seed coat content, the grains are sprayed with 3 -5 % addition water, tempered for about 10 min, pulverised and sieved. This treatment renders the seed coat leathery and reduces its pulverizibility during grinding. Hence, by sieving the meal, it is possible to separate out major portion of the seed coat from the flour. The refined flour can be prepared conventionally using the mini grain mill. The refined flour thus prepared will be more suitable for bakery products and noodles. The seed coat which forms the by product of the refining process contains about 600 mg calcium and may serve as natural source of this important dietary mineral or as an ingredient for calcium biofortification.

Noodles

Now-a-days, the millet noodles made out of finger millet flour are gaining popularity (Fig. 7). For preparation of noodles, the millet flour is blended with wheat flour to derive the benefits of wheat gluten, that enables cold extrusion. However, the noodles could be exclusively millet based. The pretreatment to millet enables extrusion and retention of the texture of the noodle vermicelli without fissuring when cooked in water.

Papads

Papad preparation consists of cooking the fine flour in appropriate quantity of water to completely gelatinize the starch, flattening the dough using roller pins to desired size and finally drying. Even though, the millet papads appear dark and less appealing, their expansion characteristics are very good and on deep frying, toasting or micro-

waving the product turns to light coloured papad with good consumer acceptability (Fig. 8).

Popping

Popping of finger millet is one of the popular traditional methods and the popped millet flour commonly known, as "hurihittu" is a ready-to-eat product. For this purpose, the millet is normally mixed with 3-5% additional water or buttermilk, tempered for 2-4 hrs, and then popped by agitation in sand heated to about 230^{o}C (High temperature and short time (HTST) treatment). During popping, the sugars in the aleurone layer react with amino acids of the millet causing Millard reaction and as a result, highly desirable aroma develops. When the grain is subjected to HTST treatment, the moisture content in the grain turns into steam, gelatinizes the starch and explodes (Fig. 9). In view of this, the popped millet is a precooked ready-to-eat product. The popped millet is pulverized and flour is mixed with vegetable or milk protein sources such as popped Bengal gram, milk powder and oil seeds and sweetened by jaggery or sugar to prepare a ready-to-eat nutritious supplementary food. Since popping is a dry process, the product will be almost free from microbial contamination and will have good shelf - life also. However, the traditional method of popping, where in hot sand is used as a heat transfer media contaminates the product with minute particles of sand and affects its eating quality. To overcome this drawback, air-popping machines using hot air as heat transfer media could be used. But, during air popping, some portion of aroma is lost rendering the product slightly bland compared to that prepared using sand as the heat transfer media.

Malting

Among the various tropical cereals, finger millet has good malting characteristics. Traditionally the millet malt is utilized for infant feeding purpose and also to prepare milk-based beverage from good old days. Some of the inherent qualities of the millet are: resistant to fungal infection and elaboration of alpha and beta amylase during germination and development of highly desirable aroma as well as taste on kilning the malt, qualifies it as an ideal raw material for malt foods. Besides, the ragi malt is a good source of sulphur amino acids and calcium. The malting process involves soaking, germination, drying, de-rooting and kilning. Although, these unit operations are of importance with respect to the quality of malt, the germination process is the single most important step because, the hydrolytic enzymes developed brings endosperm

modification. Besides, some of the vitamins are synthesized and the bioavailability of the minerals increases. Soaking millet for about 8-12 hr is needed for increasing its moisture content to about 30%. It is desirable to change the soak water once or twice, to discard the leacheates to free it from the carbon-di-oxide formed and to prevent excessive growth of microorganisms. The soaked grains are germinated either on clean floor or on moist cloth or gunny. During germination, it is essential to mix and overturn the material to dissipate heat developed and also to provide good aeration to the sprouts. Normally, germination up to 48 hr is desirable, but in summer, the germination period can be reduced to 24-36 hr.

The protease and cell wall degrading enzymes developed during germination, partially digest the cell walls. On the other hand, the amylases digest the starch to some extent. Hence, the malted ragi will have softer endosperm texture. To stop the germination process, the sprouts are dried either in sun or mechanically. In case of mechanical drying, the air temperature should not exceed 75ºC; as otherwise it will impart parboiling effect and hardens the grain, affecting its milling as well as food qualities. Sun drying the sprouts for 5-6 hours will dehydrate to 12-14% moisture level. Subsequently, the root and shoots form the dried sprouts are separated. De-rooting could be effected by gentle brushing or using fruit pulper or rice huller. The de-rooted malt is kilned or cured by toasting at about 70ºC by exposing to hot air or in conventional toasting pan or in rotary heaters. The product prepared in rotary heater develops better aroma with desirable qualities due to uniform exposure to contact heat.

The malt is not a ready-to-eat product and needs further processing for various food uses. Conventionally, the malt is pulverized and sieved through the nylon or thin fine cloth to prepare malt flour free from husk. Alternately, the malt is milled and the whole meal is suspended in excess water, the starchy portion settled is collected and dried. The malt flour thus prepared (either by sieving or by drying the settled material) is used for infant feeding and also as a base for the milk based beverage. Both the above said methods have drawbacks; in the former method, the yield of the malt flour is poor and hardly 35-40% whereas in the later method, the soluble nutrients from the malt such as amino acids, free sugars, vitamins and minerals are lost along with the discarded water. To overcome these drawbacks, CFTRI, Mysore has developed a **dry malt milling process.** It consists of mixing the malt with 5-7% additional water just to wet the surface of the grains and then pulverized. Then, the meal is sieved through a fine mesh to

separate out the seed coat as coarse flakes. Addition of water imparts rubbery texture to the seed coat and minimizes its pulverisibility and because of that, most of it is separated as coarse flaky bran. Normally, the yield of good quality husk free flour prepared following this process is about 65% on the malted grain basis.

The malt flour is a good source of nutrients besides, serves as a source of amylases and hence termed as **"Amylase Rich Food"** (ARF). It can be mixed with powdered sugar, milk powder and flavouring agents such as cardamom to use as milk based beverage, which is popularly sold as "ragi malt" in Southern India. Since, the malt flour contains hardly 3-5% protein, it can be blended with vegetable or animal protein source such as grain legumes, milk powder, egg powder etc., to prepare supplementary nutritious food for children. Now-a-days, about 5% ragi malt is invariably blended with the energy food to improve its texture. This food is produced on bulk and supplied to the weaning children. The process for preparation of weaning food based on malted millet (two parts) blended with malted green gram (one part) has been developed at CFTRI, Mysore and the food is popularly termed as **"Malted Weaning Food"** (MWF) (Fig. 10). Controlled child feeding trials on the MWF have shown its superior nutritional and textural qualities compared to several proprietary weaning foods. The food on reconstitution with water and heating to boiling, forms nutrient dense slurry (low bulk) and under comparable consistency, the MWF contains twice the amount of nutrients than the roller dried weaning foods. The malt flour as a substitute to maltodextrin, can be blended with milk and spray dried to prepare the **infant food** also.

The special feature of the malt flour to form nutrient dense free flowing slurry (about 1 kcal /ml) has been utilized towards the development of enteral foods. For this purpose, the malt flour is blended with other ingredients such as milk powder, sugar, soya flour, legume flours, vegetable oils and the blend is fortified with essential vitamins and minerals. The blend can be cooked to use as low cost enteral food or can be spray dried to prepare ready-to-eat enteral foods. The enteral foods prepared using the millet malt were found to be cost effective and clinically efficient in improving the nutritional status of patients and in reducing the hospitalization period.

The milk-based beverages marketed worldwide contain malt extract normally made from barley. While preparing the product, the mixed ingredients are dried and at this stage Millard reaction occurs and as a result, the lysine content of the product gets damaged. This affects the protein quality of the beverage formulations. Instead of using

barley malt extract, the spray dried millet malt can be dry blended to prepare health foods wherein, the interaction between amino acids and glucose will be very low and due to this, the product retains its good nutritional value. Thus, the finger millet malt has the potential of becoming a new ingredient in speciality / health food industry (Fig. 11).

Ragi rice

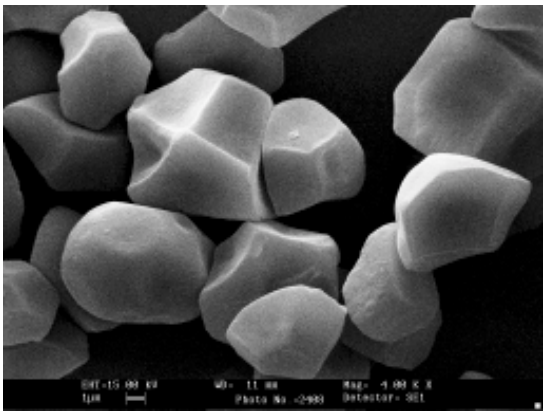
Finger millet has soft endosperm to which the tough seed coat is rigidly attached. Due to this characteristic grain texture, efforts to decorticate the millet similar to other cereals have not been successful. In view of this, the millet is always pulverized into flour and used for food preparation. Recent R&D work at CFTRI, Mysore, has shown that, finger millet could be decorticated to prepare ready-to-cook grain similar to rice. This has been made possible, probably first time by suitably modifying (hardening) the endosperm texture of the millet. The decorticated millet termed as *"ragi rice"* (Fig. 12) retains most of the nutrients of the millet (Table 4) and is suitable for cooking in the form of grains. It has good culinary characteristics and cooks to soft texture within 5 mins. The cooked grains retain their discreteness without exhibiting any stickiness. The cooked millet can be consumed along with *sambar* or other adjuncts or even can be seasoned with spices and condiments. *Ragi rice* can be size graded to semolina to use as a substitute to wheat semolina for conventional food products such as *upma*, porridge, and such other products.

Thus, it is now possible for the non-traditional millet consumers to utilize finger millet conveniently in readily acceptable form. The decorticated millet can be subjected to HTST treatment after pre-conditioning to prepare **expanded cereal** (Fig. 13). The expanded cereal is a novel product from the millet and likely to be accepted by the non-traditional millet consumers. The expended cereal has potential for use as an adjunct in confectionary and also as a base for snack foods. It is free from the seed coat with near spherical shape having cream colour, porous, crunchy and crisp texture. It can be seasoned with spice and condiments or coated with desirable adjuncts for use as a snack food. Among the brown and white seeded finger millets, the white cultivars are more suitable for preparation of ragi rice, because of the ease decortication and pearly appearance.

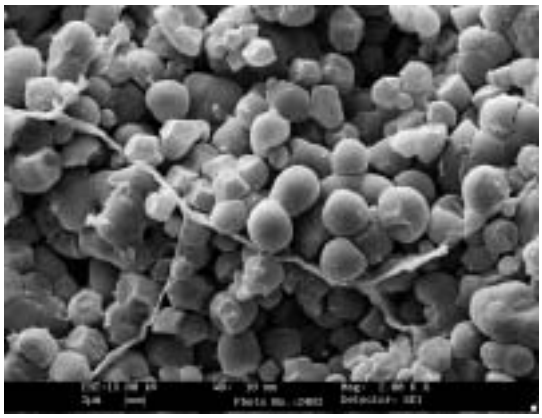
In summary, it can be stated that, the nutritional and technological features of finger millet enables application of traditional as well as contemporary food processing methodologies to prepare value added products which will have global market.

Table 4: Physicochemical characteristics of the native and decorticated millet (dry weight basis)*

Parameter	Native	Decorticated
Appearance	Spherical	Spherical and opaque
Color (% whiteness, DE)	Brown	
(3.2+1, 78.6)	Light cream	
(10.8+1.2, 59.3)		
Hardness (kgf)	1.1+0.5	7.1+0.6
1000 kernel wt (g)	2.9+0.4	2.6+0.5
1000 kernel volume (ml)	2.1+0.3	1.7+0.4
Density	1.379+0.019	1.501+0.032
Protein (g%)	8.1+0.7	6.3+0.6
Fat (g%)	1.5+0.2	0.9+0.2
Starch (g%)	58.1+2.0	74.0+3.4
Total Dietary fibre (g%)	22.0+1.2	14.7+1.8
Soluble dietary fibre (g%)	2.5+0.6	2.4+0.5
Insoluble dietary fibre (g%)	19.7+1.0	12.3+1.0
Minerals (g%)	1.9+0.1	1.0+0.2
Acid insoluble ash (g%)	0.12+0.02	0.07+0.01
Calcium (mg%)	317+17	180+15
Phosphorous (mg%)	211+8	109+10
Phytate (mg%)	236+7	142+8
Polyphenols (mg%)		
(Catechin equivalent)	265+7	67+9
Equilibrium moisture content (%), at 30^0 C	33+0.5	55+0.5
Solubility (%), at 30^0 C	3.9+0.5	8.5+0.4
Swelling (%), at 30^0 C	70+4	190+7
Swelling (%), at 80^0 C	260+8	270+11
Cooking time (min)	17+1	5+1



Ragi starch granules



Ragi endosperm

Fig. 1: Photomicrographs

Fig. 2: *Roti* and *mudde* made out of brown and white ragi

Fig. 3: Serving *mudde*

Fig. 4: Ragi *ambali* (thin porridge)

Fig. 5: Ragi *idli*

Fig. 6: Ragi *dosa*

Fig. 7: Ragi noodles

Fig. 8: Millet papad

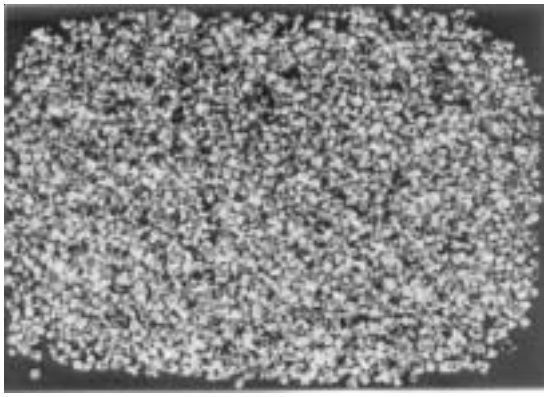


Fig. 9: Popped millet

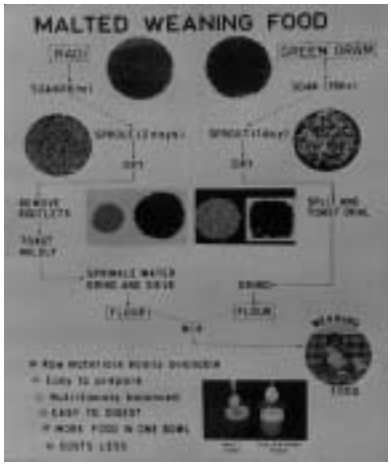


Fig. 10: Malted weaning food from ragi and green gram

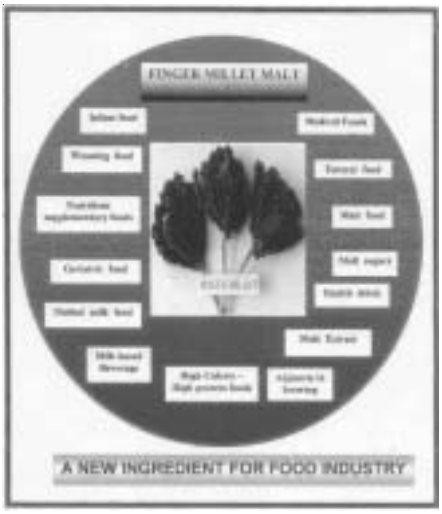


Fig. 11: Finger millet – the new ingredient

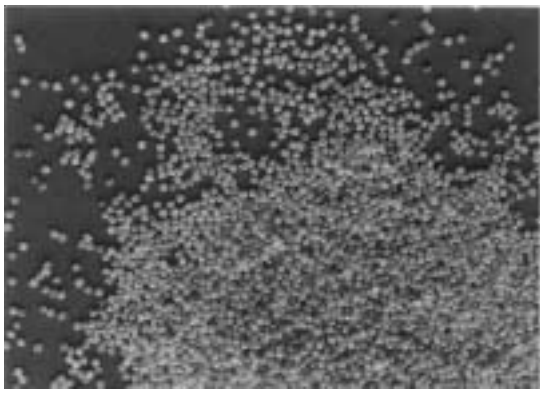


Fig. 12: Decorticated ragi

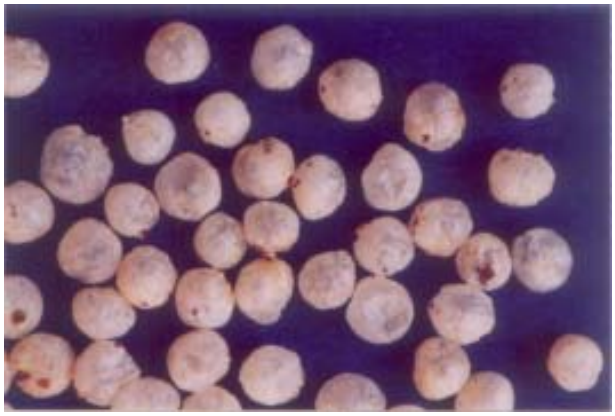


Fig. 13: Expanded millet

SMALL MILLETS: NUTRITIONAL AND TECHNOLOGICAL ADVANTAGES

S. R. Ushakumari and N. G. Malleshi
Department of Grain Science & Technology
CFTRI, MYSORE - 570013

Introduction

Small millets such as foxtail millet (*Setaria italica*), little millet (*Panicum sumatrense*), kodo millet (*Paspalum scrobiculatum*), proso millet (*Panicum miliaceum*) and barnyard millet (*Echinochloa frumentacea*) are regionally important food and feed crops in the country. Some of these millets are cultivated in other parts of world too especially foxtail millet in China, proso millet in USSR and middle east and barnyard millet in Japan.

Physical properties and morphological features

The small millets as the name implies are small seeded grains but resemble paddy or rough rice in their morphological features. The kernel consists of distinct husk, bran and endosperm tissues. Although, embryo is a distinct tissue, its proportion in the kernel is hardly 2%. The husk is non-edible similar to the husk in rough rice or paddy whereas bran may be part of the edible component but is separated to prepare milled millets for food uses. Normally, husk accounts to 15 to 20% of the kernel whereas the bran amounts to about 5% and the endosperm to about 75% of the kernel respectively. These grains are round to oval shaped and their 1000 kernel weight and volume range from 1.9 - 5.5 g and 1.3 - 3.8 ml respectively. The seed coat and husk of foxtail, little and proso millet are generally of single entity with glossy appearance whereas kodo and barnyard millet contain multiple layered seed coat. Normally the seed coat of kodo millet is of brown color, foxtail millet is yellowish whereas the other millets are grayish colored. The husk is non-edible matter similar to the husk in rough rice, whereas the bran is edible. Hence, to prepare edible millets, the husk is separated by milling and along with that generally, the bran is also separated similar to milled rice (Fig. 1a, b & c).

Nutritional characteristics

Small millets grains are comparable to major cereals such as rice, wheat, maize and sorghum with respect to their nutrient composition (Table 1). On the other hand, some of these millets contain considerably higher proportion of phytochemicals with

neutraceutical qualities. The protein content of small millets ranges from 7- 12% and fat content varies from 3-5%.

Table 1: Proximate composition of the small millets (g/100 g)

Millet	Protein	Fat	Carbo-hydrate	Dietary fibre	Minerals	Calcium (mg%)	Phosp-horus (mg%)
Foxtail millet	10-12	4-5	60-70	15-19	3	31	290
Little millet	5-10	3-5	60-70	12-19	1.7	17	220
Barnyard millet	5-7	2-3	60-70	15-19	3.7	14	121
Kodo millet	7-12	1.5-3	60-70	15-19	2.6	27	188
Proso millet	10-12	1-3	67-75	12-15	1.9	14	206

Protein

The protein quality is of fairly good biological value since they contain about 2.54 g of lysine and other amino acids in desirable proportion including leucine to isoleucine ratio (Table 2). Some of the millets contain good amount of arginine, which is considered as an essential amino acid for growing children. Prolamins, albumins, globulins and glutelins are the proteins of these millets and among these, prolamins form the major constituent. Presence of proteinaceous enzyme inhibitor have been reported but they are heat labile and hence their protein digestibility is not affected. Similar to other cereals, the millet proteins are also deficient in lysine and tryphtophan.

Table 2: Essential amino acid contents of minor millets (g /100g protein)

Millet	Isoleu-cine	Leu-cine	Lysine	Methio-nine	Phenyl-anine	Threo-nine	Trypto-phan	Valine
Foxtail millet	7.6	16.7	2.2	2.8	6.7	2.7	1.6	6.9
Little millet	7.2	15.9	2.1	2.4	6.0	2.1	1.9	6.4
Barnyard millet	8.8	16.6	2.9	1.9	2.2	2.2	1.0	6.4
Kodo millet	3.0	6.7	3.0	1.5	6.0	3.2	0.8	
Proso millet	8.1	12.2	3.0	2.6	4.9	3.0	0.8	6.5

Fat

Among small millets, foxtail and proso millet contain about 5% fat and the fat is distributed in bran as well as in endosperm. The fat generally consists of more than 60% unsaturated fatty acids including essential fatty acids namely linolenic acid. Hence millet consumption provides the consumer with considerable amount of invisible fat energy. The note worthy aspect about the millet fat is that unlike pearl millet and sorghum, development of rancidity in the millet products is very low.

Carbohydrates

The millet carbohydrates comprising of free sugars, non-starchy polysaccharides and starch form the major source of energy to the consumers. While free sugars hardly amounts to 2-3% in milled grains, the non-starchy polysaccharides account to 15-20% and starch content varies from 60 to 75%. Among the free sugars, glucose, fructose and sucrose are prominent and the presence of flatulence causing oligosaccharides such as arabinose, stachyose and verbascose are generally absent. The non-starchy polysaccharides form the major part of dietary fibre and comprise of cellulose, hemicelluloses and pectinaceous material. The presence of β-glucans and lignin like material is generally negligible. The insoluble dietary fibre normally amounts to 90% of the total dietary fibre and most of it is contributed from the aleurone layer and cell wall matter of the kernel. Similar to other cereals, the millet starch consists of amyloses and amylopectin, which are generally present in the ratio of 25:75. Although, most of the millets are considered as high amylose cereals, waxy millets are also cultivated in China. Very little information is available on the structural features of the amylose and amylopectin and the starch granules appear compacted in the cellular matrix and major portion of the endosperm is of vitreous nature. The morphology of the granules differ from one another but most of the granules are of smaller size (3-10 μ) when compared to wheat.

Neutraceuticals

Small millets are also good source of micronutrients and B group vitamins. These millets also contain polyphenols, carotenoids, tocopherols and tocotrienols which exhibit antioxidant properties (Table 3). Some of them are known to contain β-carotene also. Probably next to maize, foxtail millet may be the richest source of β-carotene and it is present in the form of its isomers.

Table 3: Antioxidants, carotenoids, tocopherols and tocotrienol contents of small millets

	Total antioxidants (mM TE/g)	Total carotenoids (μg/100g)	Tocotrienols (mg/100g)				Tocopherols (mg/100g)				Total Vit E
			γ	δ	α	Total	γ	δ	α	Total	
Little millet	3.1-6.3	51-104	0.01	0.02	0.00	0.03	0.63	0.5	0.15	1.3	1.33
Foxtail millet	4.5-5.2	126-191	0.00	0.09	0.00	0.09	0.03	0.97	0.18	1.2	1.29
Proso millet	4.2-6.3	249-518	0.00	0.02	0.00	0.02	0.7	2.6	0.3	3.6	3.62

The contents of polyphenols in millet grain is negligible compared to other major millets such as finger millet but the presence of pigment in some of the millet varieties which is bestowed with golden yellow color has been reported.

Processing

Milling

Similar to rice, barley, oats and rye, the whole grains of these millets are not edible and need dehusking prior to its food use. This involves the primary processing namely milling to prepare ready-to-cook grains. Although they are ancient grains, very little R & D has gone towards development of exclusive milling technology for them. In good old days, dehusking and debranning was normally carried out manually using hand pounding system (Fig. 2) but now a days with the advent of milling technology, polishing of these millets to prepare ready-to-cook grains similar to rice has been made possible. However, most of the large capacity small millet mills differ from rice milling system as dehusking and debranning is carried out in a series of emery coated inverted cones and as a result the yield of good quality head grains is hardly 45%. However, but the experiments at CFTRI, Mysore has shown that the millet could be dehusked in rubber roll or cetrifugal shellers and the husked material can be debranned in rice milling machinery. Adapting this technology it has been possible to separate husk and bran in pure form to prepare head grains of about 55% yield besides the bran (free from husk), containing about 15% oil which could be used as an extender to rice bran for oil extraction. The de-oiled bran can find uses as a component of animal feed and can also be utilized as a source of dietary fibre in specialty foods. The milled grains are ready-to-cook product and can be cooked as discrete grains similar to rice or can be size graded into grits or semolina or can be pulverized into flour for various food uses similar to rice flour (Fig. 3). The flour can be used with refined wheat flour to prepare composite flour for use in for bakery products also (Fig. 4).

Flaking

The small millet grain can also be given secondary processing to prepare flakes or pregelatinized food material. For flaking, grains soaked in water to hydrate to their equilibrium moisture content are steamed and pressed in roller flaker and dried to safe moisture level (Fig.5). The flakes may be used to prepare snacks by subjecting to blistering by high temperature and short time treatment using salt, air or oil as the heat transfer media. The blistered material will have flowery attractive look and crisp taste and are amenable for coating with spice or malt extract and such other desirable additives. The meal from the milled grains has potential for preparation of fabricated foods, noodle preparation (Fig. 6) or simply to use for the preparation of many traditional food items.

Extrusion cooking

The milled material contains good amount of starch and exhibit good extrusion cooking characteristics. The millet grits equilibrated to about 18% moisture on extrusion cooking form well expanded ready-to-eat food products with porous and crunchy structure (Fig. 7). The extruded material can be prepared in different shapes and sizes such as flakes, small balls or cheese rolls or can be pulverized into grits for different end uses. In case the product need to be used as a supplementary then the millet can be blended with grain legumes in appropriate proportion and fortified with vitamins and minerals or alternately the extruded can be pulverized and mixed with milk powder, grain legumes etc. to prepare supplementary foods for children and mothers (Table 4). To prepare snack foods, the millet food is mixed with different spice such as chilli powder, pepper, salt and cumin and other desirable condiments including permissible color so that the extruded product serves as a snack (Fig. 8). Ultimately the extrudates may be coated with malt extract or other sweet or savory adjuncts to prepare snacks mainly suitable for school going children.

Roller drying

The flour from the millets could be roller dried to prepare a ready-to-eat food, most suitable as a thickener in soup or porridge. The roller dried millet may also find usage as a component of edible films. The nutrient composition and some of the functional properties of the millets processed adapting contemporary food processing technology such as extrusion cooking, roller drying, flaking and popping indicate their potential for preparation of value added products (Table 5).

Table 4: Nutrient composition of extruded supplementary foods (g/100g)

	Formulations	
	I (M+SOY I)	II (M+BG+CG)
Protein (%)	16.0	14.7
Fat (%)	4.4	4.7
Minerals (%)	2.8	2.5
Dietary Fibre (%)	1.7	1.2
Carbohydrates (%)	61.3	65.2
Energy (for 100 g) (Kcal)	388	362
Calcium (mg %)	81	48
Phosphorus (mg %)	381	314
Iron (mg %)	8.8	7.1

I M+Soy : Millet (85%) + Soya (15%)
II M+BG+GG : Millet (70%) + Bengal gram (20%) + Green gram(10%)

Table 5: Nutrient composition of decorticated and differently processed foxtail millet (dry weight basis) *

	Decorti-cated	Popped	Flaked	Roller dried	Extruded
Protein (g %)	10.2	12.7	10.4	10.4	10.3
Ether extractives (g %)	2.3	4.6	0.7	0.6	0.7
Starch (g %)	77.0	68.0	76.0	79.3	79.2
Dietary fibre (g %)					
Soluble	3.6	5.0	4.8	3.7	4.4
Insoluble	5.2	6.8	6.0	4.6	3.8
Total	**8.8**	**11.8**	**10.8**	**8.3**	**8.2**
Ash (g %)	1.7	2.9	2.1	1.4	1.6
Calcium (mg %)	29	38	32	31	28
Phosphorus (mg %)	210	289	128	143	170
Starch digestibility (%)	96	95	93	97	95
Bulk density (g /ml)	0.94	0.12	0.44	0.17	0.10

* Average of duplicate determinations

Popping

The millets could be popped similar to other cereals. However, equilibrating them to 16-18% moisture level is needed prior to subjecting to high temperature short time treatment to produce the popped material with higher expansion ratio. Normally the volume of the expanded material varies from 5 to 9 ml/g. Generally, during popping, husk gets detached from the popped grain and hence the popped millet is totally a ready-to-eat product (Fig. 9). Since it contains almost all the bran of the millet, the popped material is a good source of dietary fibre also. Moreover, the material undergoes high temperature short time treatment, it will be almost free from microbial contaminants. Probably due to the lower moisture level and inactivation of lipase during heat treatment and also due to the presence of antioxidants, the popped millet will have good shelf-life. The popped grain is a pre-cooked food and may find usage as an adjunct in brewing. The popped millets could be blended with ready-to-eat grain legumes, oil seeds, milk powder, sugar or jaggery and fortified with necessary vitamins and minerals to formulate nutritious food suitable for supplementary feeding program.

The flour can be used with refined wheat flour as composite flour for bakery products also.

Malting of these millets does not offer economic advantages because of the low yield of malted grains, poor levels of amylolytic enzymes. Another disadvantage is that during germination some of the millets especially kodo and barnyard, which have multilayered seed coat facilitate to harbor some of the microorganisms.

Parboiling

Traditionally, the practice of parboiling is in vogue especially in little millet. Parboiling or hydrothermal treatment seems to be highly promising because of the nutritional benefits, improved milling qualities and improved culinary characteristics. However, no concerted efforts to standardize the methodology of parboiling has been carried. Since the millets resemble rice in their morphological features, the husk provides protection to the grains during steaming and prevents burst opening. Normally the grains can be soaked at ambient to higher temperature (80^{o}C). Soaking grain at higher temperature reduces the time of hydration to a few hours. The grains soaked to their equilibrium moisture content (35%) can be steamed at atmospheric or at higher pressure to gelatinize the starch. The millets can also be parboiled adopting shella or dry heating methodology.

The steamed grains can be dried in a conventional manner and milled in rice milling machinery similar to parboiled rice offer considerable advantages with respect to milling characteristics namely reduced breakage during milling and higher yield of head grains. As in the case of rice, the parboiled millets are likely to contain better retention of vitamins especially the thiamine and enhanced storage life. Parboiled grains on cooking form less sticky food products and the cooked material can be utilized similar to rice (Fig. 10) along with other adjuncts or can be seasoned with spice and condiments to prepare various types of pulse. The parboiled millets can be processed to prepare a ready-to-eat product similar to expanded rice. However, by incipient germination and hydrothermal treatment, the expansion could be 4-5 times. The expanded millets posses all the desirable characteristics for preparation of snacks and also adjuncts in specialty health products. Now a days, there is a growing demand for ready-to-eat high fibre products and hence the expanded millets will be of great potential value.

Fig.1a: Milling fractions of Foxtail millet

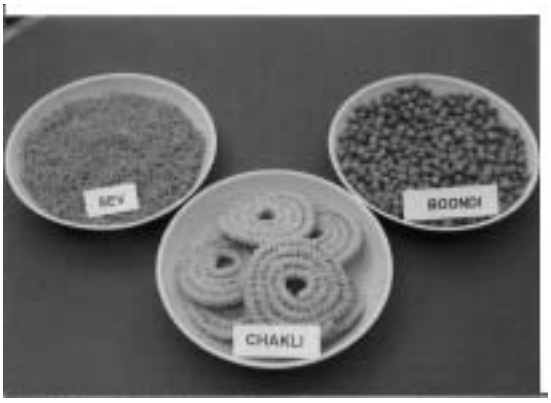
Fig.1b: Milling fractions of Proso millet

Fig.1c: Milling fractions of Kodo millet

Fig. 2: Hand pounding to prepare dehusked millet

Rice

Pongal



Fried Items

Kheer

Fig 3.: Traditional products from millets

Fig. 4: Bakery products from foxtail millet

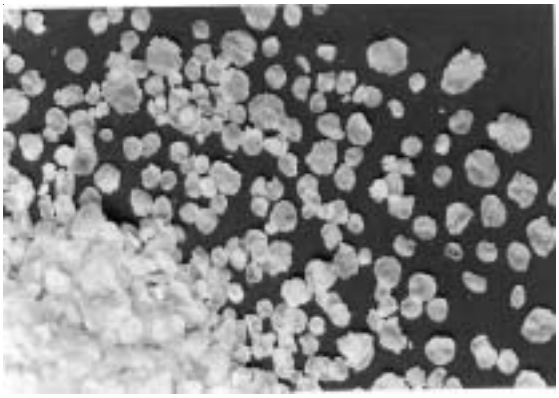


Fig.5: Foxtail millet flakes

Fig. 6: Extruded foxtail millet

Fig. 7: Ready-to-eat snacks from small millets

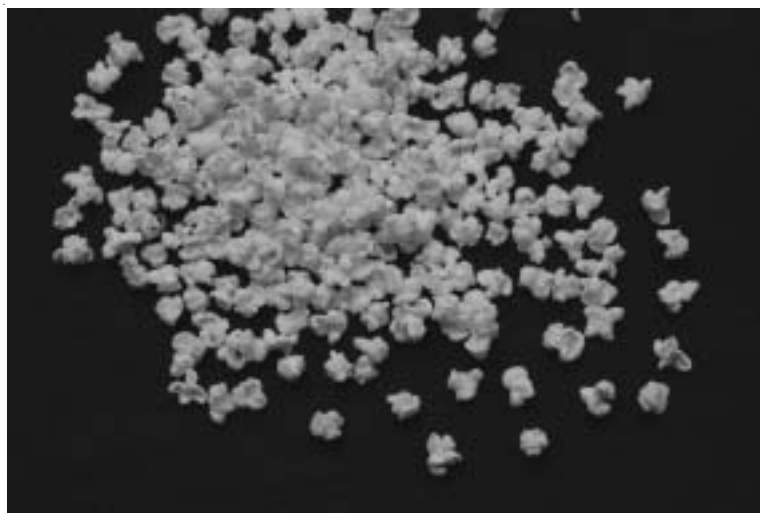


Fig. 8: Popped little millet

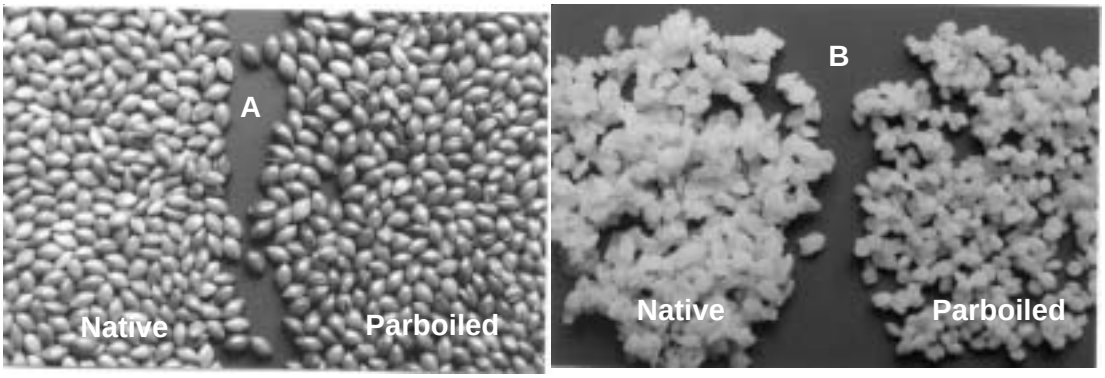


Fig. 10: Native and parboiled millet grains; A- Control, B- Milled and cooked

PROCESSING AND VALUE ADDITION OF SMALL MILLETS WITH SPECIAL REFERENCE TO *Paspalum, Setaria* AND *Panicum* sp.

Nandita Kar
Department of Agricultural and Food Processing
Indian Institute of Technology
Kharagpur-721302

Small millets - *Paspalum scrobiculatum* (Kodo millet)*, Setaria italica* (Foxtail millet)*, and Panicum sumatrense* (Little millet) - are indigenous food grain resources and have a long history of cultivation. Their importance has diminished and marginalized as poor man's crop in spite of recognizing them as nutritious cereals.

Small millets are generally coarse and have conspicuous outer coverings, which are difficult to remove, increase the fibre content and contribute to the coarse texture of grains. Milling, a basic processing operation for grains, is a prerequisite for the development of value added products for urban market such as polished grains, grits and flour for food uses. Mechanised dehusking and polishing of millets paves the way for this value addition.

Dehusking and polishing of small millets

Rice milling machines viz., rubber roll sheller, abrasive polisher, a McGill polisher, a rice huller and a dal mill were tested for dehusking raw and parboiled grains and polishing small millets. The results are presented below:

Kodo millet

The outer coverings of kodo millet constitute 30-40% of the grain and grain yield will range from 60-70 per cent only. From tables 1.1 to1. 3 it is evident that the best results for dehusking and polishing raw kodo millet is by moisture conditioning the grains to 16 % and using an abrasive polisher. The raw husk-bran mixture contained 3.5% and parboiled husk-bran 5.2 % oil. The parboiled grains gave a better yield (68%) in an abrasive mill.

Table 1.1: Dehusking of *kodo* in a satake rubber roll sheller

Sample	Yield (%)	Coefficient of dehulling (%)	Coefficient of milling (%)
Raw	56.0	84.0	83.0
Parboiled	65.0	97.0	98.0

Table 1.2: Polishing of dehusked kodo in abrasive polisher

Sample (%)	Polish (%)	Head yield (%)	Brokens
Raw	1.3	92.0	5.75
Parboiled	1.5	95.0	3.0

Table1.3: Dehusking-polishing of *kodo* grains in an abrasive polisher

Batch size (g)	Pearling time (min)	Pretreat-ments	Yield (%)	Coefficient of dehulling (%)	Milling efficiency (%)
250	26	—	62.0	96.8	96.5
250	26	Mois. Cond. IMC 16%	61.2	98.0	97.8
250	26	Soaked-dried 30min-60min	60.0	97.8	96.8
250	18	Parboiling	68.0	98.0	99.0

Foxtail millet

Dehusking and polishing of foxtail millet in a Rubber roll sheller-abrasive polisher yields 63.0% grains (Table1.4 and 1.5) but moisture conditioning and abrasive polishing will further improve the yield (Table 1.6).

Table 1.4: Dehusking of foxtail millet in a rubber roll sheller

Sample (%)	Yield dehulling	Coefficient of (%)	Coefficient of Milling (%)
Raw	68.0	99.5	82.0
Parboiled	70.0	99.0	98.0

Table 1.5: Polishing of dehusked foxtail millet in an abrasive polisher

Sample	Polish (%)	Head yield (%)	Brokens (%)
Raw	4.0	92.0	4.0
Parboiled	3.0	95.0	2.0

Table 1.6: Dehusking-polishing of foxtail millet and little millet grains in an abrasive polisher

Millet Sample (Raw)	Yield (%)	Coefficient of dehulling (%)	Coefficient of Milling (%)
Foxtail millet	60.2	92.0	90.0
Little Millet	61.2	88.0	87.0

Little millet

The dehusking-polishing of little millet in a rubber roll sheller-abrasive polisher yields 69% grains (Table 1.7,1.8) but dehusking polishing in abrasive polisher gives low yield (Table 1.6)

Table 1.7: Dehusking of little millet in a rubber roll sheller

Sample	Yield (%)	Coefficient of dehulling (%)	Coefficient of Milling (%)
Raw	75.0	96.5	87.0
Parboiled	78.0	99.0	98.0

Table 1.8: Polishing of dehusked little millet in an abrasive polisher

Samples (%)	Polish	Head yield (%)	Brokens (%)
Raw	5.0	92.0	3.0
Parboiled	3.0	95.0	2.0

Parboiling of millets

Parboiled kodo grains can be dehusked in a rice huller and *Dal* mill as the outer coverings are loosened due to parboiling. Grains can be parboiled in a drum parboiler

(Kar *et al*., 2004). The raw, parboiled grains, grits and flour could be obtained by marginally modifying existing grain milling machines.

These millet grains have a better nutrient content (Table 1.9) and other health benefits. They have high dietary fibre, low glycaemic index and slower digestion of carbohydrates. They are beneficial for diabetes, high blood pressure and duodenal ulcers. Due to their short cooking time they can be used as breakfast cereals. They can also be used as health cereals and alternative cereals for use during fasts and other rituals not allowing consumption of regular cereals.

Table 1.9: Nutrient composition of small millets and cereal grains

Cereal grain	Protein (g)	Carbo hydrate (g)	Fat (g)	Crude fibre (g)	Mineral Matter (g)	Calcium (mg)	Phos phorous (mg)	Iron (mg)
Kodo millet	8.3	66.5	1.4	9.0	2.6	27	188.0	5.2
Foxtail millet	12.3	60.9	4.3	8.0	3.3	31	290	5.0
Little millet	7.7	67.0	4.7	7.6	1.5	17	220	6.0
Wheat	11.8	71.2	1.5	1.2	1.5	41	306	5.3
Rice	6.8	78.2	0.5	0.2	0.6	45	160	-

Mechanized grain milling

Mechanized milling of whole foxtail millet yields 30% husk, 3% bran (with 12% oil) and 66% grain (with 3.5 % oil and 13.6% protein), which cooked in 6 minutes. These grains have the potential as quick cooking cereal and substituting rice in traditional products.

Mechanized milling of little millet yields 20% husk, 5% bran (with 3% oil) and 73% grains (with 9 % protein), which cooked in 8 minutes. These grains also have the potential as quick cooking cereal and substituting rice in traditional products.

Dosas from batter prepared by soaking, grinding and fermenting parboiled and raw kodo grains, black gram dal (3:1:2) and methi seeds were well appreciated. Idlis prepared by soaking raw kodo and black gram in the ratio of 2:1 were soft and well accepted. Utthapams were made from dosa /idli batters.

Raw kodo grains were made into *kheer* and substituted rice in traditional products like Bhakri (unleavened bread), idli, d*osas* and *utthapam*. All products proved popular and earned good sensory scores. Raw grains can also be consumed as breakfast cereal with or without milk/curd and cook in 8 minutes.

Puffing and popping millet grains

Kodo, Foxtail and Little millets were converted into puffed and popped products. These grains were parboiled in an inexpensive set up like the drum parboiler and dehusked and polished. Thereafter grains were puffed in a grain-puffing machine.

Puffed and popped products from kodo (Fig. 1), foxtail and little millet (Fig. 2) were well appreciated. Puffed Kodo, a crunchy product (expansion volume 6.5), was best appreciated with a sensory evaluation score of 9.7. Popped product from Kodo (popping 67 %, expansion volume 18) is suitable for consuming by itself or with milk had a sensory score of 7.5/10. Popped products from foxtail millet and little millet had an expansion volume of 9 ml/g and had a sensory score of 6/10. Puffed kodo flour with sugar and cardamom gave a '*Hurihittu'* like product and was liked extremely well (9/10). This precooked flour was also evaluated as '*sattu'*, a savoury dough popular in North and Eastern India. Puffed kodo was further made into 'moa' or 'laddu' with molten jaggery. This is a popular sweet in West Bengal.

Popping and puffing kodo in a grain-puffing machine gives a profit of Rs. 60 -70 for a 4 hour operation.

Millet flours

Flours were obtained from foxtail millet and kodo millet after grinding the polished grains. The flours with particle size less than 0.2 mm were converted into pancakes. These pancakes of weight 28 g, diameter 13.5 cm and thickness 2.6 mm had a sensory acceptability of 7/10.

The flours were given to a professional baker and cookies were made with 100% millet flour. Cookies (weighing 18 g, diameter 6 cm, spread ratio 6) had sensory score 8/10.

Small millet flours had potential for developing into vermicelli, pasta and ready to eat bhujia (Fig. 3, 4). Vermicelli and pasta cooked in 6 minutes.

The vermicelli from raw kodo, fried directly, was well appreciated (9/10) and can be projected as **millet bhujia.**

Kodo and blackgram flours with some additives were formulated into dosa and idli mixes. Dosas and idli prepared from these mixes scored 7.0 and 7.7 in a Hedonic scale. These can be commercially exploited.

Development of such products of urban-domestic and commercial use will enhance the contribution of these underutilized crops to the food basket. Thus it is evident that appropriate processing of small millets such as *Paspalum, Setaria* and *Panicum* will lead to the development of nutritious products and health foods, lessen the load on major cereals, be remunerative to marginal farmers improve the economy of hilly and tribal areas and drylands.

Fig. 1: Popped and puffed grains of kodo millet

Fig. 2: Popped grains of little and foxtail millet

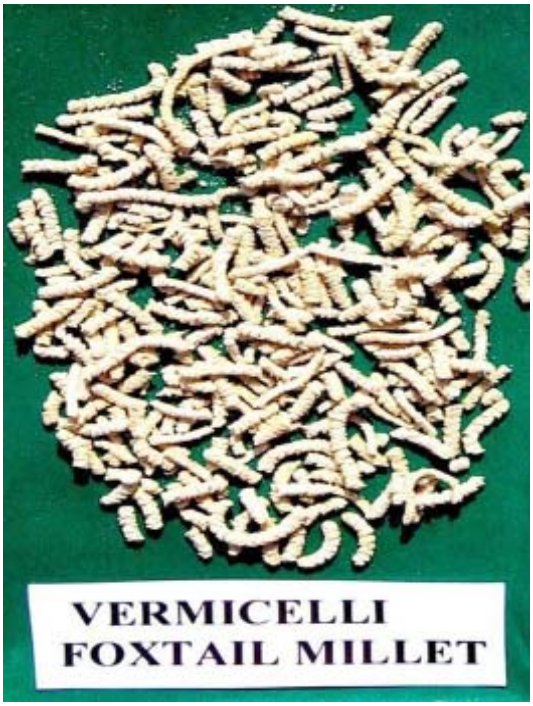


Fig 3: Vermicelli made from foxtail millet

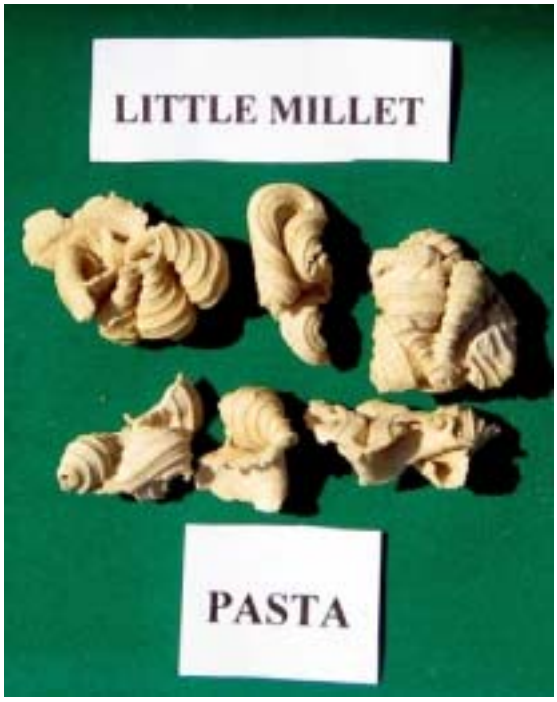


Fig 4: Pasta product made out little millet

REFINED PROCESSING AND PRODUCTS FOR COMMERCIAL USE AND HEALTH BENEFITS FROM FINGER MILLET

J. Mushtari Begum
Former Co-ordinator, AICRP (FN),
Division of Home Science, UAS, Bangalore-560 065

Finger millet occupies a premier place in the diet of rural population in Karnataka. Millet is nutritionally rich and provides protein, minerals, vitamins, dietary fibre, phytochemicals besides iron and other micronutrients in ample quantities.

The grain can be subjected to processing such as germination and puffing for improving the flavour and enhancing the nutritive value and bioavailability of nutrients, minerals and vitamins. After processing several ready to eat and malted beverages can be prepared. It can also be utilized in the formulation of weaning foods for infants and geriatric foods for the elderly. Refining technology can be applied to remove the seed coat and the resulting refined flour can be utilized in the preparation of health foods, baked foods and foods for commercial market.

Utilization of finger millet in the daily dietary at present is largely restricted to the rural areas. Farmers consider that the stiff porridge (mudde) prepared from finger millet provides them the satiety to work in field for long hours and hence has been the most preferred food item. However, similar consumption pattern is not seen in urban areas probably due to unavailability of products suiting to the taste of urban dwellers. The further promotion of finger millet requires diversification of products in terms of infant foods, health foods, ready to eat foods, ready to prepare fermented foods, bakery products and confectionary, pasta products, snack foods, preserved foods, food adjuncts like papads and wafers, ready mixes and beverages. In the process, food processing industry can add value to the crop to increase the income of the farmer, create new employment opportunities, diversify the rural economy and provide scope for rural development.

Processing of Finger Millet

Primary processing of finger millet includes malting, roasting, popping and refining. The products of primary processing are further processed for the preparation of traditional

foods, specialty foods, baked foods and health foods. Processing is advantageous in terms of nutrition as it reduces the tannin content and improves the bioavailability of nutrients. Reduction in tannin content on account of germination, roasting and popping will be to an extent of 33 %, 54 % and 36 % respectively.

Finger millet has excellent germinating capacity to the extent of 99 per cent and hence suitable for malting. Germination process requires cleaning, washing and soaking of grain overnight and then germinating for 48 hours at room temperature. Afterwards, the germinated seeds are dried in sun or in electrical driers at 60^{o}C.

Roasting of finger millet can be done by heating the grain at 110-150^{o}C with proper mixing for uniform distribution of temperature. Popping requires determination of initial moisture in order to bring it to 19 per cent. Grain has to be equilibrated in closed container for 8 hours prior to popping in an iron frying pan. The temperature needs to be maintained at 175-200^{o}C during popping. Unpopped grains can be separated by sieving.

Refining of finger millet helps in improving the colour and bioavailability for utilization in commercial products specially baking industry. The method involves cleaning and conditioning of finger millet with 7 per cent moisture and tempering for 10 minutes; milling and sieving using 80 mesh to remove husk.

Products of commercial value

1) Finger millet based vermicelli

Pasta products are convenience foods prepared through cold extrusion system. A pasta product includes spaghetti, macaroni, vermicelli and noodles. These products are hard, brittle pieces extruded into different shapes and dried. Vermicelli can also be cut into desired size to get uniform pieces (Fig. 1).

Processing of finger millet based vermicelli

Finger millet flour (500g) + whole wheat flour (400 g) + defatted soy flour (100 g)

↓

Premix in pasta extruder for 2 minutes

↓

Add180ml water & remix for 2 minutes

↓

Extrude & cut attaching cutter

↓

Oven dry at 60°C

↓

Finger Millet Vermicelli

The finger millet vermicelli on analysis contains nearly 18 per cent protein and negligible amount of fat. Carbohydrate content is around 71 per cent with an energy content of 206 Kcal. Calcium and iron content being 214 mg % and 5 mg % respectively.

The vermicelli can be utilized in many traditional food preparations such as uppuma, pongal, dhokla, pulao, pulyogere, limebath, cutlet and kheer. The resulting preparations are as nutritious as that of preparations made out of maida based vermicelli.

2) Finger millet malt for weaning

Weaning is a process in which an infant changes from breast milk to a mixed diet, other foods being given regularly over time in increasing amounts until replacement is virtually complete. It is important that foods are selected properly so as to provide adequate balance between the nutrients. The foods selected for weaning mix should be grown locally, easily available in the market and of low cost. Considering these, finger millet would be the best choice for utilization in infant food formulation.

The simplest recipe for weaning food is a combination of a cereal and legume. Other foods such as cooked vegetables and fruits can be added to make a complete food. Cereal and pulse used are germinated to enhance the amylase activity and get the benefit of higher calories.

Preparation of finger millet based malt

Finger millet (70%) + Wheat (15%) + Greengram (15%)

↓

Soaking

(12-16 hrs)

↓

Sprouting

→ Green gram (24 hrs)

→ Wheat and finger millet (48 hrs)

↓

Sun / oven drying at 60°C

↓

Kilning and toasting

↓

Conditioning (5% moisture)

↓

Tempering (10 minutes)

↓

Milling, Sieving (60 mesh)

↓

Finger Millet Malt

Cereals in the malt mix provides the necessary energy and legume provides protein in adequate quantities (Fig. 2). Cooked vegetables and fruits added at the time of feeding the child enriches the food with minerals and vitamins.

Nutritive value of finger millet malt based weaning food

Nutrients	Per cent
Moisture (%)	6.2
Protein (g)	9.0
Fat (g)	1.5
Ash (g)	1.9
Crude Fibre (g)	2.6
Carbohydrate (g)	79
Energy (Kcal)	365
Calcium (mg)	193
Phosphorous (mg)	268
Iron (mg)	5.2

3) Finger millet papad

Papads are commonly used as dietary adjuncts and traditionally made from black gram dhal. However, finger millet flour can be substituted to an extent of 60 per cent without affecting the rolling quality and appearance (Fig. 3).

Processing of finger millet papads

Finger millet flour (60%) + Black gram dhal flour (20%) + Sago flour (20 %)

→

↓

Add papad khar (2.5g) & Salt (5g)

↓

Add coarsely pounded cumin, pepper & redchilli (1tsp each)

↓

Make dough with hot water & knead oil

↓

Rest for 30 minutes

↓

Divide the dough into 16 balls

↓

Press using papad press

↓

Dry in sun/shade

↓

Deep fry / Roast

Nutritive value of papads

Nutrients	Percentage
Moisture (%)	4.8
Protein (g)	8.6
Fat (g)	1.4
Ash (g)	5.3
Crude fibre (g)	1.8
Carbohydrate(g)	78
Energy (Kcal)	359
Calcium (mg)	157
Phosphorus (mg)	265
Iron (mg)	5.4

Papads making can be promoted among women in rural areas as a cottage level industry for income generation and requires very little investment. Since, it is traditional product and when it is partly substituted with finger millet it is going to cost less and this way it can be easily promoted in commercial markets in urban areas. The finger millet papad has very high level acceptance as a crispy and tasty product both in rural and urban areas.

4) Ready to Eat (RTE) puffed finger millet mix

Puffing of finger millet with additional ingredients can produce a nutritious mix which requires no further cooking and with proper packaging it can be hygienically fed to children in feeding programmes and to pregnant and lactating mothers enrolled in Anganwadi centers. Nutritionally the mix contains higher amount of protein, energy, calcium and iron with higher bioavailability.

Composition of the RTE puffed finger millet mix

Ingredients	Per cent
Puffed finger millet flour	30
Sugar powder	33
Defatted Soy	10
Desiccated coconut	25
Cardamom	02

Nutritive value of RTE puffed finger millet mix

Nutrients	Per cent
Moisture (%)	2.9
Protein (g)	12.0
Fat (g)	16.7
Ash (g)	0.1
Crude Fibre (g)	1.7
Carbohydrate (g)	67.0
Energy (Kcal)	465
Calcium (mg)	132
Phosphorous (g)	131
Iron (mg)	1.0

Fig 1: Different finger millet based pasta products

Fig 2: Finger millet malt

Fig 3: Roasted finger millet papad

VALUE ADDING STRATEGIES FOR PRODUCTION AND SUSTAINABLE USE OF INDIGENOUS SMALL MILLETS

Nirmala Yenagi,
Department of Food Science and Nutrition,
College of Rural Home Science,
University of Agricultural Sciences, Dharwad-580 005, Karnataka

Introduction

Among the food grains, millets are the cheapest and widely available source of energy and their intake is the highest among the poor income families. The use of millets is becoming less popular especially among urban population due to non availability of suitable post harvest technologies to develop consumer attractive processed products similar to rice or wheat.

Traditional knowledge on the use of millet for consumption

Though regular consumption of millet in general is on gradual decline; it is still consumed as staple food regularly among millet growers and low income families. Rice from decorticated little millet and foxtail millet, *roti, mudde* from ragi are the most common staple foods consumed regularly. Sweet products like *hurakki holige*, ragi *halubai*, and sweet cheese from foxtail millet (*ginna*), fried products like *chakkali, dosa*, *and hurihittu* from ragi are some of the traditional foods having cultural significance. Fermented beverages of millets and malt beverage from ragi are also prepared occasionally. Preparation of a few selected millet products during festivals is strictly followed by rural communities and thus have preserved the traditional cultural significance of millet use in their regular diet. Rural consumers are more familiar with traditional products of millets only. *Hal Navane* is a special foxtail millet cultivar specially used for patients as it has soft textural quality characters and easily digestible. Decorticated little millet has a special significance and used as food during fasting in the form of cooked rice or *uppuma.*

Consumers knowledge

The knowledge of use of millets as *roti, mudde, ambali* and rice was found in 50% consumers. Only a few consumers (5 to 25%) had the knowledge of use of millet for other diversified uses like *idli,* malt, porridge and other health foods. None of the consumers were aware of availability of secondary processed products like bakery

products, extruded products, papad, fryums and malt in local markets. Nearly 50% consumers had the knowledge of medicinal value of millets and its health benefits. Only 15% mentioned the high satiety value of millets and its role in the management of diabetes.

Existing millet processing units

Decortication of millet by hand pounding still exist in rural communities. This being laborious and time consuming, majority of women experience difficulty in processing millets. The local flour mills are often utilized for the initial de-husking and polishing which is again hand pounded at home for refinement of grains. Polished grain yield is only 50% as broken grains and flour yield is more in local flour mills.

Marketing strategy of millets

Whole grains and decorticated millets of little and foxtail are sold at villages and in towns in weekly markets. Survey of retail shops revealed that millets are not available in all shops unlike the other staple cereals. Decorticated millets are costly as compared to rice with price ranging from Rs. 12-14.

Development of consumer need based value added millet products

Each region has its own traditional food habits. One of the ways to combat the malnutrition is through enriching the traditional recipes, which are liked and accepted by the population. Thus, the value addition was given to traditional recipes by incorporating millets for nutrition security (Table 1, Fig.1). Most commonly used traditional recipes *viz., bisibelebath*, *pongal, uppuma, idli, dosa, paddu* and *talipattu* are selected for value addition through millets and green leafy vegetables to provide more protein, iron and β- carotene security to population (Table 2).

Table 1: Millet incorporated traditional recipes

Methi Rice: Samai/ foxtail millet-one cup, oil-10ml, Mustard-½ tea spoon(tsp), black gram dhal- 1ts, bengalgram dhal-1ts, methi- 2 bundles, onion-1 big, green chillies-2-4 no. lime juice-2 tsp, curry leaves-7-8, turmeric powde-pinch, salt-to taste.	Cook rice. Heat oil, add mustard, black gram dhal, bengal gram dhal, green chillies and curry leaves. When these turn golden brown in colour, add chopped onions and methi leaves. Fry every thing well and add lime juice, turmeric powder, salt and add to the cooked rice.
Pudina Rice: Samai/ foxtail millet- one cup, oil- 10ml, Mustard- ½ tea spoon(tsp), black gram dhal-1ts, bengal gram dhal-1tsp, pudina-2 bundles, onion-1 big, green chillies-2-4 no. lime juice-2 tsp, curry leaves-7-8, turmeric powde-pinch, salt- to taste.	Cook rice. Heat oil, add mustard, black gram dhal, bengal gram dhal, green chillies and curry leaves. When these turn golden brown in colour, add chopped onions and pudina leaves. Fry every thing well and add lime juice, turmeric powder, salt and add to the cooked rice.
Hurakki Holige: Foxtail millet-1cup, jaggery-1cup, maida- 1 cup, oil- to fry, poppy seeds-2 tsp.	Prepare dough from maida, Roast foxtail millet and poppy seeds and powder it, add little water to jaggery and make a thin syrup, add powder to the boiling syrup and stir properly, make equal portions from the prepared dough and roll into circles, stuff the mix of jaggery and roll in to thin circles and deep fry.
Hurihittu: Save/foxtail millet flour-1 cup,coconut- one, chilli powder-2 tsp, salt to taste.	Grate the coconut and add the rest of the ingredients and roast.
Samai Idli: Samai- 1 cup, blackgram dhal-½ cup, methi-10 g, salt- to taste	Soak rice and blackgram dhal separately for 5-6hrs, grind to smooth paste and mix the paste, keep the batter over night, steam the dough in idli maker
Dosa: Samai/foxtail millet-1&½ cup, blackgram dhal-½ cup, salt- to taste	Soak rice and blackgram dhal separately for 5-6hrs, grind to smooth paste and mix the paste, keep the batter over night, make dosa in a dosa pan
Millet muruku: Samai/finger millet -1 cup, Bengal gram dhal -¼ cup, salt- to taste, chilli powder-2tsp, asafoetida-little, cumin powder-1tsp, oam seeds-1tsp, poppy seeds-½ tsp, sesame seeds-½ tsp, vegetable oil-to fry.	Roast millet and Bengal gram dhal separately to golden brown and powder into fine flour, mix all the ingredients to flour and add water and make dough. Press the dough with the extruder using muruku die, and deep fry.
Papad: Samai/finger millet flour-1 cup, sour butter milk-½ cup, green chillies-2-4, salt to taste.	Add coarsely ground chilli to flour, make dough with butter milk and keep it aside for 3 days, steam it and pound the steamed dough to soft consistency, make equal portions from the dough and roll into thin circles and dry.

Source: Nirmala Yenagi, 2004

Table 2: Value added traditional recipes

Traditional food	Food incorporated	Food substituted	Value added product
Sweet pongal	-	Proso millet to rice by 100%	Proso millet sweet pongal
Idli	Carrot by 25%, methi leaves by 25%	Little millet to rice by 100%	Little millet masala idli
Paddu	Chakramuni leaves by 25%	Little millet to rice by 100%	Little millet paddu with Chakramuni leaves
Dosa	Chakramuni leaves by 25%	Little millet to rice by 100%	Little millet dosa with Chakramuni leaves
Bisebelebath	Bengalgram leaves by 50%	Foxtail millet to rice by 100%	Foxtail millet *Bisebelebath* with bengalgram leaves
Vada	-	Foxtail millet to rice by 100%	Foxtail millet vada
Talipattu	-	Little millet to rice by 100%	Little millet talipattu
Upama	Bengalgram leaves by 50%	Little millet to wheat semolina by 100%	Little millet upama with bengalgram leaves
Upama	Drumstick leaves by 50%	Little millet to by wheat semolina 100%	Little millet upama with drumstick leaves
Upama	Drumstick leaves by 50%	Barnyard millet to rice by 100%	Barnyard millet upama with bengalgram leaves

Source: Lata kulkarni, 2003

The RTE (ready to eat) foods are gaining popularity in today's world. Hence, the RTE products were developed by substitution and /or incorporation of foxtail and little millet (Table - 3). The products developed were Chakkali with substitution of flour, sev with substitution of little millet flour at 50% to Bengal gram flour and incorporation of 25% chakramuni leaves and khara gritters with substitution of 50% little millet flour to maida flour. Incorporation of millets and other micronutrient rich foods to traditional products enhanced the nutritional quality of food products. Millet possess certain significant quality characteristics for product development. All millet products possess excellent taste, crispy texture (foxtail millet found suitable in biscuits, cookies and in fried products). Soft non-sticky textural quality of ragi starch is highly suitable for ragi halwa and little millet based fermented products like idli and dosa are light, soft and

have puffy quality characters. Millets products like malt, laddu and fried products and decorticated grains have shelf life of 2 months. Millet can be incorporated 100% in majority of rice based products. Millet can be easily incorporated up to 25–30% in bakery and confectionery items as well as in composite flour. The value of added traditional RTE products can be very well developed and can fetch the market value.

Table 3: Details of ready to eat (RTE) value added products developed from millets

Traditional product	Food incorporated	Foods substituted	Value added product
Chakali	-	Foxtail millet to rice by 50%	Foxtail millet chakkali
Sev	Chakramuni leaves by 25%	Little millet to Bengal gram flour by 50%	Little millet green sev
Khara gritters	-	Little millet to maida by 50%	Little millet khara gritters

Source: Lata kulkarni, 2003

Millet based therapeutic food for home industry

Recent studies indicate that small millets are nutritionally superior to conventional food grains and exhibit hypoglycemic effect due to presence of higher proportion of unavailable complex carbohydrate, resistant starch and release sugar slowly. In addition, millets contain water soluble gums β-glucans, which might improve glucose metabolism. Therefore, the millets are suitable in diabetic diet to improve metabolic control of glucose. The flavour and difficulty in processing of millets are the limitations for their use in the routine diets. Hence, combination of millets, pulses and spices with suitable processing protocol may be emerged to develop composite foods/mixes which will cater the needs of the diabetic and over come the problem of aroma with improvements in functional quality of the products.

Millet based diabetic mix

The diabetic composite mixes are prepared from foxtail and little millet in grain and flour form. The formulation of the composite mixes are foxtail millet, blackgramdal, wheat semolina and spices. Nutrient composition of diabetic composite mixes are presented (Table - 4). The clinical trial of diabetic composite mix in terms of glycemic and lipemic

response in non-diabatic and type 2 diabetic subjectes was also done. The foxtail and little millet composite food/mix contributed 80% increase in dietary fibre content of the meal. The dietary fibre content of developed composite mix /food helped to decrease post prandial glycemic response in diabetic volunteers by 22-23 percent compared to rice and wheat products. The developed diabetic composite flour conveniently substitute staple cereals *viz*., rice and wheat flour in preparations like chapatti, roti, pancake, mudde, dumpling and thalipattu. Inclusion of millet based composite mix/food in regular diet for a period of four weeks exhibited several nutraceutical benefits in experimental volunteers. The feeding of developed diabetic composite food/ mix resulted in improving carbohydrate tolerance among experimental volunteers, as shown by reduction in fasting plasma glucose after 4 weeks. The assay of plasma lipid fractions highlighted the effect of diabetic composite food on lipemic control also among the volunteers. The decrease in triglycerides by 19% and an increase in HDL- cholesterol up to 8% were noted in both the groups. It has been reported that the controlled diabetics with lower level of plasma glucose aids in alteration of metabolism of low-density lipoproteins, triglycerides and total cholesterol bringing beneficial change in the lipid profile. In conclusion the developed diabetic composite food is an inexpensive, readily available food with acceptable cooking and organoleptic properties. It is a suitable diabetic food for maintaining normal glycemia and aids in preventing coronary complications. At present the demand for diabetic composite food is increased in the host institution's counseling centre and opened challengeable avenue to start production of such health food/mix at commercial scale to benefit innumerable diabetic population and enthusiastic entrepreneurs.

Table 4: Nutrient composition of diabetic composite mixes (% dwb)

Millets	Moisture	Protein	Fat	Crude fibre	Ash	Carbo hydrate	Total dietary fibre	Energy (Kcal)
Foxtail millet								
Grain mix	6.12	12.91	3.47	1.42	1.86	74.04	23.40	379
Composite flour	6.31	13.42	4.24	1.55	2.12	72.36	22.50	381
Little millet								
Grain mix	4.67	10.21	3.30	1.46	1.72	78.64	20.60	385
Composite flour	5.15	10.71	3.71	1.57	1.81	76.59	22.10	387

Source: Sunanda Itagi, 2003

Millets in Bakery Industry

Incorporation of 50 per cent foxtail millet or ragi flour to standard recipe, adversely affected the quality of millet based bakery products. Products were more dense, compact and too dry to swallow (muffins and bread). Products prepared by modified recipe (change in the proportion of fat addition) were light, well puffed and very tasty (Table 5). Wholegrain ragi flour biscuits had astringent taste but showed very good spreading quality and breaking strength. Foxtail millet biscuits were tasty and possessed good spreading quality with crispy and light feature. 50% incorporation of any millet flour was found ideal for preparation of biscuits. Mineral content of millet biscuits ranged from 0.2 to 1.0 percent and maximum was found in ragi based biscuits. The zinc content was higher in peanut and melting moment biscuits. Melting moment biscuits prepared from foxtail millet at 50% level scored the highest for overall acceptability followed by peanut, nan khatai and chilli biscuits. Modification of the standard recipe with increase in fat to 20 percent improved the physical and sensory quality character of millet muffins. Sensory quality scores of ragi muffins were on par with standard muffins and it was highly acceptable for taste and texture. Millet based bakery products are rich in fibre, micronutrients and have good potential to enter bakery industry as value added products.

Conclusion

Processing technologies of indigenous products are simple, less expensive and easy to adopt. Tradition and culture have preserved the significance of millet by preparing compulsorily on special occasions. Ethnic foods have excellent taste, crispy texture, light and fluffy characters, superior textural quality of cooked starch and blends well with milk and milk products. Ethnic foods are highly acceptable for taste and texture by both rural and urban consumers. There is a need to explore these qualities for value addition and designing processing equipments for cottage industries for better market potential. By and large it was found that fifty Indian traditional recipes of major cereals such as wheat, rice and pulse, could be prepared by substituting with millets from 25-100%. Promotion of indigenous and value added products through different communication techniques enhanced the consumer knowledge and readiness to incorporate millets in the daily diet. Nutritionally and functionally superior small millets with nutraceutical properties are highly suitable in the development of therapeutic foods as metabolic disorders are emerging increasingly in the urban population. In the age of nutritional awareness and health consciousness, promotion of health foods may open an avenue for the wide spread utilization of small millets for the health security in the cross section of the society.

Table 5: Use of optimized composite flour in different types of biscuits

Raw materials required	Method of preparation
Nan-Khatai Biscuits	
Foxtail millet flour- 100 g, maida-100 g, vanaspati-120 g, powdered sugar-100 g, nutmeg powder- one pinch, cardamom powder- one pinch, soda-¼ tsp, ammonium bicarbonate-¼ tsp, curds-2 tsp	Cream vanaspati and sugar till light and fluffy, add soda, nut meg, cardamom, curds and mix well, sieve millet flour and maida, add sieved flour to the cream and make stiff dough, divide the dough into small equal portions, round them and place on greased baking trays and bake at 275^0 F for about 15 min.
Melting moment (coconut biscuits)	
Foxtail millet flour- 75 g, maida-75 g, vanaspati-120 g, powdered sugar-90 g, egg-½, coconut powder-50 g, soda-¼ tsp, vanilla-few drops	Cream vanaspati and sugar till light and fluffy, beat the egg with vanilla and add to the cream mixture, sieve millet flour, maida and baking powder, add sieved flour to the cream and make soft and smooth dough, divide the dough into small equal portions, round them and place on greased baking trays and bake at 300 ^{0} F for about 10min.
Peanut biscuits	
Foxtail millet flour- 125 g, maida-125 g, vanaspati-150 g, powdered sugar-100 g, egg-½, peanuts- 50 g, milk-as required, vanilla-few drops	Cream vanaspati and sugar till light and fluffy, beat the egg with vanilla and add to the cream mixture, sieve millet flour and maida, add sieved flour to the cream and make soft and smooth dough, add milk if required, roll the dough into ¼" thickness and cut with fancy biscuit cutter, arrange them in a greased baking trays and bake at 300 ^{0} F for about 10min.
Chilli biscuits	
Foxtail millet flour- 75 g, maida-75 g, vanaspati-75 g, powdered sugar-5 g, soda-¼ tsp, 15gms (curry leaves+ coriander leaves + green chilies+ ginger), curds-2 tsp.	Sieve millet flour and maida with baking powder and salt, rub in fat and then add sugar, mix the chilly mixture and curds, knead it to a soft dough, roll the dough into ¼" thickness and cut with biscuit cutter, arrange them in a greased baking trays and bake at 300 ^{0} F for about 15min.

Source: Nirmala Yenagi and Shakuntala Masur, 2004

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VALUE ADDED FOOD PRODUCTS FROM FOXTAIL, BARNYARD AND FINGER MILLET

Sarita Srivastava[1] and Gurmukh Singh[2]
[1]Department of Food and Nutrition, College of Home Science
[2]Department of Food Science & Technology, College of Agriculture
G.B.P.U.A& T., Pantnagar-263145, U.S. Nagar, Uttarkhand.

Small millets are important to hill agriculture especially in Uttarkhand state. The use of small millets for food is mostly confined to the traditional consumers and people of lower socio-economic strata. Its use among urban dwellers is limited, partly due to the non-availability of these grains in ready to use forms and or difficult to processing besides posses a characteristic flavour, grittiness and lack gluten. Traditional practices of consumption of small millets in Uttarkhand as revealed by survey are given below:

Utilization and consumption pattern of small millets in Nainital district

A survey was conducted in two villages namely Chhera and Ghuna from Betalghat block of Nainital District, Uttarkhand. The important small millets grown in the region are finger millet (mandua), barnyard millet (madira) and foxtail millet (kauni).

Agricultural Practices

Small millets are generally grown in mixed cropping system along with other cereals. Majority (88.04%) respondents raise one crop of mandua/ madira in a year. Majority (71%) respondents had opioned that millets can be grown on less fertile land for home use and not much sold in the market. Majority (91 %) respondents stored millet grains in gunny bags for year long use.

Processing methods and consumption pattern

All respondents used winnowing (phalana) and dehusking as primary processing prior to food use. Only 14.29 per cent respondents know about roasting (bhutana) or popping of millets and none has any idea of malting of millet grains.

Finger millet (madua) is the most popular and commonly used millet in villages followed by barnyard millet (madira) and foxtail millet (kauni). Small millets are consumed as *chapati, bhaat* (cooked rice), *jaula* (gruel) or *kheer* and *halwa*. Generally finger millet is consumed in the form of *chapati* and barnyard millet in the form of *kheer* or rice. Both small millets are used as thickening agents in various food preparations like

dal, dubke (a black soybean preparation). Sometimes small millets are also mixed with other cereals to prepare items like *puri, kachouri, pakouri and bada.*

Small millet based foods are mostly eaten by elderly people as there is strong dislike for millets among young people owing to its colour and characteristic taste. Millets use is also avoided for very young children, as they are difficult to digest. Respondents reported seasonal consumption of small millets. Use of madua (finger millet) is favoured in winter (it is considered helpful in keeping the body warm) and madira (barnyard millet) in summer (it is considered as 'cool food) season.

Therapeutic uses

Foxtail millet (kauni) has therapeutic use in curing diseases like chicken pox. About 74.29 per cent of respondents believed in the nutritive and therapeutic benefits of foxtail millet. *Khichri* prepared from foxtail millet in a very thin consistency is given to the patients suffering from measles. The raw grains of foxtail millet are also sprinkled on the bed of patients, for quick relief.

The use of millets in preparation of value added and health foods is the need of the day. Foxtail, barnyard and finger millet incorporated health foods for various purposes are described below.

Convenience mixes for value added food products

Two types of convenience mixes were developed.

1. Multipurpose convenience mixes
2. Individual convenience mixes.

Multipurpose convenience mix

Three multipurpose convenience mixes were made using malted foxtail, barnyard and finger millet as base (upto 65%). The composition of mixes is given in Table 1. These multipurpose convenience mixes were passed through 40 mesh sieve to prepare traditional food items viz. laddu, halwa and sem (Table 2). For preparation of weaning gruel, these multipurpose convenience mixes were sieved through 100 mesh sieve. It was observed that all the products, except weaning gruel, developed from convenience mix 3 were liked by the most respondents.

Table 1: Composition of the multipurpose convenience mixes

Ingredients (%)	Mix 1	Mix 2	Mix 3
Malted barnyard millet	50	-	25
Malted foxtail millet	-	50	25
Malted finger millet	15	15	15
Roasted black soybean	20	20	20
Roasted amaranth seeds	15	15	15

Table 2: Food products from nutritious multipurpose convenience mix

Sl. No.	Name of recipe	Description of recipe	Ingredients used	Wt. of Ingredients (g or ml)	Cooked Weight
1.	Laddu	Cook convenience mix in heated oil. Prepare sugar syrup and add to the roasted convenience mix. Quickly make round balls.	Convenience mix Sugar Refined oil Water	25 25 20 50	100 g
2.	Halwa	Cook convenience mix for 5 min in the heated oil. Add water and sugar. Cook for 3 min.	Convenience mix Sugar Refined oil Water	25 25 12 60	110g
3.	Sem	Mix well all the ingredients. Add water and knead the dough. Roll the dough into ¼ cm thickness. Cut into equal diamond shape. Deep fry in hot oil at low flame.	Convenience mix Maida Oil Salt Ajwain	25 5 5 to taste 2	35 g
4.	Weaning gruel	Add warm water (70^0C) to the convenience mix. Add sugar to it and serve.	Convenience mix Sugar Water (70^0C)	25 10 60	100 g

Nutrient composition

The values of protein and energy of mixes and food products are given in Table 3. The energy value of convenience mixes ranged from 359-374 kcal/100 g. The energy values for food products developed from the convenience mixes revealed that *laddu* prepared from convenience mix 2 had the highest energy value (533 kcal/100 g). The protein content of convenience mix 2 was the highest (15.46 g/100 g). The protein content of food products prepared from the convenience mixes ranged from 2.41-12.60g/ 100g.

Table 3: Protein and energy values of multipurpose convenience mixes and food products per 100 g.

	Convenience mix		Laddu		Halwa		Sem		Weaning gruel	
	Protein (g)	Energy (K cal)	Protein (g)	Energy (K cal)	Protein (g)	Energy (K cal)	Protein (g)	Energy (K cal)	Protein (g)	Energy (K cal)
Mix 1	10.50	359	3.80	527	2.41	275	9.08	434	5.27	259
Mix 2	15.46	374	5.60	533	3.54	277	12.60	446	7.75	267
Mix 3	13.71	367	4.94	530	3.15	276	11.37	440	6.88	263

Individual convenience mixes

Individual convenience mixes were developed for various food products *viz*. *mathri*, *sevain, kachari, kachouri, laddu and cheela. R*ecipes have been given in Table 4. The mixes were analysed for proximate composition, iron, calcium, tannins, phytates and vitamins (Table 5). *Kachari* mix had the highest moisture content (6.57 %) and the values ranged from 5.05-6.57 per cent. *Cheela* mix had the highest protein (18.3%), fat (6.45%), total ash (3.36%) and fibre content (3.17%) among the mixes prepared. The carbohydrate and energy value of the mixes prepared ranged from 63.72-76.79 per cent and 358-386 K cal/100g, respectively. In various convenience mixes, the range for iron and calcium was 4.10-9.88 mg per cent and 66.67-316.67 mg per cent, respectively. *Laddu* mix had the highest iron (9.88 mg %) and calcium (316.67 mg %) content. Phytate content varied from 64.40-74.40 mg %, while niacin and tannin content varied from 2.67 - 5.12 mg % and 94.46 -137.68 mg %, respectively.

Table 4: Food products from convenience mixes

Sl. No	Name of recipe	Description of recipe	Ingredients used	Wt of Ingredients (g or ml)	Cooked Weight
1.	*Mathri*	A small amount of fat was rubbed into the mix and tight dough was prepared. Small mathries were rolled out of it and deep-fried.	Malted barnyard millet flour*	60	150 g
			Wheat flour	40	
			Lentil flour	10	
			Spinach powder	3	
2.	*Sevain*	The convenience mix was made into tight dough. Sevain were made by hand and dried. Sevain were boiled in 850 ml milk with sugar.	Malted barnyard millet flour*	60	630 ml
			Wheat flour refined	30	
			Black soybean powder	10	
			Spinach powder	3	
3.	*Kachari*	The convenience mix was flavoured with spices and cooked with water. The thick batter was put in muslin cloth. Kachari were made as in traditional method, dried and deep fried in hot oil.	Malted barnyard millet flour*	60	120 g
			Soybean powder	10	
			Rice	30	
			Spinach powder	3	
4.	*Kachouri*	*Kachouri* were prepared using convenience mix, potatoes, onion etc. Tough dough was prepared by mixing all the ingredients together. Kachouri were rolled out and deep-fried in hot oil.	Malted barnyard millet flour*	60	200 g
			Wheat flour	20	
			Black soybean powder	20	
			Spinach powder	3	
5.	*Laddu*	The mix was cooked into thick jaggery syrup adding fat. *Laddus* were made as round balls.	Popped barnyard millet**	50	180 g
			Popped amaranth seeds	40	
			Black soybean powder	10	
6.	Cheela	A thick batter was prepared by using convenience mix. Vegetables potatoes and tomatoes were chopped finely and mixed in the batter along with spices. It was then cooked on a hot 'tava' from both sides by adding oil.	Malted barnyard millet flour*	60	210 g
			Black soybean flour	30	
			Wheat flour	10	
			Spinach powder	3	

* Malted barnyard millet flour has been prepared by steeping the grains at 20^{0}C for 24 hours, germinating at 22± 2^{0}C for 36 hours, drying in oven at 45^{0}C for 6-8 hours, devegetating, kilning at 70^{0}C for 45 minutes, dehusking, grinding and sieving.

** Popped barnyard millet flour was prepared by soaking the grains in water for 1 hour, drying at room temperature, popping in salt, sieving, and grinding.

Table 5: Nutrient composition of convenience mixes

Mix	Moisture (%)	Crude Protein (%)	Crude fat (%)	Crude fibre (%)	Total ash (%)	Carbo-hydrate (%)	Energy K cal/ 100 g	Calcium (mg %)	Iron (mg %)	Vit C (mg %)	Niacin (mg %)	Tannins (mg %)	Phytates (mg %)
Mathri	5.88	11.09	0.68	2.33	3.23	76.79	358	66.67	6.62	28.33	4.54	118.93	74.40
Sevain	6.32	13.49	2.28	0.83	2.97	74.11	371	116.67	6.44	22.67	4.63	133.00	65.20
Kachari	6.57	10.66	2.87	1.67	3.28	74.95	368	66.67	4.10	22	5.12	137.68	65.60
Kachouri	6.47	15.77	4.38	2.66	2.30	68.42	376	116.66	6.59	23	4.53	130.49	68.80
Laddu	5.05	14.29	2.72	3.16	3.27	73.51	376	316.67	9.88	-	2.67	94.46	64.40
Cheela	6.00	18.3	6.45	3.17	3.36	63.72	386	133.33	6.99	25.66	4.49	118.93	69.60

Foxtail millet food products

Noodles, sev, papad and *kachari* have been developed by incorporating foxtail millet flour. *Noodles* can be commercialized. *Sev, papad* and *kachari* are traditional food products, can be prepared by rural people for home use and also by Self Help Groups for selling locally. Recipes for preparation of *noodles*, *sev, papd* and *kachari* are given in Table 6.

Table 6: Recipes of foxtail millet

Sl. No	Name of recipe	Description of recipe	Ingredients used	Wt of Ingredients (g or ml)	Cooked Weight
1.	Noodles	The dry ingredients were mixed with hot water (65^{0}C) to obtain dough of optimum consistency. Noodles are prepared using a press after which they are dried at 60^{0}C for 3.5-4 hr. Cook in water for 20 min.	Semolina Millet flour Gluten Salt GMS Water	70 30 3.5 2 1 As required	317 g
2.	Sev	Mix well manually all the ingredi-ents in dry state and then knead with adequate amount of water to yield soft and pliable dough. Extrude the dough through a manually operated sev press directly into the frying pan containing oil at 180 ± 5^{0}C. Frying is complete when frothing in the oil seizes. Take out sev from the pan and spread over paper to remove excess oil from surface. Cool to room temperature. Pack in self-sealing polythene bags.	Foxtail millet flour Bengalgram flour Common salt Red chilli powder Turmeric powder Hydrogenated vegetable fat Sodiumbicarbonate	30 70 4 0.8 0.3 4.0 0.4	114 g
3.	Papad	Take 100 g flour mix & add water to it. Take on greased dish of 8 cm diameter & pour 10 ml batter into it. Steam it for 1.5 to 2 mins. Dry it at 50-60^0 C in oven. Fry in refined oil.	Foxtail millet flour Rice flour Cumin seeds Salt	55 45 5 5	28–30 nos.
4.	Kachari	Take 100 g flour mix. Add water and cook for 10-12 mins. till tooth- paste like consistency is achieved. Shape the gruel as Kachari. Dry it in oven at 50-60^{0}C. Fry in oil.	Foxtail millet flour Cumin seeds salt	100 5 5	

Finger millet food products

Among all the food grains, finger millet is the richest source of calcium, good source of minerals and vitamins. Cake and *halwa* with improved nutritive value were

standardized by incorporating finger millet 50 and 60 per cent, respectively (Table 7). Both food products were acceptable. Cake consisted of 6.3 % protein, 55 mg % calcium and 1.48 mg % iron. Halwa contained 1.63 % protein, 170 K cal energy per 100 g, 26.10 mg % calcium and 0.90 mg % iron.

Table 7: Recipes of finger millet food products

Sl. No	Name of recipe	Description of recipe	Ingredients used	Wt of Ingredients (g or ml)	Cooked Weight
1.	Cake	Cream sugar and fat until thoroughly blended and aerated. Add the beaten eggs to creamed mixture and the batter is beaten until fluffy. To this, a well- mixed blend of sifted dry ingredients and milk were mixed. Pour this mixture in a well greased cake baking pan. Bake for 30 mins. at 180°C in a baking oven.	Finger millet flour Refined wheat flour Sugar Shortening Whole eggs Milk Baking powder Cocoa powder Vanilla	50 50 100 80 2 10 ml 3 g 5 g Few drops	345 g
2.	Halwa	Millet flour, bengalgram flour and groundnut powder were put in heated fat and cooked by stirring for 10 mins. Water, sugar and cardamoms were added, stirred continuously for 5-6 mins.	Roasted finger millet flour Roasted bengal gram flour Roasted groundnut powder Sugar Fat Cardmoms(crushed) Water	60 30 10 125 60 3 nos. 520 ml	830 g

Therapeutic uses of small millets

The epidemological evidences indicate that people on millet based diets suffer less from degenerative ailments such as heart disease, diabetes, hypertension, cancer etc. Recent studies have shown hypoglycemic effect of small millets. They contain higher proportion of unavailable carbohydrate and release of sugar from millet is slow. Small millets contain water soluble gum,β-glucan and resistant starch which are useful in improving glucose metabolism. Food products *viz*., foxtail millet biscuit, barnyard millet biscuit, foxtail millet sweets, barnyard millet sweets, barnyard millet fenugreek *pulao*, barnyard millet *idli* and barnyard millet fenugreek *idli* have been developed for diabetics. Recipes for these food products have been given in Table 8.

The food products were analyzed for protein and energy content and it was evident that small millet grains are nutritionally superior and a good source of quality protein, minerals, phytochemicals and vitamins. With appropriate processing and value added strategies, the millet grain can find a place in the preparation of several value added products to the liking of large urban population and nontraditional users.

Table 8: Therapeutic Food products

Sl. No	Name of recipe	Description of recipe	Ingredients used	Wt of Ingredients (g or ml)	Cooked Weight
1.	Barnyard millet/ foxtail millet based biscuits	Rub beaten sugar and fat into barnyard/ foxtail millet flour, maida, soybean flour, baking powder. Knead the dough. (brown dough). Rub beaten sugar and fat to maida, soybean flour and baking powder. Knead the dough (white dough). Roll out both the dough separately. Put the layers together and roll tightly. Cut slices. Bake in preheated oven at 200^0 C for 8-10 mins.	Refined wheat flour Barnyard / foxtail millet flour Roasted black soybean flour Cocoa powder Sugar Fat Milk Vanilla essence (drops) Baking powder	50 50 15 10 62 62 25 1-2 ½ tsp.	240 g
2.	Foxtail / barnyard millet based *burfi*	Add the flour mixture in heated fat. Stir for few mins. Prepare sugar syrup in a separate pan. Add the cooked mixture to it. Pour into greased tray and cut into the square shape burfi.	Millet flour Bengalgram flour Sugar Hydrogenated fat Water Cardamoms	36.4 27.3 27.3 9.0 100 4	100 g
3.	Barnyard-methi *pulao*	Clean and wash barnyard millet. Soak fenugreek seeds overnight and discard the water after washing. Fry spices in heated oil. Fry fenugreek seeds, add chopped onion until golden brown. Mix barnyard millet and salt well with spices. Mix it well with spices. Add water and cover it. Cook for 10 min.	Dehusked barnyard millet Fenugreek seeds Finely chopped onion Cooking oil Salt Spices (Tej patta, Badie-laichi, black pepper)	80 20 50 5 To taste	520g
4.	Barnyard idli	Soak barnyard millet and black gram dhal separately for 8-10 hrs. Grind barnyard millet to thick and blackgram dhal to thin paste. Mix both the pastes well and add little salt. Leave it overnight to ferment at room temperature (30^0C-32^0 C). Grease idli stand and put the paste in it. Steam cook for 10-15 minutes.	Barnyard millet Blackgram Oil for greasing	255 85	750 g
5.	Barnyard methi idli	Soak barnyard millet and black gram dhal separately for 8-10 hrs. Grind barnyard millet to thick and blackgram dhal and fenugreek seeds to thin paste. Mix all the pastes well and add little salt. Leave it overnight to ferment at room temperature (30^0C-32^0 C). Grease idli stand and put the paste in it. Steam cook for 15-20 minutes.	Barnyard millet Blackgram dhal Fenugreek seeds Oil for greasing	137.5 62.5 50.0	920g