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Ways for Better Utilization of Finger Millet through Processing and Value Addition and Enhance Nutritional Security among Tribals

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Abstract- Finger millet is in food use since time immemorial, and large number of traditional food preparations is in practice in the rural areas (predominantly tribal areas), particularly in the production catchments. Finger millet also known as ragi in India is one of the important cereals occupies highest area under cultivation among the small millets. Finger millet is comparable to rice with regard to protein (6-8%) and fat (1-2%) and is superior to rice and wheat with respect to mineral and micronutrient contents. It is a major source of dietary carbohydrates for a large section of society. However, its utilization in the daily dietary at present is largely restricted to rural areas/tribal areas only. Unavailability of products to the taste of urban community is the main reason. Processing the finger millet using traditional as well as modern techniques for the development of value added and convenient food products would be the possible solution for its promotion and enhancement of consumption, nutritional status and thereby increasing profitability and better livelihood to the tribal community. This will also help the country to diversify the food basket for nutritional sustainable food availability to the common mass with low purchasing capacity. The present paper describes some of the possible value added products from finger millet.

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Abstract- Finger millet is in food use since time immemorial, and large number of traditional food preparations is in practice in the rural areas (predominantly tribal areas), particularly in the production catchments. Finger millet also known as *ragi* in India is one of the important cereals occupies highest area under cultivation among the small millets. Finger millet is comparable to rice with regard to protein (6-8%) and fat (1-2%) and is superior to rice and wheat with respect to mineral and micronutrient contents. It is a major source of dietary carbohydrates for a large section of society. However, its utilization in the daily dietary at present is largely restricted to rural areas/tribal areas only. Unavailability of products to the taste of urban community is the main reason. Processing the finger millet using traditional as well as modern techniques for the development of value added and convenient food products would be the possible solution for its promotion and enhancement of consumption, nutritional status and thereby increasing profitability and better livelihood to the tribal community. This will also help the country to diversify the food basket for nutritional sustainable food availability to the common mass with low purchasing capacity. The present paper describes some of the possible value added products from finger millet.

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I. Introduction

Of the estimated total of 80000 plants with possible economic use, approximately 30,000 plants have been found edible in nature, and 7,000 have been cultivated by the mankind at one time or the other; but out of these, only 158 plants are used widely for food. Among these, 30 crops provide 90% of world's food, 10 supply 75% of world's food basket; and over 60% of world's total protein and calories are provided by only three crops – rice, wheat and maize. Our food security, with such a high dependence on these narrow food-base, faces and will face high risk owing to growing uncertainties in the climate and emergence of new biotic and abiotic stresses. Consequently, there is a global concern to collect, introduce, evaluate and utilize vast array of lesser known, under-exploited, alternative crop-plants for diversifying agricultural systems.

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India is the leading producer of small millets namely, finger millet (*ragi*), kodo millet (*kodo*), foxtail millet (*kangni*), barnyard millet (*sawan*), proso millet (*cheema*) and little millet (*kutki*). Annual planting area under them is around 2.5 million hectares; and nearly 1.5 million hectares is under finger millet comprising about 40-50% of crop's global area. During the last three decades, area under finger millet has declined but with the significant improvement in the productivity (1,500 kg/ha), its annual production is maintained at around 2.4 million tonnes. At present, small millets account for less than 1% of food grains produced in the world (ICAR, 2010). Their cultivation dates back to nearly 5000 years, and in India, they form an important component of the traditional cropping systems and contribute significantly to the regional food and nutritional security and diversity in the national food basket; and they are important in areas of their production as dryland crops, as well as for hill agriculture. The small millet grains have longer storage life, and can be termed as famine reserve. The resilience exhibited by them may prove good for their adjustment to different eco-systems and make them potential crops for contingency plantings.

Cereals form a major portion of human diet and are an important source of starch and other dietary carbohydrates (dietary fibre), which play an important role in the energy requirement and nutrient intake of human. The millets are with higher fibre content, and their protein quality and mineral composition contribute significantly to nutritional security of a large section of population residing in the millet growing areas, considered to be the most disadvantaged groups. Millets are most recognised nutritionally for being a good source of minerals magnesium, manganese and phosphorus. Research has linked magnesium to a reduced risk for heart attack and phosphorus is important for the development of body tissue and energy metabolism. Millets are also rich in phytochemicals, including phytic acid, which is believed to lower cholesterol, and phytate, which is associated with reduced cancer risk. Thus, millets are strategic in terms of their food, nutritional and livelihood security and their role in local agro-ecosystems.

Food uses of millets have, however, been confined only to traditional consumers; limited especially

to areas of their cultivation, and still have remained underutilized. Processing them using traditional as well as contemporary methods for preparation of value added and convenience products would certainly diversify their food uses. Their exploitation for preparation of ready-to-use or ready-to-cook products would help in increasing the consumption of millets among non-millet consumers and thereby nutritional security. The present paper is an attempt to describe some basic information about finger millet, the processing requirement and some avenue for its value addition and food uses.

Finger millet (*ragi*) is rich in protein, iron, calcium, phosphorus, fibre and vitamin content. The calcium content is higher than all the cereals and iodine content is said to be highest among all the food grains (Desai et al., 2010). *Ragi* has best quality protein along with the presence of essential amino acids, vitamin A, vitamin B and phosphorus (Gopalan et al., 2004). Finger millet (*ragi*) provides highest of level of calcium, antioxidants properties, phytochemicals, which make it easily and slowly digestible. Hence it helps to control blood glucose levels in diabetic patients very efficiently.

II. Methodology

a) Nutritional composition of finger millet

Like other cereals grains small millets are predominantly starchy. The protein content is more or less equal and comparable to that of wheat, rice and maize. Finger millet has 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 lowest fat. One of the characteristic features of the grain congestion of millet is their high ash content (mineral composition). They are relatively rich in iron and phosphorus. Finger millet has the highest calcium content≈(300 - 400 mg/100 g) among all the food grains. High fibre content and lower digestibility of nutrients is the other characteristic feature of millet grains. The nutritional composition of small millets has been reported and published many places by researchers. However, an average nutritional composition of finger millet along with other cereals is being reproduced here for easy look of the readers (Malleshi, 2007).

b) Processing and value addition

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

c) Milling

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

In recent years the consumption of finger millet along with other millets has been increased particularly in the urban sector due to awareness about the inherent nutritional and medicinal properties of millets. Looking to the growing demand of ready-to-eat and ready-to-cook products, there is a need exists to prepare the millet flour suitable for different traditional food products. Fortified ready mixes for the conventional preparation of popular traditional foods combining finger millet (ragi) as one of the ingredients are available in the market which further encourages for milling of ragi into flour. Millet is gluten-free and safe to eat for those who experience gluten sensitivity.

III. Results and Discussion

a) Value addition and value added products

In the foregoing paragraphs, some of the examples of value added products and possibilities of utilizing finger millet as one of the basic ingredients are

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

i. *Multi-grain flour /Composite flour*

The concept of multi-grain flour/composite flour is not new to the mankind. Mixing of two-three types of grains or grain and pulses has been in practice since long ago depending upon the availability of such commodities locally or the food habits, but in such cases, the understanding of nutritional security is not necessarily linked. Multi-grain flour by combining wheat and finger millet in the ratio of 7:3 (wheat:finger millet) is one of the simple semi-finished products suitable for making chapatti (roti), as no Indian meal is complete without Indian style bread or roti. In the proposed blend, though the gluten content is reduced significantly the making of chapatti while flattering is not affected. However, the colour of the chapatti turns to slightly dark. Fortification of finger millet in chapattis not only improves the taste but also helpful in controlling glucose levels in diabetic patients very efficiently. The bulkiness of the fibres and the slower digestion rate makes us feel fuller on, fewer calories and therefore may help to prevent from eating excess calories. Its high fiber content is further helpful to the individuals having the problem of constipation.

ii. *Papad*

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

Papad from finger millet flour is also prepared in which it is used as base material mixed with spices and salt. Flour is first cooked in water till it is gelatinized and dough is prepared. Thin sheet from the dough is prepared by rolling it and cutting into desired shapes and sizes followed by drying of these papad pieces to desired moisture content of 7-8% (db). Since the pericarp is not separated out from the starch, it gives a little dark colour to the papad which again upon frying or roasting turns to lighter with good consumer acceptability.

iii. *Puffing or popping*

Puffing or popping of cereals is an old practice of cooking grains since time immemorial to be used as snack or breakfast cereal like corn either plain or with some spices/salt/sweeteners. Popping or puffing of finger millet is one of the popular traditional methods and the popped millet and its flour is a ready-to-eat (RTE) product with pleasing texture and appealing flavour. Popping improves the nutritional value by inactivating some of the antinutritional factors (enzymes and enzyme inhibitors) and thereby enhancing the protein and carbohydrate digestibility; it also enhances the appearance, colour, taste and aroma of the processed raw material (Mangala et al., 1999). The flour can be used for different types of RTE food preparations depending upon the taste and likings. For puffing, the whole finger millet grain is conditioned by mixing additional water so as to reach its moisture content in the range of 18-20% and tempered for about 4-6 hours under shed. The conditioned grains are puffed by agitation on the hot sand surface maintained at about 230 - 250˚C for short time following HTST (high temperature and short time) process. During this process, the sugars present in the aleurone layer react with amino acids of the millet causing Millard reaction and as a result, a pleasant and highly desired aroma is developed. Further, during this process, the vapour pressure of the grain increases and the moisture present in the grain turns into steam; gelatinization of the starch takes places and explodes. Since during popping or puffing grains are dehydrated to the extremely low level of moisture content, nearly 3-5%, the shelf-life is enhanced. Now a day modern air puffing machines have been developed which can be used for mass production of puffed or popped millet grains. In addition to this, there will be no risk of sticking sand particles with the product in machine popping or puffing.

iv. *Puffed finger millet mix*

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

v. *Malting – Weaning food*

Traditionally the millet malt is utilized for infant feeding purpose and also to prepare beverages either with milk of luke warm water with the addition of sugar since pretty old times. Finger millet being good malting characteristics, its malting is popular in the area of cultivation particularly in Karnataka and part of Tamilnadu. Malting of finger millet improves its

digestibility, sensory and nutritional quality as well as pronounced effect in lowering the antinutrients (Desai et al., 2010). Finger millet has some of the inherent qualities which make it superior compare to other cereals and also qualify for malting and preparation of malted foods. It is resistant to fungal infection and elaboration of alpha and beta amylase during germination and during roasting/ kilning a desirable aroma as well as is developed which makes it an ideal grain for malt foods. In addition to these, finger millet is a good source of sulphur amino acids and calcium. An example of composite malt flour (malted weaning food) preparation combining finger millet, green gram and bengal gram is presented in the following process flow chart. This blend is nutritional in addition to rich source of protein and calcium.

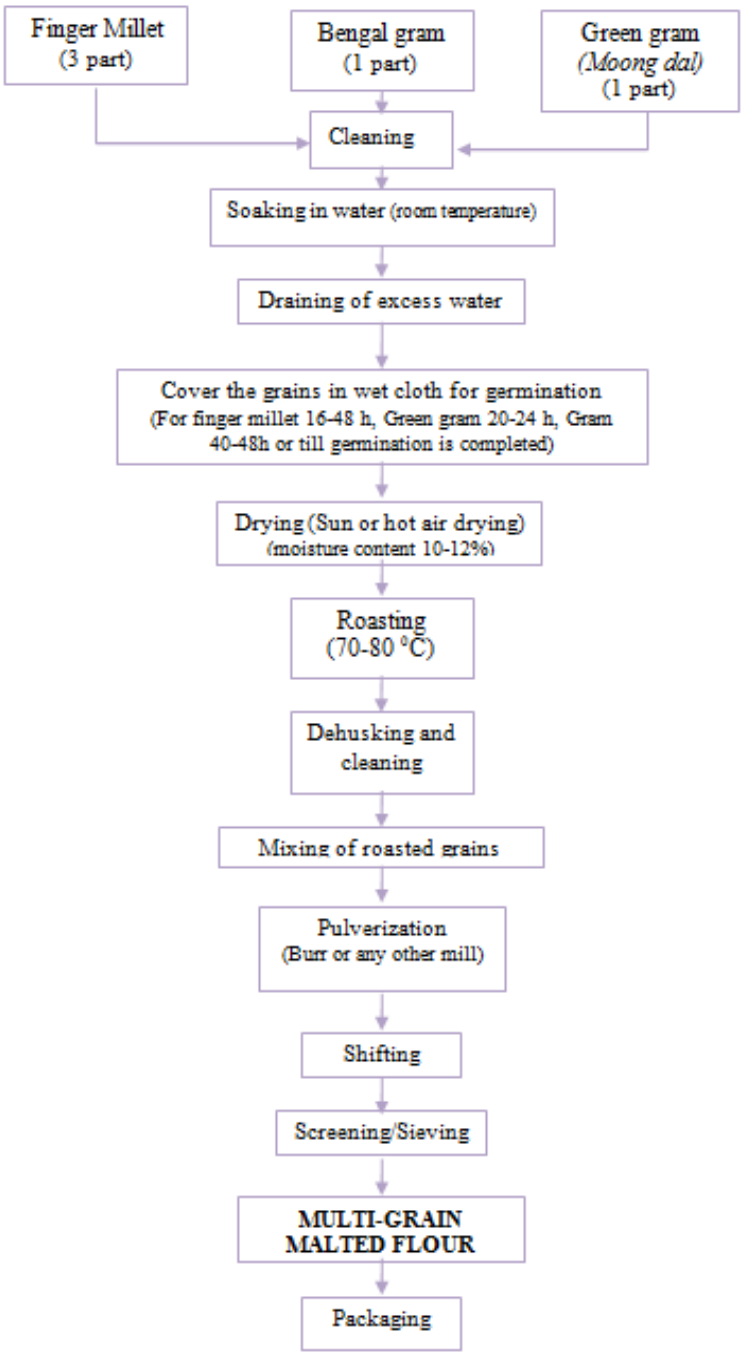

Figure 1 : Process flow chart for multi-grain malted flour preparation

In the above unit operations, the germination is an important unit operation which needs greater attention. During germination process, the hydrolytic enzymes bring changes in the endosperm. Some of the vitamins are also synthesized and the bioavailability of minerals increases. During soaking, the soak water is

required to be changed once or twice to prevent the excessive growth of micro-organisms and also to make it free from CO_2 formed during soaking. During germination, it is essential to mix or turn the grains to provide good aeration to facilitate better germination. Germination period of about 48 hours is desired but in summer it can be reduced to 36 hours. To stop the germination process, the grains are dried either sun or mechanically drying. While drying it should be kept in mind that the drying temperature should not exceed 75˚C. Higher drying temperature may cause parboiling effect and hardening of the grains which may have adverse effect on milling and quality of the malt flour. The sprouted grains should be dried to a final moisture content of nearly 10-12% and subsequently the separation of roots and shoots is done which can be accomplished by various traditional and modern methods by giving a mild rubbing or abrasion action to the grain mass. These grains (malted) are then roasted uniformly at 70 - 80˚C either by conventional toasting pan or heaters. Uniform heating and roasting helps in developing characteristic aroma and desirable quality of the product. The malt so obtained is pulverized to convert it into ready-to-eat (RTE) form. The pulverization can be accomplished by any size reduction facilities suitable to convert into fine flour. The pulverized malt is then subjected to sieving through the fine sieve to separate the husk and fine malt flour is obtained.

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

vi. *Noodles – Vermicelli*

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

vii. *Extruded products*

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

viii. *Bakery products*

Incorporation of finger millet flour in the preparation of bakery products like biscuit, nan-khatai, muffins and bread has been attempted and efforts are being made to standardize the recipe and product quality. The use of millets in bakery products will not only superior in terms of fibre content, micronutrients but also create a good potential for millets to enter in the bakery world for series of value added products. In a recent study attempts have been made to improve the nutritional quality of cakes with respect to the mineral contents and fibre content by supplementing with malted finger millet flour (Desai et al., 2010). In recent years finger millet has received attention and efforts are

under way to provide it to consumers I n convenient forms (Malleshi and Desikacher, 1986).

ix. *Fermented foods*

Fermented foods like *Dosa* and *Idli* are popular in many parts of India. These are very common as breakfast foods and even as the evening meals in southern part of the country. Finger millet is widely used as one of the ingredient for these kind of fermented foods. It not only improves the taste but at the same time enriches the food value in terms of protein, calcium and fibre. Sprouting of finger millet grain or the malted grains are also used for fermented foods depending on the taste and choice. Ragi flour is blended with the other base ingredients for fermented foods following other procedures.

x. *Ragi Soup*

Mix Ragi flour in Water without any lumps. Heat this Ragi water mix in medium heat for 15 minutes or till its cooked. Stir this mix frequently to avoid forming lumps. Then remove from heat, mix Curd and Salt to it. Serve warm or cold.

xi. *Ragi Pakora (finger millet fritters)*

Cut Onion lengthwise. Crush the Garlic using a knife. Keep them aside. Mix Ragi flour, crushed Garlic, Cumin seeds, Red chili powder and Salt to a bowl. Add 1/2 to 3/4 cup of water to the ingredients and make a more liquid like paste. Add the cut Onion to the flour mix and coat it well with the mix. Heat oil in a pan. Once the oil is hot enough, add the flour coated Onion to the oil and fry till it becomes crispy. Serve Hot.

xii. *Ragi Vada*

Chop Onion and Greens (Keerai). Keep aside. Take a vessel and mix all the ingredients except Oil. Add required Water and make a soft dough (like chapati dough), but slightly thinner than chapati dough. Heat Oil in a pan. Take a small amount of dough, press that with help of fingers and drop that in hot Oil. Fry till it turns into crispy or till the bubbles are almost stopped.

In addition to the above preparations many other local preparations are in practice making use of finger millet depending upon the local habits and choice of the groups, some of them are common across the regions but some typical products remain in the domain which need to be popularized. Few modern products incorporating finger millet are now available in the market such as, ragi health drink (baby vita), foodles, multi-grain noodle, ragi biscuit, ragi vermicelli etc.

IV. Conclusion

Finger millet is well comparable and even superior to many cereals in terms of mineral and micronutrient contents. Its major use as food has remained only in the area where it is cultivated and to the traditional preparations. Finger millet has good potential of providing nutritional security to the consumers. Its consumption in urban area can be increased through its proper processing and value addition. With the advancement of post harvest processing and value addition technologies, it has become possible to process and prepare value added products which are acceptable by both rural and urban consumers. This will not only help in increasing the profitability of its cultivators but will also help in providing income and employment opportunities in rural area.

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

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

Table 2 : Example of a RTE mix

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