

Development and Evaluation of Functional Food Mixes Using Ragi and Jowar

Deepika, P.S

(12PFN005)

Thesis submitted to

**Avinashilingam Institute for Home Science and Higher Education for
Women, Coimbatore- 641 043**

**In Partial Fulfilment of the Requirement for the
Degree of Master of Science in Food Science and Nutrition**

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Signature of the Supervisor


**Signature of the Head of the
Department**

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I INTRODUCTION

A food either natural or fermented will enhance physiological performance and prevent or treat diseases. Functional foods include those foods developed for health purpose as well as for physical performances. The Institute of Medicine's Food and Nutrition Board of United States defined functional foods as any food or food ingredients that may provide a health benefit beyond the traditional nutrient it contains (Bamji *et al.*, 2010).

The term functional food was first introduced in Japan in 1980's which refers to processed foods containing ingredients that aid specific body functions in addition to being nutritious. To date, Japan is the only country that has formulated a specific regulatory approval process for functional foods. Japanese coined the term Foods For Specified Health Use or FOSHU, to which a functional ingredient has been added for a specific healthful effect (Bailey *et al.*, 2009).

Functional properties of foods and food products decide their use and application in different food systems. High water absorption capacity of foods could be useful in bakery products and pulses could be preferred to reduce oil absorption (Kalim *et al.*, 2009). In recent years, cereals and its ingredients are accepted as functional foods and nutraceuticals because of providing dietary fibre, proteins, energy, minerals, vitamins and antioxidants required for human health (Popoulous *et al.*, 2012).

The consumption of cereals and legumes all over the world gives them an important position in international nutrition besides the high starch and protein and lipids rich in essential fatty acids. In addition, interactions between cereals and legumes with nuts, oilseeds and condiments have effects on the nutritional quality of food products (Banu *et al.*, 2012). The world's total production of millet grains at last count was 76, 2712 metric tons and the top producer was India with an annual production of 33, 4300 tons (FAO, 2012). India is the largest producer of many kinds of millets, which are often referred to as coarse cereals. However, realizing the nutrient richness of these grains they are now considered as 'nutri cereals' or small millets including several

grain crops namely finger millet (ragi), kodomillet (varagu) and litte millet (pannai varagu) (Stanly *et al.*, 2013).

Millet is one of the most important drought resistant crops and the sixth cereal crop in terms of world agriculture production. Millet has resistance to pests and diseases, requires short growing season and productivity under drought conditions, compared to major cereals (Devi *et al.*, 2011).The millets are with high fibre content, and their protein quality and mineral composition contribute significantly to nutritional security of a large section of a population residing in the millet growing areas (Desai *et al.*, 2010).

Millets are highly nutritious, non–glutinous and non acid forming foods, hence they are soothing and easy to digest .They are considered to be the least allergenic and most digestible grains available (Stanly *et al.* ,2013). Millets are also rich sources of phytochemicals and micronutrients (Mal, 2010; Singh *et al.*, 2012). Millets also contain B vitamins, especially niacin, B6 and folic acid, calcium, iron, potassium, magnesium and zinc (Vachanth *et al.*, 2010). It also contains higher proportion of unavailable carbohydrates and release of sugar from millet is low (Karuppasamy *et al.*, 2011).

Traditionally breakfast cereals were prepared using corn, however due to the recent advancement in technology there are breakfast cereals made using different cereal sources like wheat, rice, maize, oats, rye, barley, sorghum and millets which are known to be excellent sources of carbohydrates ,dietary fibre, protein, vitamins and minerals (Bharya *et al.*, 2012).

The presence of all the required nutrients in millets makes them suitable for large scale utilization in the manufacture of food products, such as baby foods, snack foods, and ready to eat foods and increasing more millet products have entered into the daily lives of people including millet porridge, millet wine and millet nutrition powder from both grain and flour form (Subramanian and Viswanathan, 2007; Liu *et al.*, 2012).

Pulses are second to cereals as an important source of human food. They are meats of vegetable world and close to animal flesh in protein food

value. Pulses are widely grown throughout the world and can play an important role in bridging the protein gap in solving protein energy malnutrition (www.livestrong.com).

Bengal gram provides an excellent source of molybdenum. It is also a very good source of folic acid and fibre. They are good sources of protein as well as minerals such as iron, copper and zinc. It contains both soluble and insoluble dietary fibre which helps to remove cholesterol containing bile from the body, and also prevents digestive disorders like irritable bowel syndrome and diverticulosis. It contains phytochemicals called saponins, which can act as an antioxidant. It could lower the risk of breast cancer. It can also protect against osteoporosis and minimize hot flashes in post- menopausal women (www.livestrong.com).

Iron deficiency affects 80 per cent of the world's population according to the World Health Organization. Women and children have the greatest need for iron and one of the most risks for deficiency. As a source of iron, green gram helps to meet the daily iron needs (www.glittoexports.com).

Nuts are also rich sources of antioxidant vitamins (e.g) tocopherols and phenolic compounds, necessary to protect the germ from oxidative stress and preserve the reproductive potential of the seed, but also bioavailable after consumption and capable of providing a significant antioxidant load (Blomhoff *et al.*, 2006). When peanuts are consumed with their skins, their antioxidant capacity doubles and roasting can actually increase this capacity as well (Craff, 2010). Roasted peanuts with skins have high antioxidant capacity than blue berries (Fransisco, 2008). Groundnuts are rich in energy and contain health benefits, nutrients, minerals, antioxidants and vitamins that are essential levels of mono unsaturated fatty acids especially oleic acid. It helps to lower LDL or bad cholesterol and increases HDL or good cholesterol level in the blood. It is an excellent source of resveratrol, another polyphenolic antioxidants it has been found to have protective function against cancers, heart disease, degenerative nerve disease and Alzheimer's disease. Roasting enhances taste, augments antioxidants levels like P- coumaric acid and helps remove toxic aflatoxin (www.nutritionandyou.com).

Acceptance of moringa leaves as a nutritional supplement in undernourished populations is compatible in that culture, that currently uses green leafy plant sources in traditional dishes. Rural populations and those populations who rely heavily on subsistence farming may find using moringa leaves more compatible than purchasing non-locally produced food. Because households can produce their own to use just as they market, they are able to use it just as they would with other grown foods such as grains, legumes, roots and tuber vegetables(Melance *et al.*, 2010). Drumstick leaves are also rich sources of flavonols such as kampferol and 3-ome quercetin. A flavones, acacetin and a glycoflavone 4-ome vitexin are also identified. The phenolic acids identified included melotic acid, p-coumaric acid and vanillic acid. One of the most important components of moringa leaves is quercetin, which is used as inhibition for the growth of cancer cell in human being (Kowsalya *et al.*, 2006).

Ragi has enormous health benefits and also a good source of valuable micronutrients along with the major food components .In order to develop the value added food products based on ragi ,that are able to enrich the nutritional value and also benefits for good health is the current need for the wellbeing of the society (Verma *et al.*,2013).

Whole of the finger millet produced in India is consumed in the form of various foods depending on the region and their food habits. The amino acid profile of finger millet is better than that of sorghum and maize and is comparable to wheat, barley and rice (Saikrishna *et al.*, 2011).

Ragi (Finger millet) is usually used for preparation of flour, puddings, porridge and roti (Chaturedi *et al.*, 2008). With the changes in scenario of utilization pattern of processed products and awareness of the consumers about the health benefits, finger millet has gained importance because of its functional components, such as slowly digestible starch and resistant starch (Wadikar *et al.* ,2007).

Sorghum (Jowar) is a cereal perceived to be an important coarse grain food crop. It is cultivated widely across Maharashtra, Madhya pradesh, Uttar

Pradesh, Haryana, Andhra Pradesh, Tamil Nadu and Karnataka and in parts of Rajasthan.

Jowar contains essential nutrients like vitamin E and B, magnesium, fibre and iron along with other valuable antioxidants. Consumption of jowar is beneficial in preventing common cardiovascular disease like atherosclerosis. It also reduces the risk of certain cancer like digestive tract cancer, as well as breast cancer and abdominal cancer. Jowar can reduce the risk of respiratory disorders such as asthma, consumption of jowar resulting in lesser tooth decay and germ diseases as it contains significant amount of selenium and magnesium (www.indiamart.com).

Millets give several potential health benefits such as preventing cancer and cardiovascular disease reducing tumour incidence, lowering blood pressure, risk of heart disease, cholesterol and rate of fat absorption, delaying gastric emptying and supplying gastro intestinal bulk have been reported for millet (Gupta *et al.*, 2012).

Whole grains like millets may have health promoting effects equal to or even in higher amount than fruits and vegetables and have a protective effect against insulin resistance, heart disease, diabetes, stroke, obesity, breast cancer, childhood asthma and premature death (Cade *et al.*, 2007).

Millets are easy to digest, contain a high amount of lecithin and are excellent for strengthening the nervous system. Millets are good for people who are gluten intolerant. Its fiber content also helps prevent constipation and may reduce the risk of developing bowel disorders including bowel colon (Stanly *et al.*, 2013).

Recently consumption of millet based foods have gained momentum in India due to their functional properties. Data on the incorporation of drumstick leaves and systematic study on nutritive value of functional food mixes are scarce. Hence, it was thought of interest to formulate and evaluate functional food mixes using Ragi and Jowar incorporating other functional foods like whole green gram, Bengal gram roasted, groundnut and drumstick leaves.

The specific objectives of the study are: To

- Develop functional food mixes using ragi and jowar.
- Develop recipes from the ready to eat functional food mixes.
- Conduct organoleptic evaluation of the formulated recipes.
- Assess the nutritive value of the most acceptable functional food mixes.

II REVIEW OF LITERATURE

The literature pertaining to the study entitled “**Development and Evaluation of Functional Food Mixes Using Ragi and Jowar**” is reviewed under the following headings:

- A. Millets –the underutilized foods
- B. Formulation of convenience mixes with functional properties
- C. Nutritional and sensory evaluation of functional food mixes
- D. Role of functional foods in health and disease

A.MILLETS –THE UNDERUTILIZED FOODS

FAO (2009) prescribed that the world production of coarse cereals grains in 2007– 2008 was estimated at 1080.4 MT, which increased upto 1142.3 MT in 2008–2009. Sorghum is one of the important staple diets in India especially of the rural poor in dryland regions of the country. It also serves as an important source of animal feed. In India, millets are grown on about 20 million ha with annual production of 18 million tonnes and contribute 10 per cent to the country’s food grain basket, supporting about 12 million people (Tonapi *et al.*, 2007; Dayakar, 2010).

International Grains Council (2011) reported that sorghum is cultivated on more than 42 million ha worldwide with the largest area in Africa (24.5 million ha) and Asia (10.6 million ha). It is also an important crop in the USA (6.6 million ha) and Australia (0.7 million ha). India ranks first with the largest sorghum area (9.1 million ha) in the world. Finger millet is grown in India in 1.64 million ha with a productivity of 11.79 quintal/ha. Barnyard millet is grown in 0.28 million ha land having a productivity level of 8.63 quintal/ha in India.

Chandrasekara and Shahidi (2010) explained that millets are important crops in semi-arid and tropical regions of the world due to their resistance to pests and diseases, short growing season and productivity under hardy and drought conditions when major cereals cannot be relied upon to provide

sustainable yields. Millets are underutilized in many developed countries. There is an immense potential to process millet grains into value-added foods and beverages in developing countries. Furthermore, millets, as they do not contain gluten and hence are advisable for celiac patients.

Suman *et al* (2013) reported that millets are the most drought resistant grains requiring little input for its production and are often considered to be "poor man's cereal". Millets are tiny, pale, yellow seeds with a nutty flavor which lends itself well to being cooked and eaten whole. With gradually increasing human population, millets are acquiring a status in the diet of health conscious consumers. This is the vital food crop for millions of people in parts of Africa and Asia. They are an underutilized food crop in most developed countries. In India, millets are the staple to a large section of population residing in the semi-arid region.

Wu *et al* (2014) opined that world hunger and food imbalance, challenges such as diminishing natural resources and aggravating natural disasters, emerging climate changes, and persisting poverty, illiteracy, and diseases are posing great threats to the world's efforts to ensure food security and alleviate the hunger crisis. In the face of these challenges, the goal to combat hunger should be achieved not only by increasing food availability but also by optimally integrating all different aspects of science, technology, and education to form a multifaceted strategy to comprehensively tackle world food imbalance, hunger and malnutrition from all angles. All these international efforts will doubtlessly pave the way to a sustainable and equitable food security, especially for the poor.

Verma *et al* (2013) explained that millets can play very specific role in human nutrition because of their multiple qualities. Though they are generally regarded as 'coarse grains' their potential for augmenting the grain supplies and bridging the protein gap is highly realized. Besides being staple foods, these grains are also raw materials in the production of various food and industrial products.

Dykes *et al* (2007) said that coarse cereals can provide viable alternatives to diversify sources of health components in foods, especially the benefits are highest for whole grain cereal consumption.

Kaur *et al* (2011) assessed the nutritional attributes of coarse cereals and also their utilization as food and as formulated foods. These cereals are laden with phytochemicals including phenolic acids, tannins, anthocyanins, phytosterols, and policosanols. Suman *et al* (2013) pointed out that, there is a growing demand for gluten-free foods and beverages for people with coeliac disease and other intolerances to wheat, which cannot eat products from wheat, barley or rye, to that millet has been established as the substitute.

Verma *et al* (2013) observed that millets are the basic cereals in India and eaten by a large section of the poor community. Minor cereals consisting of maize, sorghum, pearl millet, finger millet and other millets constitute a little less than 25 per cent of the total food grain production in India. The nutritional composition of small millets compares well with other cereals and with regard to the the nutrient content, some of them are even superior to rice and wheat.

Dayakar *et al* (2010) created awareness about jowar among more than 20,000 consumers via in-mall promotions and road shows, which encouraged the entrepreneurs to launch jowar-based foods. Popularization of millet-based recipes was attempted by training the rural social groups through mid-day meal program, and through the small-scale processors and potential entrepreneurs for marketing of millet foods.

According to Verma *et al* (2013) millets have great potential for being utilized in different food systems by virtue of their nutritional quality and economic importance. There is a wide scope of their exploitation in different food products including baked foods like breads, biscuits, cakes, cookies, breakfast cereals, muffins, pies, pancakes, snacks and extruded food stuffs.

Studies concluded by Shukla *et al.*, (2011) reported that development of acceptable food products through the judicious uses of such foods and later

on its commercialization may serve the people suffering from diabetes in an excellent way. There is tremendous opportunity to develop functional food targeted for those at risk for diabetes. The millet grains offer many opportunities for utilization in diversified products.

B. FORMULATION OF CONVENIENCE MIXES WITH FUNCTIONAL PROPERTIES

Klopi *et al* (2013) said that convenience has been an ongoing trend for some time and will continue, but the speed will largely depend on the industry realizing that convenience means different things to different people, and that there is a need for more products that combine convenience with healthiness and good sensory and culinary properties.

Kowsalya and Indra (2010) reported that processed foods include convenient food like instant mixes, extruded foods, canned foods and dehydrated foods. Among the processed foods, extruded products and nutrient mixes have better shelf life and are easily acceptable by all age groups.

An attempt has been made Banu *et al* (2012) to prepare the multigrain composite mixes and its various functional, nutritional, anti-oxidant properties have been studied. These multigrain composite mixes have been used for the preparation of food formulations which finds use in the preparation of savory products, snacks, pan cake, snacks like muruku etc.

Research and Development work carried out at CFTRI on processing and value addition to sorghum and millets has indicated the possibility of preparation of a number of new generation products (Meera *et al.*, 2008; Meera, 2009).

Chen *et al* (2007) suggested that powdered food products have extremely wide practical applications. There is a large variety of products available in the market such as sugar products, cereal products, starch products, dairy powders, flavorings, etc. Some of these powdered food

products are low-cost commodity products but some others are expensive food ingredients. Food powders may also be used as convenient raw materials for extraction processes for making pharmaceuticals.

Venn *et al* (2010) reported that incorporation of pulses and wholegrain foods into a weight loss program resulted in a greater reduction in waist circumference compared with the group consuming a control diet, although no difference in weight loss was noted between groups. Retention of several nutrients was better with the pulse and wholegrain.

Liu *et al* (2011) demonstrated the utility of extrusion processing in incorporating high levels of leafy vegetable ingredients in expanded snacks. The extruded products, based on Moringa (*Moringa oleifera*) leaf powder and oat flour, had substantially improved macro and micronutrient profiles as compared to commercially available snacks. These Moringa leaf powder -oat flour snacks had at least 20 and 90 per cent more fiber and protein, respectively, and also lower post-coating fat and higher vitamin A, iron, and calcium than a typical puffed commercial product.

Das *et al* (2012) convenes that the developed countries, due to large obesity problem and also for maintaining normal and sound health, different formulations and activities are coming up, specially delivering soluble fibers to the consumers via different foods like cereals and cereal products containing antioxidants. Cereals like wheat, maize, rice, oats etc. are now employed in preparation of food that are similar in appearance to conventional food and used in normal diet but have an added advantage of aiding physiological functions along with providing nutrition. Eating habits can drastically reduce health care expenditures if individuals were to modify their diets based on an existing knowledge of nutrition. In today's world the development and utilization of different cereal based functional foods is a challenging task. Invention of newer technologies for processing of cereals to improve their nutritional value vis-à-vis their acceptability by the end users will be the focus area in the near future.

Jiwan *et al* (2007) reported that efforts for new product development are being directed by the food industry towards the newly emerging area of functional foods, primarily to meet consumer's demand for healthier foods. For this purpose, cereals such as wheat, oat and barley, as well as their constituents offer unlimited opportunities for the production of functional foods.

According to Liu *et al* (2011) snack foods is one of the fastest growing segments of the food industry however, the delivery of nutrition via incorporation of fruits and vegetables in ready-to-eat expanded snacks is a relatively new concept and is motivated mainly by health concerns.

Studies by Balasubramanian *et al* (2012) reported that rapid urbanization, industrialization and consequent changes in eating habits of people have lead to development of instant dry mixes and ready-to-eat convenience foods. Dry mixes of several traditional Indian foods such as idli mix, vada mix, kheer mix have gained worldwide popularity and popular choice of most of these products has been wheat and rice. Other food grains such as pearl millet have remained underutilized due to lack of technology or some inherent shortcomings.

Physico -chemical properties of starches in these halwa mixes and preparation, nutritional composition, functional properties and antioxidant activities of multigrain composite mixes were also reported by Itagi and Singh (2010, 2011).

Kotilainen *et al* (2006) referred that the leading food market sections where functional food products have been mainly launched include dairy, bakery, confectionery, soft drinks and baby foods.

Singh *et al* (2012) in their study found that finger millet upto 60 per cent can be successfully incorporated to formulate iron rich namakpar mixes. These mixes are low cost, nutritious, had good storage stability and were

acceptable at both laboratory and field level. These mixes can be successfully used for supplementary feeding programmes.

Pradeep *et al* (2013) revealed that popped sorghum, pearl millet and grain amaranthus can be mixed with expanded legumes to prepare a ready-to-eat snack mix. This mix can be shaped into either laddu or burfi or can be consumed in porridge form also. This mix contains adequate amount of protein and minerals and was found suitable for feeding children and also people of all age groups.

Jiwan *et al* (2007) expressed that cereal grains and germs are good sources of various phytochemicals. The major phytochemicals present in cereal grains are: phenolic acids, flavones, phytic acid, flavanoids, coumarins, and terpenes. Cereal germs are good sources of ferulic acid, phytic acid, glutathione, and phytosterols. In addition, the cereal germ contains the vitamins E, B1, B2, and B3, the minerals P, K, Mg, Ca, Zn, and S, and fiber. Because of its rich nutrient content, cereal germ would be a valuable ingredient for production of functional foods.

C. NUTRITIONAL AND SENSORY EVALUATION OF FUNCTIONAL FOOD MIXES

Sensory evaluation of products incorporated with different levels of dehydrated *Amaranthus paniculatus* and *Peucedanum graveolens* greens revealed that they could be incorporated in traditional products at lower levels of four per cent with no detrimental effects on sensory quality. Addition of dehydrated greens increased the nutrient density of all products. Value addition of traditional products with dehydrated greens can be advocated as a feasible food based approach to combat micronutrient malnutrition (Gupta *et al.*, 2011).

Verma *et al* (2013) found that physical characteristics of the dough, sensory and nutritional characteristics of the small millet incorporated bread, at 20 per cent incorporation level was found to be highly acceptable. The

fiber, calcium and iron content of the small millet incorporated bread were higher than that of the refined wheat bread

Pradeep *et al* (2013) upholds that the ready to eat snack mix production methodology is economical and can be easily adopted in home to industrial scale using locally available underutilized grains. Sensory analysis and storage studies revealed that the products prepared from popped minor cereals and legumes exhibited good overall acceptability.

Saikrishna *et al* (2011) reported that finger millet flour up to 40 per cent can be incorporated for successful improvement of nutritional and organoleptic characters. The use of finger millet flour also enhances the dietary fiber and mineral contents especially iron and calcium.

Studies by Karuppasamy *et al* (2011) on sorghum and maize reported that sorghum and maize sooji mix are highly nutritious, low cost and it can be effectively used in the preparation of nutritious food items like laddu, utthiripittu, kuzhapittu, and roti after suitable processing .

Singh *et al* (2013) concluded that product of corn sev incorporated with kidney beans and lentil flour has good sensory and nutritional quality and therefore can be recommended as value added product for adolescent girls, pregnant women, celiac diseases and cancer patients.

Sangeetha and Murugan (2013) from their study found that pasta with 50 per cent multi millet powder has a better sensory profile and improved nutritional value.

Kumari *et al* (2013) reported that a composite mix comprising of brown finger millet flour, maize flour, rice flour, and full fat soy flour produced has the most acceptable ready to eat extrudates in terms of expansion ratio, hardness, and sensory characteristics.

Findings of study Arya *et al* (2013) concluded that cauliflower leaves and drumstick leaves helped to improve total minerals, fibre, calcium and iron content of traditional foods and hence can be utilized for value addition to traditional foods for improving micronutrient security.

Green leafy vegetables are rich in micronutrients and could be used to prepare nutritious mixes to enhance their nutrient content (Kowsalya and Indra, 2010).

Ripnar *et al* (2013) concluded that, incorporation of food groups for preparation of products improved the chemical components of the products and a combination of food groups helps to reduce micronutrient deficiency.

Fatima *et al* (2013) found that the millet and soy based weaning mixes therefore have a potential for use as weaning and or supplementary foods for older infants and younger children.

D.ROLE OF FUNCTIONAL FOODS IN HEALTH AND DISEASE

Kaur *et al* (2011) explained that understanding the requirement of food characteristics in tackling specific health problem(s), and contribution of specific food ingredients towards such benefit will definitely help in development of functional foods. Recent interests focusing on the active potential of foods and diets on oral health and disease prevention has led to the development of foods and beverages with 'functional ingredients' which provide added benefit to certain oral health conditions or may help to prevent the development or progression of impaired and diseased conditions.

Millets must be accepted as functional foods and nutraceuticals because they provide dietary fibers, proteins, energy, minerals, vitamins, and antioxidants required for human health. Several potential health benefits were reported for millets such as preventing cancer and cardiovascular diseases, reducing incidence of tumor incidence, lowering blood pressure, cholesterol

and fat absorption rate and thereby preventing heart disease, delaying gastric emptying and increasing gastrointestinal bulk (Gupta *et al.* , 2012).

Fardet *et al* (2008) reported that consumption of whole-grain cereals would protect the body against age-related diseases such as diabetes, cardiovascular diseases, and some cancers. Kaczmarczyk *et al* (2012) pointed that grains are important sources of carbohydrates, proteins, fiber and micronutrients. In recent years, there has been growing scientific evidence that grains contain a lot of health-promoting components such as antioxidants and dietary fiber, which was found to effectively lower serum LDL cholesterol concentrations and thereby protecting against cardiovascular disease, type 2 diabetes mellitus and colon cancers.

Dykes and Rooney (2006) said that millet grains can contain substantial levels of a wide range of phenolic compounds and contribute to antioxidant supplements. The health promoting properties of millets, in particular their antioxidant activity is used as nutraceutical and its utilization in functional foods is well established.

Consumption of wholegrain foods has been recommended for healthy diets. The beneficial health properties of wholegrain products have been associated with the presence of higher amounts of dietary fiber and antioxidants and lower calories as compared to their respective refined ones. Phenolic compounds are mainly attributed to antioxidant properties of wholegrain foods (Ragaei *et al.*, (2012).

According to Mishra *et al.*, (2012) and Vanisha *et al* (2008) the prospect of more aggressive introduction and utilization of drumstick leaves by the food sector, implies that it may be worthwhile for industry to take up the production of drumstick leaf powder. Such promotion of drumstick leaf incorporation into the diet in India and other countries could go a long way towards not only alleviating micronutrient deficiencies, but also towards the development of functional foods for several chronic degenerative disorders. These efforts could also be an additional source of income generation,

employment and exports providing a viable alternative to imported food supplies to treat malnutrition in poor countries.

Griel *et al* (2013) reported that peanuts are a rich source of B-vitamins, vitamin E, magnesium, copper and phosphorus. In addition, they are a source of plant protein (including arginine), dietary fiber, and unsaturated fatty acids. Numerous bioactive substances (i.e., flavonoids, resveratrol and plant sterols) also are present in peanuts. Resveratrol and -sitosterol found in peanuts have been associated with decreased risk of CHD and reduced cancer risk. Thus, it stands to reason that peanut consumption would be associated with a favorable nutrient intake.

Leonora *et al* (2008) opined that peanut, peanut products, and its byproducts—roots, leaves, hulls, skins, and kernels are potential sources of functional and beneficial components that exhibit wide biological and practical applications which are of great interest to the food industry. There is substantial evidence that peanuts are packed with bioactive compounds, therefore, it would be worthwhile to further embark on experimentation and investigation on the functionality of this valuable agricultural crop.

Das *et al* (2011) expressed that due to constant health awareness and readily available information on usefulness of different diet and their direct link with health, the demand of functional food is increasing day by day. The concept of functional foods includes foods or food ingredients that exert a beneficial effect on host health and/or reduce the risk of chronic disease beyond basic nutritional functions. Increasing awareness of consumer health and interest in functional foods to achieve a healthy lifestyle has resulted in the need for food products with versatile health-benefiting properties.

Ros (2010) found that healthy diet supplemented with one daily serving of nuts prevents cardiovascular events and development of other prevalent chronic disorders, including diabetes, cancer and neurodegenerative diseases.

Jones (2006) reported that small millets are a good source of phosphorus and iron. In view of these nutritional properties these coarse cereals have of late been also designated as nutri cereals. They are rich in compounds that help against several chronic diseases like ischemic strokes, cardiovascular diseases, cancers, obesity and type II diabetes. Duchateau and Klaffke (2008) opined that health claims for functional foods can only be made if the ingredient reaches the target site for the required physiological action.

Jiwan *et al* (2007) reported that consumer interests in functional foods has skyrocketed in the one and half decades due to a number of factors like growing health awareness, changes in food regulations, and overwhelming scientific information on highlighting the critical link between diet and health. Although a number of new functional foods based on various commodities are now appearing in the market, cereals hold a prominent place in this new market. Because whole cereal grains are rich in many phytochemicals such as dietary fiber (e.g., beta glucan), resistant starch, antioxidant nutrients (e.g., tocotrienols and choline) vitamins, minerals, lignans, phytic acid, and phenolic compounds, efforts are being made to develop a number of functional foods based on these whole grains.

III. METHODOLOGY

The methodology adopted for the present study entitled “**Development and Evaluation of Functional Food Mixes Using Ragi and Jowar**” is dealt under the following phases.

PHASE I - FORMULATION OF FUNCTIONAL FOOD MIXES

- A. Selection of raw materials.
- B. Processing of ingredients
- C. Formulation of functional food mixes

PHASE II - PREPARATION AND ORGANOLEPTIC EVALUATION OF RECIPES

- D. Preparation of selected recipes
- E. Organoleptic evaluation of functional food mix recipes

PHASE III - NUTRIENT CONTENT OF THE MOST ACCEPTABLE FUNCTIONAL FOOD MIXES

- F. Evaluation of overall acceptability of recipes
- G. Evaluation of nutrient content of the most acceptable functional food mixes
- H. Cost calculation
- I. Statistical analysis of recipes prepared with functional food mixes

PHASE I - FORMULATION OF FUNCTIONAL FOOD MIXES

A. Selection of raw materials

Food choices of an individual depend on energy and nutrient requirements, enjoyment, personal and family beliefs including cultural and environmental considerations, and social and economic factors. Taking into consideration the ICMR recommendations of five food groups essential for all age groups, the investigator had chosen the raw materials from the basic five food groups.

1. Millets

Millets are the drought tolerant crops, containing substantial levels of a variety of phenolic compounds. The antioxidant properties of the millets due to the presence of phenolic substances make them to be used as

nutraceuticals and its utilization in functional foods is well established in the recent years (Dykes and Rooney, 2006). For the present study, the investigator therefore had chosen the millets namely ragi and jowar.

Ragi contains high fiber, and more vitamins as well as minerals, which are normally deficient in Indian diet. The calcium content of ragi is eight times more than that is present in other cereals. Its protein content is comparable to rice (6-8%) and fat (1-2%) and is superior to rice and wheat with regard to mineral and micronutrient contents (Verma *et al.*, 2013).

Sorghum is one of the important staple crops in India especially in the diets of the rural poor in dry land regions of the country (Dayakar *et al.*, 2010). They are rich in phytochemicals, especially antioxidant phenolics, at levels similar to that of other rich sources such as berries. Sorghum varieties and products from them such as breakfast cereals are being promoted under the name 'grain berry' (Kamp *et al.*, 2012). These health promoting properties generates interest in developing products from ragi and jowar.

2. Pulses

Pulses are the edible seeds of legumes or pod-bearing plants including beans, lentils, chickpeas and yellow peas. Epidemiological studies have associated bean consumption with reduced risk of overweight and obesity in both adults and children (Christina *et al.*, 2013). The phenolic compounds present in Bengal gram are known to exhibit strong antioxidant, anti mutagenic and antigenotoxic activities (Gujral *et al.*, 2013). Mung beans are rich sources of protein (14.6 g to 33.0 g / 100g) and iron (5.9 – 7.6 mg). Grain colour is linked to compounds like polyphenols and carotenoids ,while grain hardness is associated with fibre content. Colours of mung bean grains may range from dark green, light yellow, light green, deep green, shining green, dull green, golden yellow to mottled yellow (Katiyar *et al.*, 2007). Dark coloured mung bean grains have been reported to contain higher polyphenol levels (Muhammed *et al.*, 2010).

3. Nuts

Consumer awareness about the energy content and nutrient value of peanuts and how they can be incorporated in the diet as a strategy for substituting unsaturated fats for saturated fat can improve the nutrient, especially micronutrient profile of the diet. Encouraging the use of peanuts

and peanut butter in both popular and familiar foods, gives additional options that may promote adherence to a healthy diet that reduces risk of chronic disease (Amy *et al.*, 2013).

4. Green leafy vegetable (GLV)

GLV are rich sources of micronutrients. Green leafy vegetables are rich sources of carotene. They are good sources of calcium, riboflavin, folic acid and vitamin C. Daily consumption of 100 g of leafy vegetable by adult and 50g by children will provide the daily requirement of carotene, folic acid and vitamin C, calcium and riboflavin requirements. They are the cheapest among the protective foods (Swaminathan *et al.*, 2008).

Utilizing these micronutrient-rich GLV in a dehydrated form can be a food-based approach to combat the micronutrient deficiency prevalent in our populations. Drumstick leaf incorporation into the diet in India and other countries could go a long way towards not only alleviating micronutrient deficiencies, but also towards the development of functional foods for several chronic degenerative disorders (Mishra *et al.*, 2012).

The raw materials thus used in the preparation of functional food mixes were two major millets namely ragi, jowar as base. The other ingredients include from pulses group green gram whole and Bengal gram roasted, from nuts groundnut and from green leafy vegetables, drumstick leaves. All the ingredients were purchased from supermarket and were further processed for the study. The raw ingredients of the functional food mix are depicted in Plate.

RAGI MIX



JOWAR MIX



RAW INGREDIENTS



a – Ragi
d- Mung bean

b- Jowar
e- Bengal gram Roasted

c- Groundnut
f-drum stick leaves powder

PLATE 1

**FORMULATION OF RAGI AND JOWAR BASED
FUNCTIONAL FOOD MIXES**

B. Processing of ingredients

The investigator purchased the selected ingredients from super market and it was then subjected to various processing methods to prepare the functional foods mixes.

1. Millets

The millets ragi and jowar were purchased and visually inspected for removing dirt and dusts. The grains without infestations were selected, subjected to dry roasting for a period of 3 to 5 minutes.

2. Pulses

The selected pulses – green gram whole (mung bean) and Bengal gram was inspected visually for removing dirt and dusts. The green gram whole was dry roasted until the green colour of the gram changed to olive green to mild brown colour. The selected Bengal gram was subjected to dry roasting for a period of 2 to 3 minutes.

3. Nuts

Good quality groundnuts were cleaned and subjected to dry roasting in a low flame until good aroma arises.

4. Green leafy vegetable

Green leafy vegetables (GLV) are micronutrient dense nature's gift to mankind. Micronutrient present in green leafy vegetables includes vitamin A, iron, β -carotene, etc. and utilizing them is one way of ensuring the micronutrient intake (Gupta *et al.*, 2011). *Moringa oleifera*, otherwise known as "The Miracle Tree" has been used for the treatment of skin diseases, respiratory illnesses, ear and dental infections, hypertension, diabetes, cancer treatment, water purification, and have promoted its use as a nutrient dense food source for hundreds of years (Anwar *et al.*, 2007). The leaves of *M. oleifera* have been reported to be a valuable source of both macro- and micronutrients.

For the present study, the investigator has chosen the leaves of *Moringa oleifera*. Young and old leaves both are suited for making dried leaf powder. Moringa leaves were purchased from the market. Damaged leaves were discarded manually just after the collection of fresh leaves. Collected leaves were washed in running tap water till the removal of dirt, and water was drained completely. High temperature may lead down to the breakage of

protein and oxidation of carotenes present in the leaves. Therefore, shade drying was adopted for the drying process in the present study.

In this study, for shade drying of the Moringa leaves, a well ventilated room was selected, which was insect, rodent and dust free . The leaves were kept in a stand and a mosquito net was used to cover the leaves so that dust particles would not get into the leaves. Personal cleanliness and hygiene were maintained by the investigator. Leaves were completely dried after 48 hours with a residual moisture of 3 to 6 per cent.

The dried drumstick leaves were ground in a mixer grinder.

All the ingredients were ground to a fine powder in a mixer grinder and stored in air tight containers separately.

C. Formulation of functional food mixes

The formulation of functional food mixes were carried out to develop a product from ragi, , mung bean, roasted Bengal gram and peanut were in the ratio of 55:25: 10:10. Instead of ragi, jowar was used to prepare another formulation. These formulations were arrived at after conducting several standardization trials in the laboratory. The ingredients and the quantity of each item for a 100 g functional food mix is given in the Table I and II. The powdered ingredients were mixed in the given ratio and were kept in air tight containers with labels.

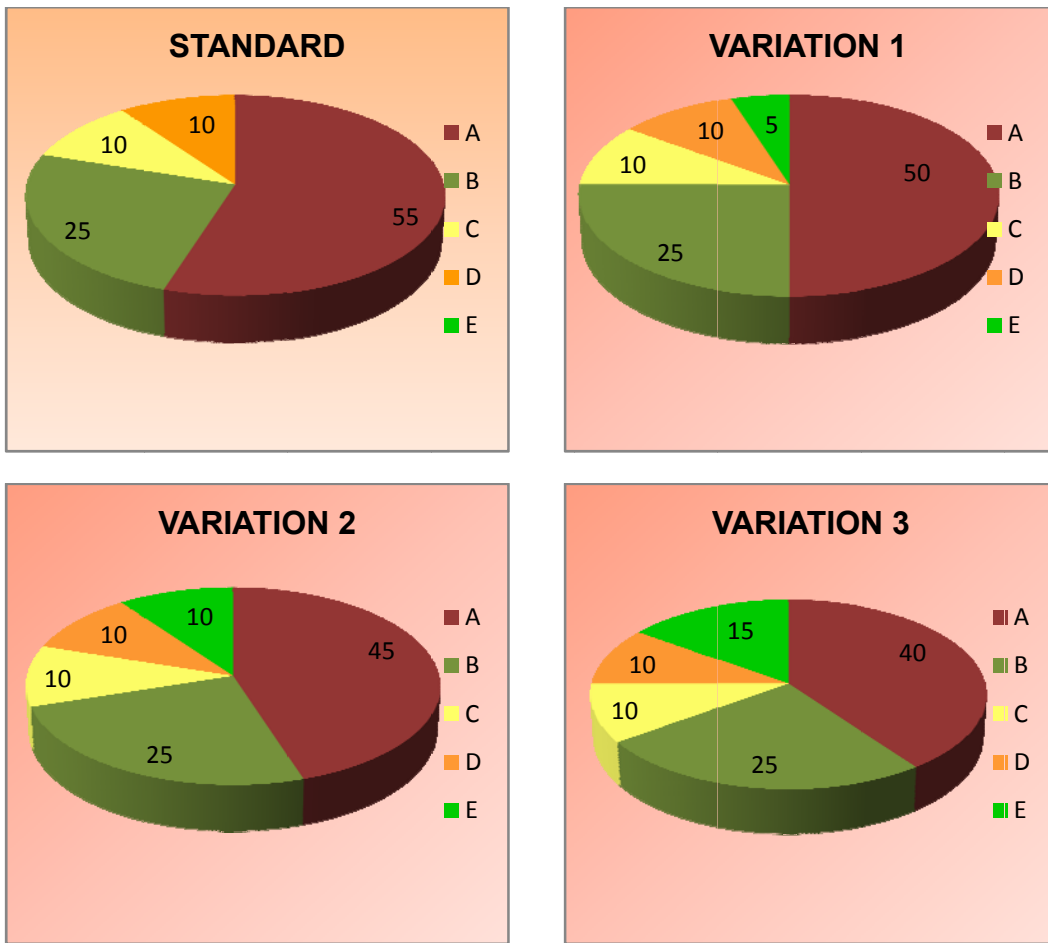
TABLE I
FORMULATION OF RAGI BASED FUNCTIONAL FOOD MIX (100g)

S.No	Ingredients (g)	Variation of functional food mixes			
		Standard	Variation 1	Variation 2	Variation 3
1.	Ragi	55	50	45	40
2.	Mung bean	25	25	25	25
3.	Bengal gram roasted	10	10	10	10
4.	Ground nut	10	10	10	10
5.	Drumstick leaves powder	-	5	10	15

TABLE II
FORMULATION OF JOWAR BASED FUNCTIONAL FOOD MIX
(100g)

S.No	Ingredients (g)	Variation of functional food mixes			
		Standard	Variation 1	Variation 2	Variation 3
1.	Jowar	55	50	45	40
2.	Mung bean	25	25	25	25
3.	Bengal gram roasted	10	10	10	10
4.	Ground nut	10	10	10	10
5.	Drumstick leaves powder	-	5	10	15

The combination of ragi and jowar based food mixes with drumstick leaves powder were V1(95:5) ,V2 (90:10),V3 (85:15) all these variation (V1,V2,V3) and the standard of mixes were used to prepare the various products like laddu, uthiri puttu, adai and sevai. The composition of the ingredients in the functional food mix is depicted in Figure 1



- A. JOWAR/RAGI
- B. MUNG BEAN
- C. BENGAL GRAM ROASTED
- D. GROUND NUT
- E. DRUMSTICK LEAVES POWDER

FIGURE 1
FORMULATION OF RAGI AND JOWAR BASED FUNCTIONAL FOOD MIXES

PHASE II - PREPARATION AND ORGANOLEPTIC EVALUATION OF RECIPES

D. Preparation of selected recipes

Using the functional food mixes formulated in the present study, four commonly consumed recipes namely laddu, uthiri puttu, adai and sevai were prepared. The procedure for recipe preparation in the study was standardized based on the procedure followed by households in Coimbatore district. The quantity of the ingredients used and the method of preparation of recipes are outlined in the following pages.

1. LADDU

Ingredients

Functional food mix	-	100g
Ghee	-	10 g
Jaggery	-	50g
Water	-	25ml
Cardamom	-	2 pods

Method

Boil jaggery with water to form thick jaggery syrup.

In a pan, add ghee and then put the functional food mix and roast it lightly under a low flame.

Remove the pan from fire and allow to cooling.

Now add jaggery syrup and crushed cardamoms in to the cooled functional food mix and using the hand form even shaped balls.

2. PUTTU

Ingredients

Functional food mix	-100g
Salt	-1/4 teaspoon
Water	-25 ml
Grated coconut	-25g
Sugar	-25g

Method

Take a big flat bowl. Add 1 cup functional food mix and salt. Sprinkle water and mix it with fingers without any clumps.

Break any balls which forms during mixing. Spray water little by little.

After mixing functional food mix, the mixture should be just wet like soft bread crumbs wet enough for steaming.

Take an idli cooker put a wet cloth and then put the functional food mixture into it. Close the idli cooker and allow it to cook for 5 - 10 minutes.

After the steaming process is complete, add the grated coconut and sugar was sprinkled and mixed it.

3. ADAI

Ingredients:

Functional food mix	-	100g
Green chilly	-	3 no's
Asafoetida	-	a pinch
Big onion	-	60 g
Curry leaves	-	a few
Oil	-	10 ml
Salt	-	to taste

Method:

Season asafoetida add curry leaves, big onion, green chilly and saute it .

Add this mixture to functional food mix and add little water and salt.

Heat pan and spread a teaspoon of oil. Pour a laddle of batter and spread to a round shape. When one side is done, turn over add another teaspoon of oil on top fry till crisp.

4. SEVAI

Ingredients:

Functional food mix	-	100g
Onion	-	60g
Carrot	-	30g
Beans	-	30g
Green chilly	-	3 no's
Coriander leaves	-	few
Salt	-	to taste
Oil	-	10 ml

Method:

Wash and chop onion, carrot, beans, green chilly

Saute all cut vegetables with oil

To functional food mix add little water and salt and made dough

Put the dough into an extruding machine and extrude manually into sevai.

Steam in idli cooker for 10 minutes.

After steaming process is complete, add the sauted vegetables into it and mix well and garnish with a coriander leaves.

Recipes prepared with ragi and jowar based functional food mixes are shown in Plate 2 and Plate 3.

RECIPIES PREPARED WITH RAGI BASED FUNCTIONAL FOOD MIXES

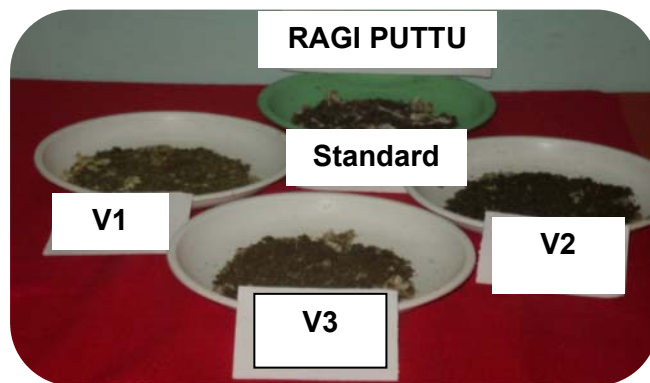


PLATE 2

RECIPIES PREPARED WITH JOWAR BASED FUNCTIONAL FOOD MIXES

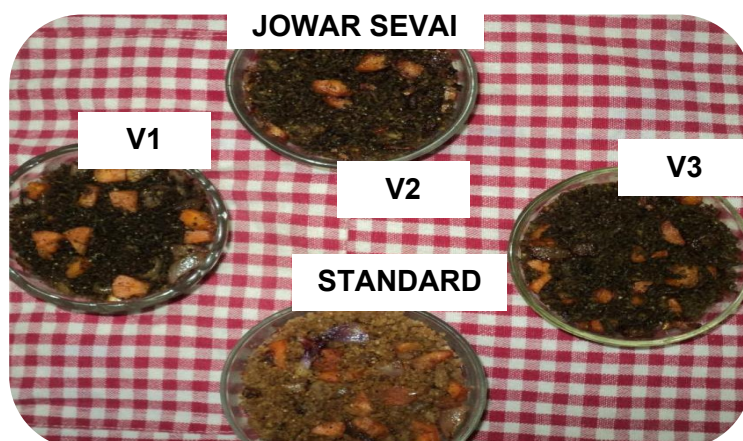


PLATE 3

E. Organoleptic evaluation of functional food mix recipes

According to Heseih and Ofori, (2007) modern nutritional science provide more information on the functional mechanism of specific food components in health promotion and disease prevention. Also, today's busy life style is driving towards the development of healthy convenience foods. The developed food products not only provide sensory appeal but also nutritional and health benefits. Also Rastigi *et al.*, (2007) found that there is an increasing demand for convenience foods with natural flavor and taste, and which are free from additives and preservatives.

The organoleptic evaluation of the recipes prepared with functional food mix was carried out by semi-trained panel members. The recipes made from the functional food mixes with incorporation of drumstick leaves in three different variations namely 5 per cent, 10 per cent, 15 pe cent drumstick leaves incorporation and the standard one were evaluated organoleptically by semi-trained panel members of 30 using a five point numerical score card. The score card of the scale was ranging from a maximum score of 5 to a minimum score of 1 for reach recipes. The criteria evaluated for each recipe was appearance, colour, flavor, taste, texture and doneness. The score card for organoleptic evaluation of the recipes is given in Appendix 1.

PHASE III - NUTRIENT CONTENT OF THE MOST ACCEPTABLE FUNCTIONAL FOOD MIXES

F. Evaluation of overall acceptability of recipes

Food is accepted when there is a pleasant situation. The selected recipes can be relished in daily menu as well as in festive occasions. The standard recipes were incorporated with 5, 10, 15 per cent of drumstick leaves in the functional food mix which were repeated three times in the laboratory. Thirty semi trained panelists were selected from the post graduate classes and teachers. Organoleptic evaluation was carried out and the overall acceptability was assessed. Based on the results of acceptability trials, recipes prepared using variation II that is incorporated with 10 per cent level of drumstick leaves incorporation was chosen for nutrient analysis.

G. Evaluation of nutrient content of the most acceptable functional food mixes

The nutrient analysis of functional food mixes were done for the most acceptable recipes. The nutrients analysed were moisture, ash and dietary fibre. The analysis was carried out by using Association of Analytical Chemists International (AOAC) procedure.

Carbohydrates estimation was done by anthrone method. The amount of protein present was estimated by macrokjeldhal's method. The iron, phosphorus and the β carotene content was estimated using colorimetric method, and vitamin-C was estimated using dye method and calcium by using titrimetry method. Fat was estimated by soxhelt extraction method.

The energy was calculated by multiplying the total amount of carbohydrates, fat and protein by their calorific value.

1. Macro nutrients

a. Carbohydrate

Carbohydrates are hydrolyzed into simple sugar using dilute hydrochloric acid. In hot acidic medium glucose is dehydrated to hydroxyl methyl furfural. This compound forms with anthrone, a green colour with an absorption maximum at 630nm.

b. Protein

The given sample is digested with concentrated sulphuric acid in a macrokjeldahl flask when nitrogen gets converted to ammonium sulphate. Ammonia is liberated by the action of strong alkali in a macrokjeldahl steam distillation apparatus. This nitrogenous substance is converted to ammonium borate by absorbing two percent boric acid is titrated against N 70 sulphuric acid. The volume of acid required to bring the test sample to the colour of the blank of till equivalent to the ammonia released.

c. Fat

The soxhelt flask was weighed to consecutive concordant weights. 2g of the moisture free sample was packed into an extraction thimble and placed in an extractor which was fixed into a soxhlet flask. Poured sufficient amount (150ml) of petroleum ether so as to permit syphon action. The thimble and the

contents were allowed to soak in ether for 24 hours. The entire set up was kept over in an electric water bath and the extractor was connected to the condenser. The nozzle of the condenser was always plugged with moistened cotton. The temperature was maintained at 60⁰c. A steady stream of water in the condensor was maintained. The ether evaporated rose up but owing to the condensor arrangement; it fell back into the condensor extractor. When the extractor got filled with ether, it was siphoned back into the flask. This went on till the ether that got collected in the extractor was free from any yellow colour indicating the presence of fat. The soxhelt flask was then disconnected and ether was evaporated in a water bath maintained at 60⁰C. When the ether in the flask was evaporated, the flask was weighed again to get concordant values. From the difference in weight, the fat content was calculated.

d. Crude Fibre

The term “crude fibre” ordinarily meant in agriculture and food analysis is the organic residue consisting largely of cellulose, that is left after other carbohydrates and proteins have been removed by successive treatment with boiling acids and alkalis. The crude fibre obtained in this way is not cellulose but contains distinct properties of hemicelluloses, and nitrogenous substances. These however are not sufficient to prevent the results from being reasonably accurate and comparable

e. Moisture

Estimation of moisture is one of the most often performed determinations in food analysis. Moisture is lost when food is heated not much higher than the temperature of boiling water or by allowing to stand overnight over dehydrating agent or by heating over vacuum.

f . Ash

By continuous heating, the substance gets charred which can be used for the determination of minerals presents.

2. Micronutrients

a. Carotene

Carotene present is extracted with petroleum ether and the intensity of the color of the colour of the extract is compared with that of the standard solution using a colorimeter

b. Iron

The food sample is oxidized with ignition or oxidation .Iron as ferric iron reacts with ammonium thiocyanate or with potassium thiocyanate to give ferric thiocyanate which is red in color .The color which is a measure of the concentration is measured colorimetrically.

c. Phosphorus

When the ash solution is treated with ammonium molybdate, phosphomolybdic acid is formed. Phosphomolybdic acid is reduced by the addition of 1, 2, 4 amino naphthol sulphonic acid reagent to produce a blue colour which is apparently a mixture of oxides of molybdenum. The intensity of the colour developed is the measure of phosphorous present.

d. Calcium

Calcium is determined by the precipitating it as calcium oxalate and titrating the oxalate solution in dilute sulphuric acid against standard potassium permanganate.

e. Vitamin C

Vitamin C is a good reducing agent and it reduces the dye 2,6 dichlorophenol indophenol. In this reaction, the ascorbic acid itself is oxidized to dehydro ascorbic acid. In the absence of interfering substances, the capacity of the extract of the sample to reduce a standard solution of a dye as determined by titration is directly proportional to the vitamin C content .Oxalic acid is not only used to reduce the pH of the extracting medium, there by establishing the vitamin C but also form complexes with metals eg. Copper thereby preventing the catalytic oxidation of vitamin.

The estimation procedures for nutrient content of functional food mixes are given in Appendix 2

H. Cost calculation

Cost of the developed functional food mixes were calculated by calculating the cost of all the ingredients used for the development of the functional food mixes. The cost of both ragi based and jowar based functional food mixes were calculated as per the prevailing cost of ingredients at the local market.

I. Statistical analysis

In this study, statistical analysis was carried out on the data using statistical package –XL stat 2007. Results are presented as means and standard deviations.

The research design of the study is given in Figure 2.

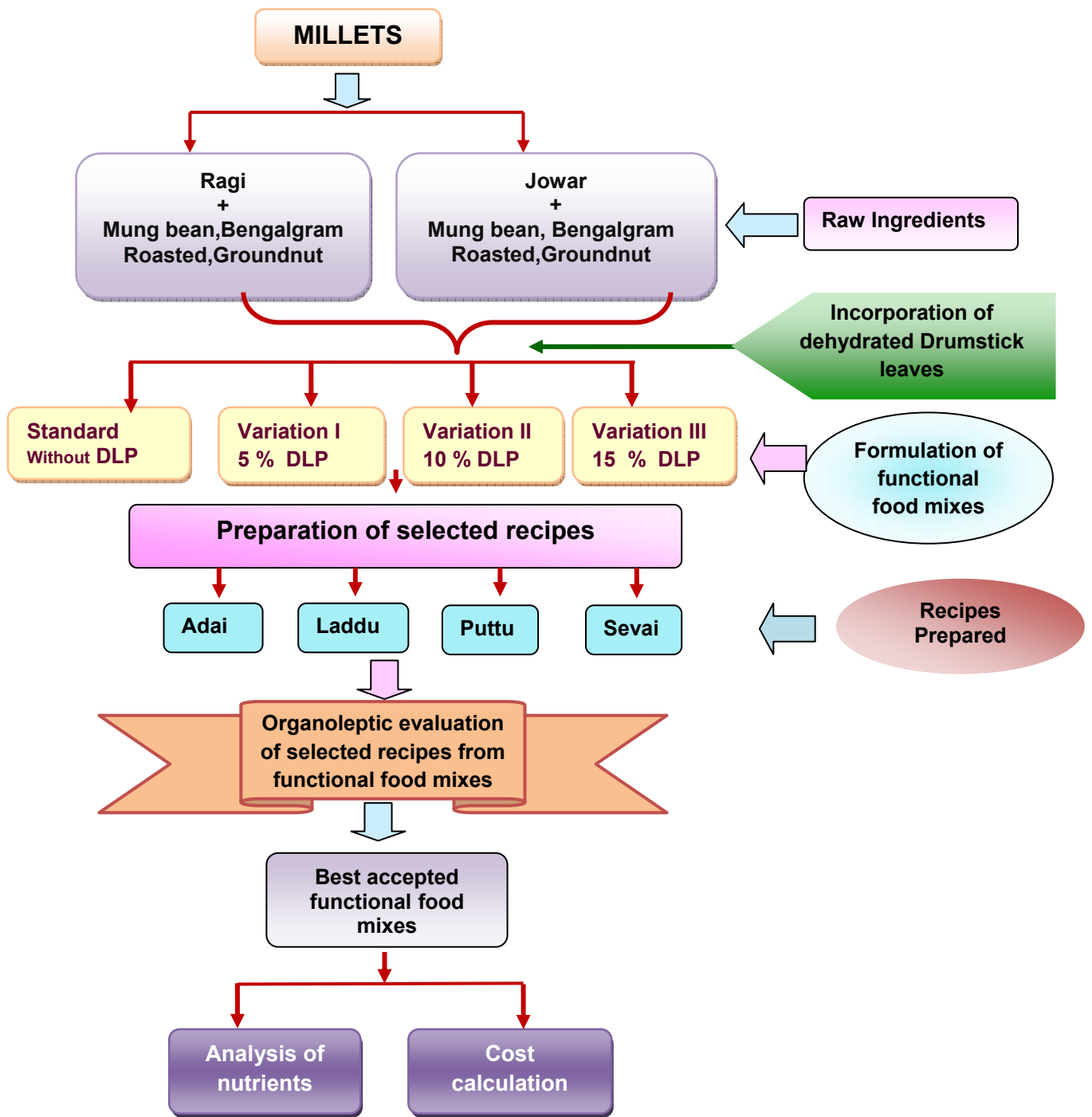


FIGURE 2
RESEARCH DESIGN

IV RESULTS AND DISCUSSION

The results of the study entitled “**Development and Evaluation of Functional Food Mixes Using Ragi and Jowar**” are discussed under the following headings:

- A. Organoleptic evaluation of the recipes developed using functional food mixes using ragi and jowar
- B. Nutrient content of the most accepted functional food mixes
- C. Cost analysis of most accepted functional food mixes

A. ORGANOLEPTIC EVALUATION OF THE RECIPES DEVELOPED USING FUNCTIONAL FOOD MIXES USING RAGI AND JOWAR

According to Sabapathy and Bawa (2007), food quality refers to many characteristics including nutrients, safety, taste, appearance, texture and convenience.

Jetter and Cassady (2006) found that many people, especially low income consumers do not successfully follow dietary recommendations to eat more whole grains and less fat and added sugar. Thus, undernourishment leads to malnutrition in terms of micronutrient and macronutrients. Also there are many factors which influence the bioavailability of nutrients from food with respect to the type of preparation and the amount of ingredients. The selected recipes were chosen in such a way that they are included in the diet most frequently with easiest preparation methods, which aids in the bioavailability of nutrients to its maximum. The recipes included for the organoleptic analysis were adai, laddu, puttu and sevai. The ingredients comprised in the selected recipes were mostly cereals and pulses. The functional food mixes in the recipes ameliorates the vitamin and mineral content of the recipes..

Totally four recipes were prepared, along with three variations. The result of organoleptic evaluation is given in the following pages.

For each recipe, standard was prepared and three variations were prepared namely 5 per cent, 10 per cent, 15 per cent. In these variations

functional food mixes were incorporated with drumstick leaves. The acceptability of these levels of variations compared to the standard were evaluated for attributes like appearance, color, flavor, taste, texture and doneness by panelists using numerical scoring method ,score cards were prepared for evaluation. The scores ranged from maximum of five to minimum of one with, the maximum score of 30.

ADAI

Table III presents the organoleptic evaluation of adai prepared with the functional food mixes

TABLE -III
ORGANOLEPTIC EVALUATION OF ADAI PREPARED WITH RAGI BASED FUNCTIONAL FOOD MIXES

Criteria	Standard	Variation 1 (5% DLP)	Variation 2 (10% DLP)	Variation 3 (15% DLP)
Appearance	4.2±0.60	4.4±0.66	4.4±0.70	4.3±0.64
Color	4.6±0.66	4.6±0.66	4.6±0.66	4.2±0.87
Flavour	4.1±0.83	3.7±0.64	4.2±0.40	3.8±0.75
Taste	3.6±0.66	4.0±0.77	4.1±0.54	3.5±0.50
Texture	4.1±0.70	3.9±0.94	4.2±0.75	4.1±0.70
Doneness	4.5±0.67	4.6±0.49	4.7±0.46	4.6±0.49
Overall acceptability	25.1±0.35	25.2±0.38	26.2±0.24	24.5±0.39

DLP –Drumstick Leaves Powder

Adai prepared from standard mix and variations I,II and III showed that in terms of appearance, variation I and II incorporated with 10 per cent and 15 per cent drumstick leaves powder respectively scored best with a mean score of 4.4.colour,as a criteria is essential for acceptability .In terms of colour, variation I,II and standard had a maximum score of 4.6.The scores obtained for flavor in adai ranged from 3.7 to 4.2,the maximum obtained by

variation II .Taste as an attribute contribute scores from 3.6 to 4.1and maximum being in variation 2 With regard to texture and doneness, variation 2 showed best result with a mean score of 4.2 and 4.7 respectively.

In terms of scores obtained for overall acceptability, variation II obtained 26.2 ± 0.24 scores followed by standard 25.1 ± 0.35 , variation I with 25.2 ± 0.28 and variation III with 24.5 ± 0.39 .

Kowsalya and Indra (2010) found that the sensory attributes of the recipes prepared with the addition of developed nutritious mix showed that adai was accepted at the level of 7.5 per cent amaranthus incorporation.

These results prove that among the adai recipe from standard, variationI, variationII and variationIII, adai prepared using variation II scored best when compared to other mixes.

LADDU

Table IV presents the organoleptic evaluation of laddu prepared with the functional food mixes.

TABLE -IV
ORGANOLEPTIC EVALUATION OF LADDU PREPARED WITH RAGI
BASED FUNCTIONAL FOOD MIXES

Criteria	Standard	Variation 1 (5%DLP)	Variation 2 (10%DLP)	Variation 3 (15% DLP)
Appearance	4.6 ± 0.50	4.3 ± 0.47	4.3 ± 0.50	4.3 ± 0.61
Color	4.4 ± 0.81	4.1 ± 0.71	4.1 ± 0.71	4.1 ± 0.84
Flavor	4.5 ± 0.51	4.1 ± 0.55	4.2 ± 0.41	3.7 ± 0.79
Taste	3.9 ± 0.55	4.3 ± 0.65	4.4 ± 0.67	3.7 ± 0.79
Texture	4.6 ± 0.50	4.5 ± 0.51	4.5 ± 0.51	4.5 ± 0.51
Doneness	4.6 ± 0.67	4.5 ± 0.68	4.5 ± 0.68	4.5 ± 0.68
Overall acceptability	26.6 ± 0.27	25.5 ± 0.18	25.5 ± 0.16	25.5 ± 0.36

Laddu prepared from standard mix and variations I,II and III showed that in terms of appearance, standard mix respectively scored best with a mean score of 4.6. Colour,as a criteria is essential for acceptability .In terms of colour, standard had a maximum score of 4.4.The scores obtained for flavor in laddu ranged from 3.7 to 4.5, the maximum obtained by standard.Taste as an attribute contribute scores from 3.7 to 4.4 and maximum being in variation 2 With regard to texture and doneness, standard showed best result with a mean score of 4.6 respectively.

In terms of scores obtained for overall acceptability, standard obtained 26.6 ± 0.27 scores followed by variation I with 25.5 ± 0.18 scores, variation II with 25.5 ± 0.16 scores, variation III with 25.5 ± 0.36 scores.

Englen (2007) found that the total protein concentration of foods and salivary amylase activity strongly correlate with the texture perception of food.

The Table revealed that the total score of standard made with ragi based functional food was organoleptically more accepted than the other variation.

PUTTU

Table V presents the organoleptic evaluation of puttu prepared with the functional food mixes.

TABLE -V**ORGANOLEPTIC EVALUATION OF PUTTU PREPARED WITH RAGI
BASED FUNCTIONAL FOOD MIXES**

Criteria	Standard	Variation 1 (5%DLP)	Variation 2 (10% DLP)	Variation 3 (15% DLP)
Appearance	4.6±0.50	4.5±0.68	4.6±0.50	4.1±1.06
Color	5±0	5±0	5±0	5±0
Flavor	4.4±0.50	4.2±0.61	4.5±0.51	4.1±1.06
Taste	4.5±0.51	4±0.64	4.7±0.47	3.6±0.93
Texture	4.7±0.47	4.4±0.50	4.4±0.50	4.2±0.61
Doneness	5±0	4.9±0.31	4.9±0.31	4.9±0.31
Overall acceptability	28.2±0.25	27±0.39	28.1±0.23	25.9±0.53

Puttu prepared from standard mix and variations I,II and III showed that in terms of appearance, standard mix and variation II respectively scored best with a mean score of 4.6. Colour, as a criteria is essential for acceptability .In terms of colour, standard and three variations got a high score of 5.The scores obtained for flavor in puttu ranged from 4.1 to 4.5, the maximum obtained for variation II. Taste as an attribute contribute scores from 3.6 to 4.7 and maximum being in variation II, with regard to texture and doneness, standard showed best result with a mean score of 4.7 and 5 respectively.

In terms of scores obtained for overall acceptability, standard obtained 28.2±0.25 scores followed by variation I with 27 ±0.39 scores, variation II with 28.1±0.23 scores, variation III with 25.9±0.53 scores.

The above table revealed that the total score of standard made with ragi based functional food was organoleptically more accepted than the other variation.

SEVAI

Table VI presents the organoleptic evaluation of sevai prepared with the functional food mixes

TABLE -VI
ORGANOLEPTIC EVALUATION OF SEVAI PREPARED WITH RAGI
BASED FUNCTIONAL FOOD MIXES

Criteria	Standard	Variation 1 5% DLP	Variation 2 10% DLP	Variation 3 15% DLP
Appearance	4.5±0.68	4.6±0.67	4.5±0.68	4.5±0.68
Color	4.8±0.61	4.8±0.61	4.8±0.61	4.8±0.61
Flavor	4.7±0.47	4.8±0.41	4.8±0.41	4.8±0.41
Taste	4.4±0.67	4.1±0.84	4.5±0.94	4.1±0.96
Texture	4.5±0.51	4.3±0.47	4.6±0.50	4.5±0.51
Doneness	4.8±0.41	4.7±0.47	4.8±0.41	4.7±0.47
Overall acceptability	27.7±0.17	27.3±0.29	28±0.15	27.4±0.27

Sevai prepared from standard mix and variations I,II and III showed that in terms of appearance, variation I respectively scored best with a mean score of 4.6. Colour, as a criteria is essential for acceptability .In terms of colour, standard and three variations got a maximum score of 4.8.The scores obtained for flavor in sevai ranged from 4.7 to 4.8, the maximum obtained for all the three variations. Tastes as an attribute contribute scores from 4.1 to 4.5 and maximum being in variation II. With regard to texture, variation II showed best result with a mean score of 4.6. With regard to doneness, standard and variation II should best result with a mean score of 4.8.

In terms of scores obtained for overall acceptability, standard obtained 27.7±0.17 scores followed by variation I with 27.3 ± 0.29 scores, variation II with 28.0±0.15 scores and variation III with 27.4±0.27scores.

The table reveals that the total score of variation II made with ragi based functional food mix was organoleptically more accepted than the other variation.

ADAI

Table VII presents the organoleptic evaluation of adai prepared with the functional food mixes

TABLE -VII
ORGANOLEPTIC EVALUATION OF ADAI PREPARED WITH JOWAR
BASED FUNCTIONAL FOOD MIXES

Criteria	Standard	Variation 1 5% DLP	Variation 2 10% DLP	Variation 3 15% DLP
Appearance	4.4±0.50	4.2±0.41	4.4±0.50	4.2±0.61
Color	4.1±0.8	4.1±0.84	4.1±0.84	4.1±0.84
Flavor	4.3±0.47	3.8±0.76	3.9±0.55	3.8±0.76
Taste	4.1±0.71	3.8±0.76	4.1±0.84	3.5±0.51
Texture	4.1±0.71	3.9±0.96	4.2±0.76	4.1±0.71
Doneness	4.5±0.68	4.7±0.47	4.8±0.41	4.8±0.41
Overall acceptability	25.5±0.18	24.5±0.34	25.5±0.31	24.5±0.4

Adai prepared from standard mix and variations I,II and III showed that in terms of appearance, standard and variation II respectively scored best with a mean score of 4.4. Colour,as a criteria is essential for acceptability .In terms of colour , standard and three variations had a maximum score of 4.1.The scores obtained for flavor in adai ranged from 3.8 to 4.3,the maximum obtained for standard. Taste as an attribute contribute scores from 3.5 to 4.1 and maximum being in standard and variation 2. With regard to texture and doneness, variation 2 showed best result with a mean score of 4.2 and 4.8 respectively.

In terms of scores obtained for overall acceptability, variation II obtained 25.5±0.31 scores followed by standard with 25.5±0.18, variation I with 24.5±0.34 and variation III with 24.5±0.4 scores.

Antioxidant rich food mixes with drumstick leaves powder, carrot powder, and mango powder along with wheat flour, wheat germ, roasted Bengal gram flour, soya flour and amla powder were found to be acceptable and rich in nutrient content especially micronutrients and antioxidants (Kowsalya *et al.*, 2006).

The Table revealed that the total score of standard and variation 2 made with jowar based functional food mix was organoleptically more than the other variation.

LADDU

Table VIII presents the organoleptic evaluation of laddu prepared with the functional food mixes

TABLE -VIII

**ORGANOLEPTIC EVALUATION OF LADDU PREPARED WITH JOWAR
BASED FUNCTIONAL FOOD MIXES**

Criteria	Standard	Variation 1 (5% DLP)	Variation 2 (10% DLP)	Variation 3 (15% DLP)
Appearance	4.5±0.51	4±0.64	4±0.91	3.8±0.61
Color	4.5±0.68	3.9±0.71	4.3±0.79	3.8±0.76
Flavor	4.6±0.67	4.1±0.71	4.2±0.61	3.7±0.65
Taste	4.6±0.50	4.3±0.47	4.3±0.47	3.7±0.65
Texture	4.8±0.61	4.7±0.65	4.7±0.65	4.7±0.65
Doneness	5.0±0	4.9±0.31	4.9±0.31	4.8±0.61
Overall acceptability	28±0.20	25.9±0.40	26.4±0.33	25.5±0.52

Laddu prepared from standard mix and variations I, II and III showed that in terms of appearance, standard mix scored best with a mean score of 4.5. Colour, as a criteria is essential for acceptability .In terms of colour, standard had a maximum score of 4.5.The scores obtained for flavor in laddu ranged from 3.7 to 4.6, the maximum obtained by standard. Taste as an attribute contribute scores from 3.7 to 4.6 and maximum being in standard, With regard to texture and doneness, standard should best result with a mean score of 4.8 and 5.0 respectively.

In terms of scores obtained for overall acceptability, standard obtained 28.0 ± 0.20 scores followed by variation I with 25.9 ± 0.40 scores, variation II with 26.4 ± 0.33 scores and variation III with 25.5 ± 0.52 scores.

The table reveals that the total score of standard made with jowar based functional food mix was organoleptically more accepted than the other variations.

PUTTU

Table IX presents the organoleptic evaluation of puttu prepared with the functional food mixes

TABLE -IX**ORGANOLEPTIC EVALUATION OF PUTTU PREPARED WITH JOWAR
BASED FUNCTIONAL FOOD MIXES**

Criteria	Standard	Variation 1 (5% DLP)	Variation 2 (10% DLP)	Variation 3 (15% DLP)
Appearance	4.8±0.41	4.6±0.50	4.7±0.47	4.7±0.47
Color	4.5±0.68	4.1±0.84	4.7±0.65	4.5±0.51
Flavor	4.9±0.31	4.8±0.41	4.8±0.61	4.8±0.61
Taste	4.6±0.50	4.7±0.47	4.3±0.92	4.5±0.82
Texture	4.5±0.51	5.0±0	4.9±0.31	4.8±0.41
Doneness	5.0±0	5.0±0	4.9±0.31	4.9±0.31
Total	28.30±0.21	28.2±0.33	28.3±0.22	28.2±0.17

Puttu prepared from standard mix and variations I,II and III showed that in terms of appearance, standard mix scored best with a mean score of 4.8. Colour, as a criteria is essential for acceptability. In terms of colour, variations II got a maximum score of 4.7. The scores obtained for flavor in puttu ranged from 4.8 to 4.9, the maximum score obtained by standard. Taste as an attribute contribute scores from 4.3 to 4.7 and maximum being in variation I, with regard to texture, variation I got a high mean score of 5. with regard to doneness, standard and variation I got a high mean score of 5 respectively.

In terms of scores obtained for overall acceptability, standard obtained 28.30±0.21 scores followed by variation I with 28.2 ±0.33 scores, variation II with 28.3±0.22 scores and variation III with 28.2±0.17 scores.

The above table revealed that the total score of standard and variation II made with jowar based functional food mix was organoleptically more than the other variation.

SEVAI

Table X presents the organoleptic evaluation of sevai prepared with the functional food mixes

TABLE -X

ORGANOLEPTIC EVALUATION OF SEVAI PREPARED WITH JOWAR BASED FUNCTIONAL FOOD MIXES

Criteria	Standard	Variation 1 (5% DLP)	Variation 2 (10% DLP)	Variation 3 (15% DLP)
Appearance	4.8±0.41	4.7±0.65	4.6±0.67	4.4±0.93
Color	5.0±0	4.8±0.61	4.8±0.61	4.8±0.61
Flavor	4.8±0.41	4.7±0.47	4.8±0.41	4.6±0.50
Taste	4.5±0.51	4.4±0.67	4.7±0.65	4.0±0.64
Texture	4.7±0.47	4.5±0.68	4.5±0.68	4.4±0.64
Doneness	4.9±0.31	4.8±0.41	4.8±0.41	4.9±0.31
Overall acceptability	28.7±0.17	27.9±0.16	28.2±0.13	27.5±0.22

Sevai prepared from standard mix and variations I,II and III showed that in terms of appearance, standard scored best with a mean score of 4.8. Colour, as a criteria is essential for acceptability .In terms of colour, standard got a high score of 5.The scores obtained for flavor in sevai ranged from 4.6 to 4.8, the maximum score obtained by standard and variation II. Taste as an attribute contribute scores from 4.0 to 4.7 and maximum being in variation II, With regard to texture, standard showed the best result with a mean score of 4.7.with regard to doneness, standard and variation II showed best result with a meanscoreof4.9.

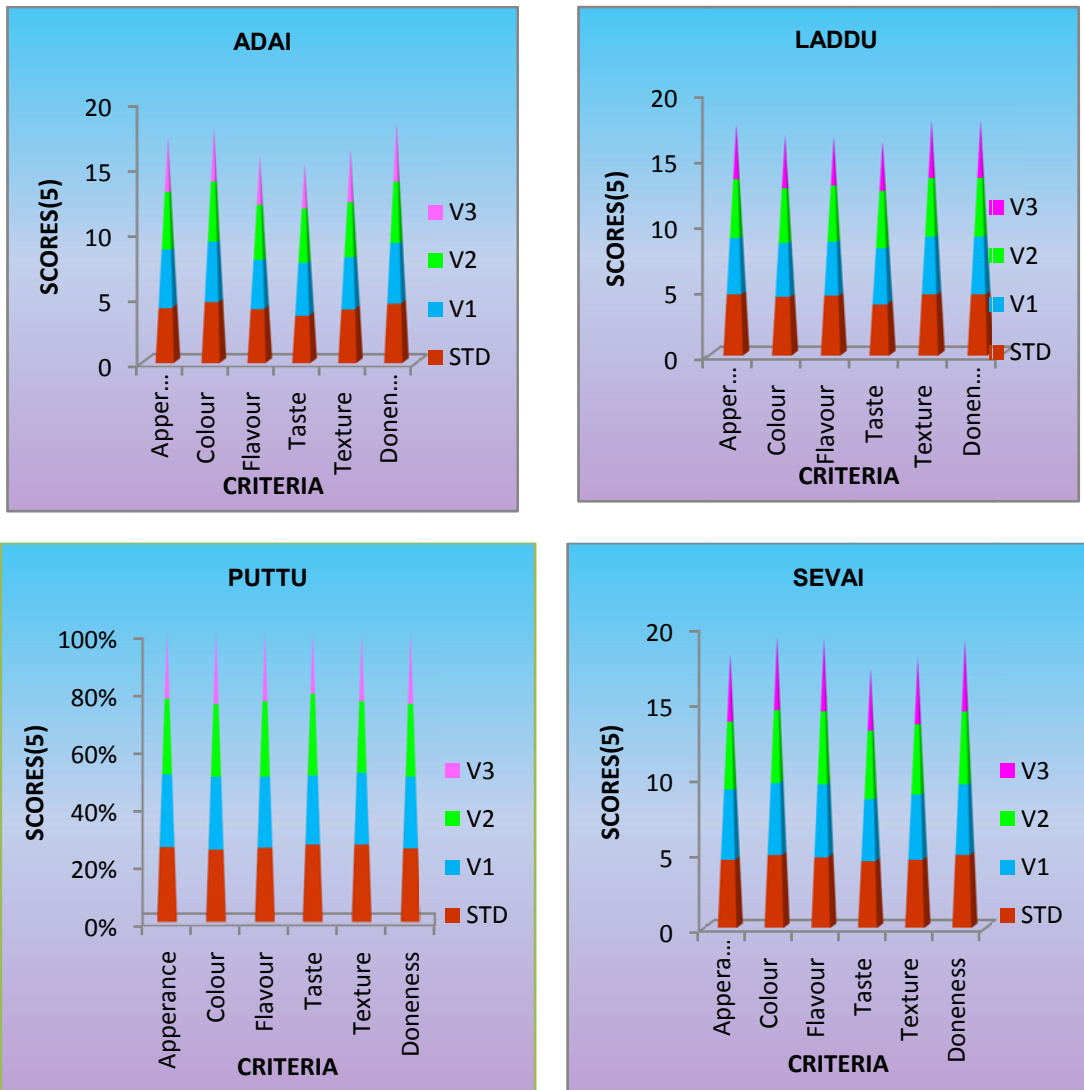
In terms of scores obtained for overall acceptability, standard obtained 28.7 ± 0.17 scores followed by variation I with 27.9 ± 0.16 , variation II with 28.2 ± 0.13 and variation III with 27.5 ± 0.22 scores.

The table reveals that the total score of standard made with jowar based functional food mix was organoleptically accepted than the other variation.

The overall acceptability of all the recipes prepared with the developed functional food mixes using ragi and jowar showed that they were acceptable. The adai prepared using ragi and jowar mixes showed that the highest score was given to ragi adai prepared with variation 2 by all the members. Then the scores for laddu prepared using two mixes showed that the highest score was given to jowar laddu standard by all the members. The ragi and jowar based puttu when compared showed jowar puttu standard and variation II that puttu ranked higher scores compared to other variations. Regarding sevai, ragi and jowar based sevai standard ranked best compared to other variations.

Organoleptic evaluation of recipes prepared with functional food mixes using ragi and jowar is represented in Figures 3 and 4.

Overall acceptability of recipes prepared with ragi and jowar is represented in figures 5 and 6



Standard-Functional food mix

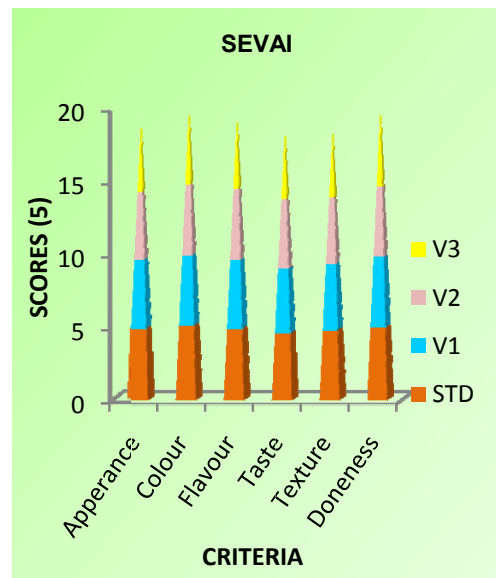
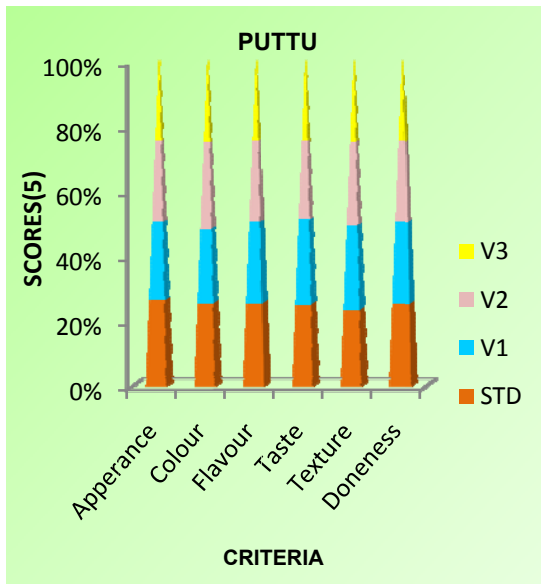
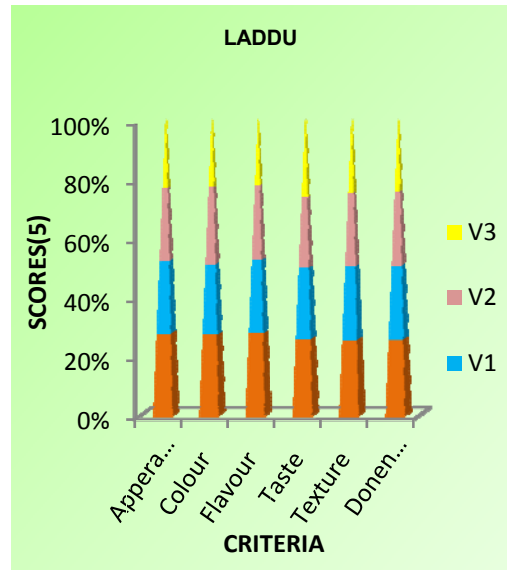
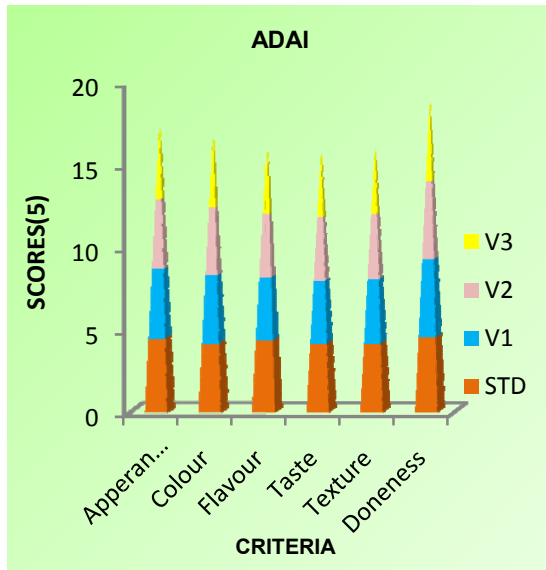
V2 - 10% DLP

V1 -5% DLP

V3 - 15%DLP

FIGURE 3

ORGANOLEPTIC EVALUATION OF RECIPES PREPARED WITH FUNCTIONAL FOOD MIXES USING RAGI



Standard-Functional food mix

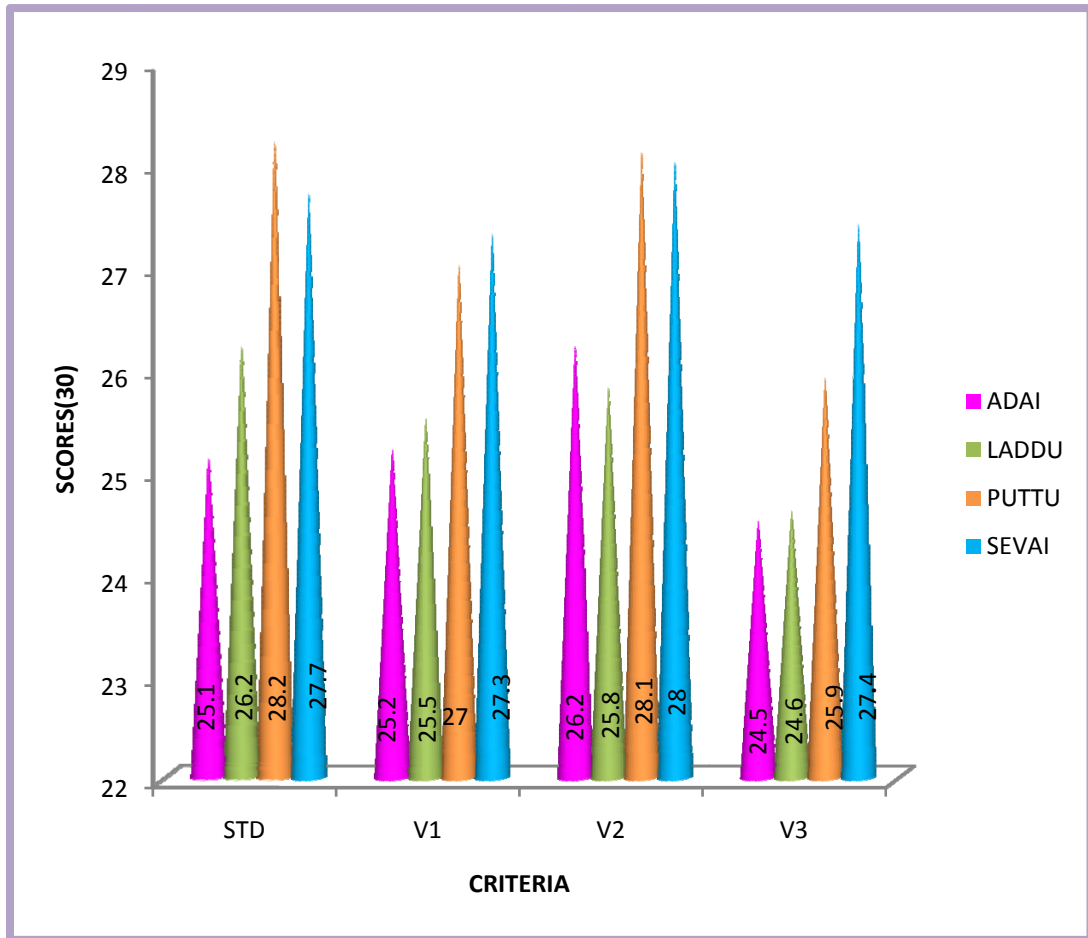
V2 - 10% DLP

V1 -5% DLP

V3 - 15%DLP

FIGURE 4

ORGANOLEPTIC EVALUATION OF RECIPES PREPARED WITH FUNCTIONAL FOOD MIXES USING JOWAR



Standard - Functional food mix

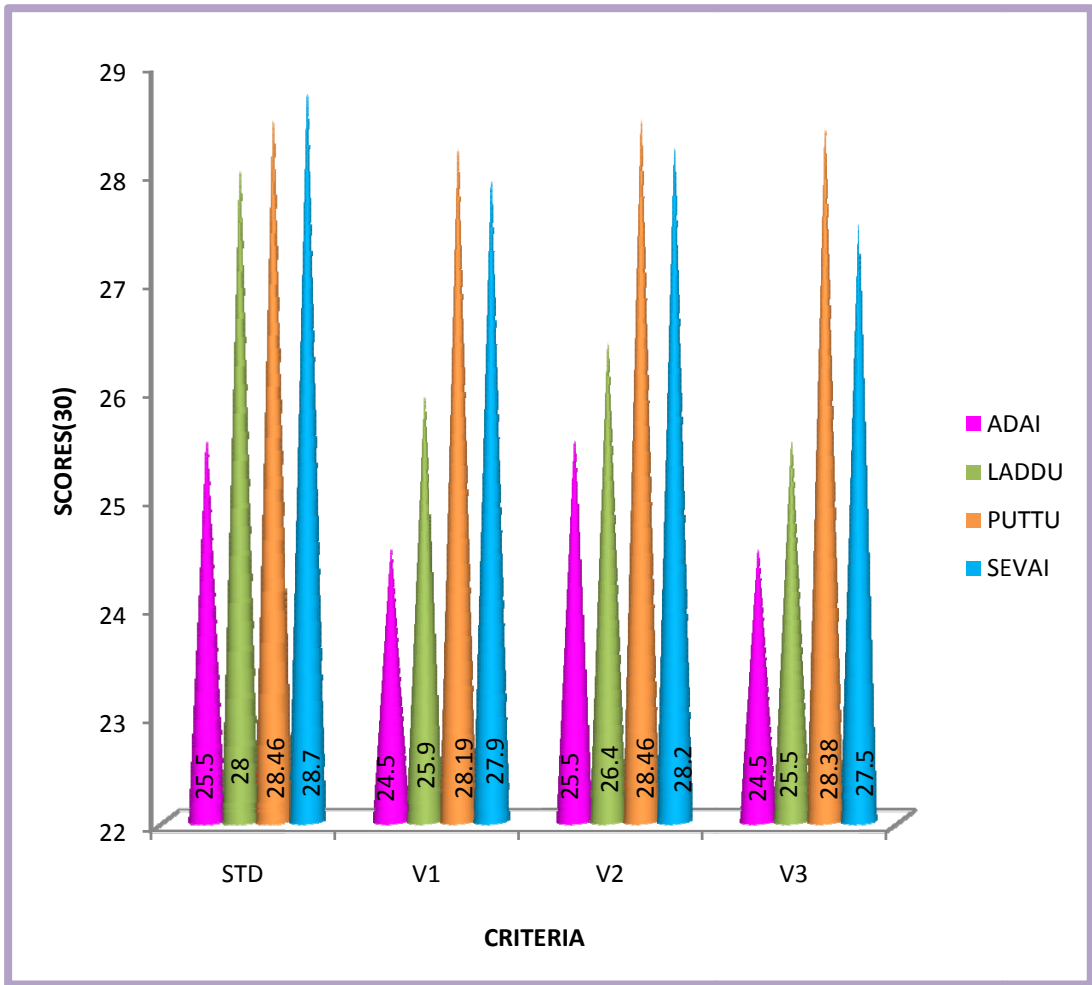
V1 - 5% DLP

V2 - 10% DLP

V3 - 15% DLP

FIGURE 5

OVERALL ACCEPTABILITY OF RECIPES PREPARED WITH FUNCTIONAL FOOD MIXES USING RAGI



Standard-Functional food mix

V1 -5% DLP

V2 - 10% DLP

V3 - 15%DLP

FIGURE 6

**OVERALL ACCEPTABILITY OF RECIPES PREPARED WITH
FUNCTIONAL FOOD MIXES USING JOWAR**

B.NUTRIENT CONTENT OF MOST ACCEPTED FUNCTIONAL FOOD MIXES

The preparation and processing of foods vary which intrude in the nutrient content and its availability .The nutrient content of the accepted products are presented dicussed under the following headings.

Table XI gives the proximate principles of the best accepted functional food mixes g/100g.

TABLE-XI
PROXIMATE COMPOSITION OF MOST ACCEPTED FUNCTIONAL FOOD MIXES

Criteria	Ragi based functional food mixes		Jowar based functional food mixes	
	Standard	Variation 2 (10% DLP)	Standard	Variation 2 (10% DLP)
Proximate composition				
Ash(g)	10	5	8	4
Moisture(g)	10	5	5	5
Energy(k cal)	370.4	371.8	409	406.2
Carbohydrate(g)	62	50	58	46
Protein(g)	8.1	9.2	10.5	10.7
Fat(g)	4	6	6	8
Crude fibre(g)	4	2.2	2	2
Vitamin and mineral composition				
β carotene(mcg)	4250	7750	5000	10000
Calcium(mg)	225.6	244	188	206
Iron(mg)	12.5	11.5	7.5	10.5
Phosphorus(mg)	240	360	260	320
Vitamin C(mg)	0	22.8	0	18.8

Standard –functional food mix without drumstick leaves powder

Variation 2-10 per cent incorporation of drumstick leaves powder

The analysis of proximate composition reveals that the ash content ranged from 4 to 10g/100g of mix, with the highest moisture content 10g/100g mix for standard ragi based functional food mix. The moisture content ranged from 5 to 10g/100g with the highest moisture content of 10g/100g mix for standard ragi based functional food mix. This was within the permitted levels prescribed by CFTRI.

The energy content ranged from 370- 409 k cal/100g with the highest energy content 409k cal/100g mix for standard jowar based functional food mix.

The carbohydrate content of ragi and jowar based functional food mix standard and 10 per cent incorporation of drumstick leaves powder were 62,58g/100g mix and 50,46g/100g respectively. The protein content ragi and jowar based functional food mix standard and 10 per cent incorporation of drumstick leaves powder drumstick were 8.1,10.5g/100g and 9.2,10.7g/100g mix respectively.

The fat content ranged from 4 to 8g/100g mix with the highest fat content 8g /100g mix for jowar based functional food mix incorporated with 10 per cent drumstick leaves powder. The crude fibre content of ragi and jowar based standard mix and incorporation with 10 per cent drumstick leaves powder were 4, 2g/100g mix and 2.2, 2g/100g mix respectively.

Vitamin and mineral composition

Green leafy vegetables are very rich sources of carotene, they are good sources of calcium, riboflavin, folic acid and vitamin C. Daily consumption of 100 g of leafy vegetables by adult and 50 g by children will provide the daily requirement of carotene, folic acid ,vitamin C. a part of the calcium and riboflavin requirements. They are the cheapest among the protective foods (Swaminathan *et al.*, 2008).

From the above table, it is evident that β carotene values were more for drumstick leaves incorporated functional food mix. Also, calcium, iron, phosphorus and vitamin C values were better than the rest of the functional food mixes.

The beta carotene values of ragi and jowar based standard mix were 4250,5000 mcg /100g and variation II with 10 per cent incorporation of drumstick leaves powder 7750,10000 mcg/100g respectively. The calcium values of ragi and jowar based standard mix and variation II with 10 per cent incorporation of drumstick leaves powder were 225.6,188g/100g and 244,206g/100g mix respectively.

The iron content ranged from 7.5 to 12.5 mg /100g of mix, ragi and jowar based standard mix were 12.5,7.5mg/100g of mix and variation II with 10 per cent incorporation of drumstick leaves powder were 11.5, 10.5 mg/100g of mix respectively. The phosphorus values of ragi and jowar based standard mix were 240,260 mg /100g of mix and variation II with 10 per cent incorporation of drumstick leaves powder the values were 360 and 320 mg/100g respectively.

The vitamin C content ranged from 18.8 to 22.8 mg /100g. Vitamin C contributed by ragi and jowar based functional food mix with 10 per cent incorporation of drumstick leaves powder.

The proximate composition of the most accepted products are shown in the figure 7. The vitamin and mineral content of the best accepted products are shown in Figure 8. Nutrient analysis of most accepted functional food mixes is represented in plate 4.

CALCIUM PRECIPITATION



BETA CAROTENE EXTRACTION



VITAMIN C TITRATION



IRON ESTIMATION



PLATE 4

NUTRIENT ANALYSIS

ASHING IN MUFFLE FURNACE



NITROGEN ESTIMATION



FAT ANALYSIS

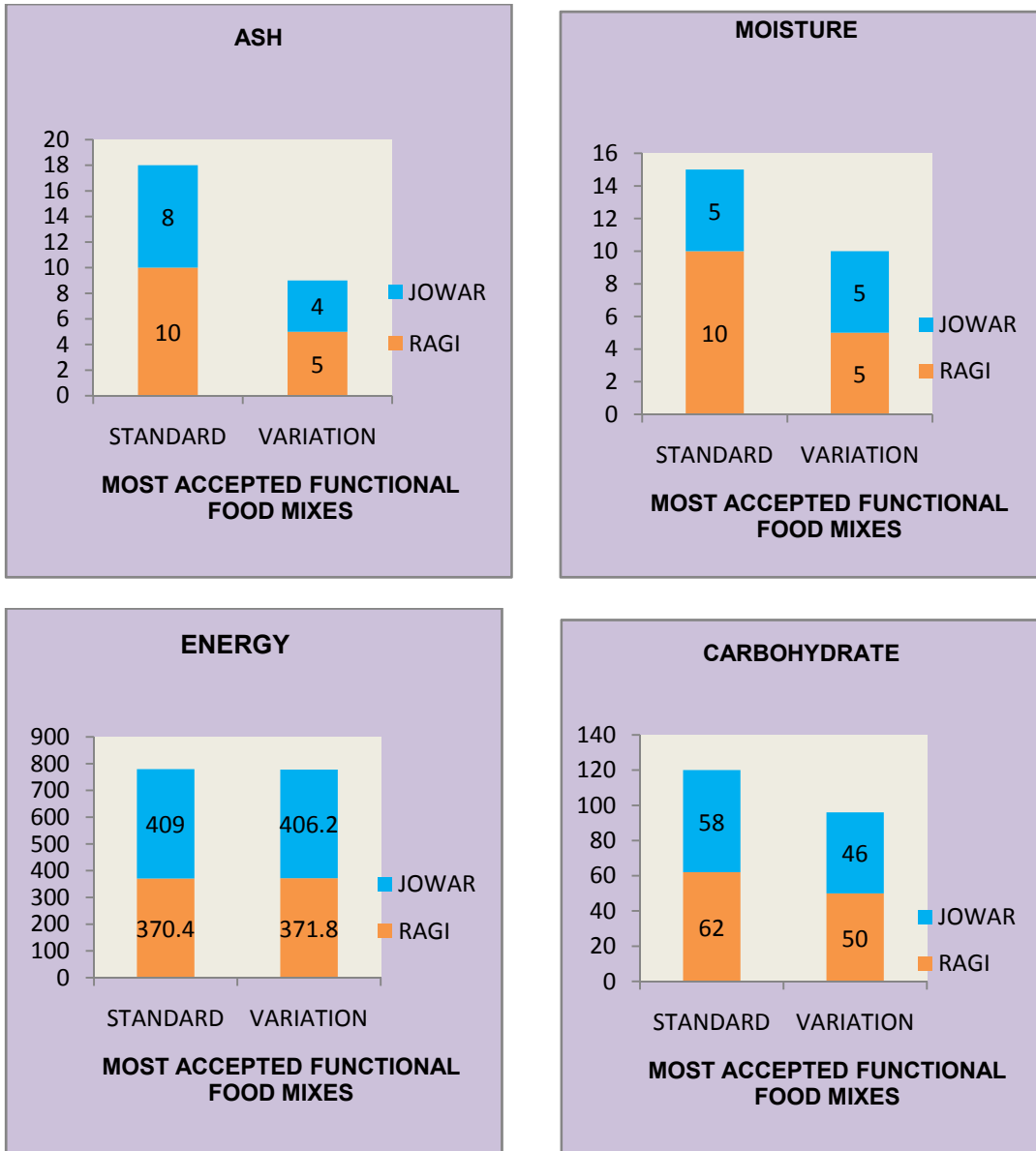


PHOSPHORUS ESTIMATION



PLATE 4

NUTRIENT ANALYSIS

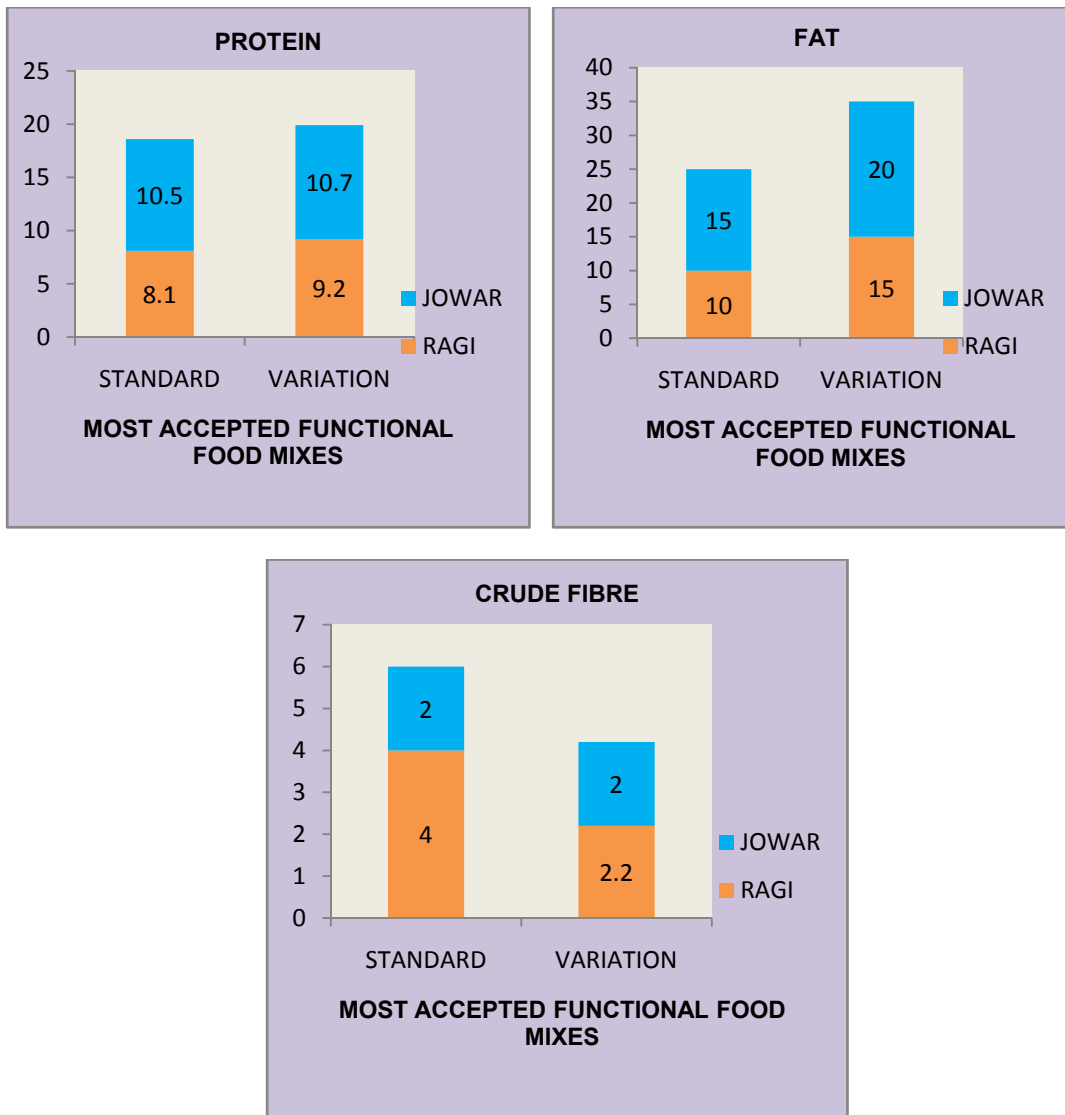


Standard- functional food mix

V2-10% DLP

FIGURE 7

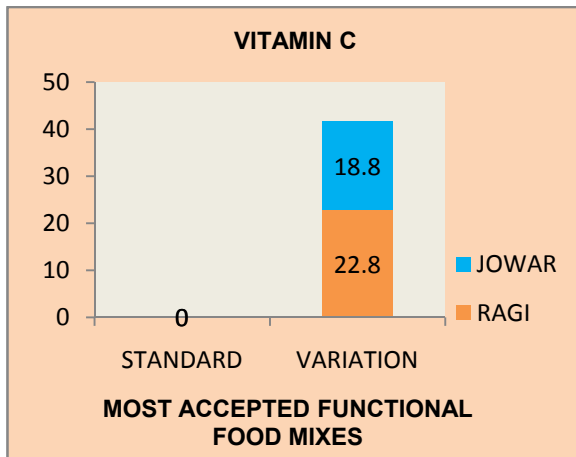
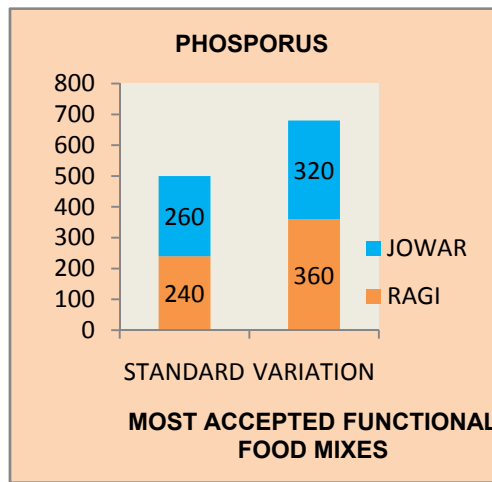
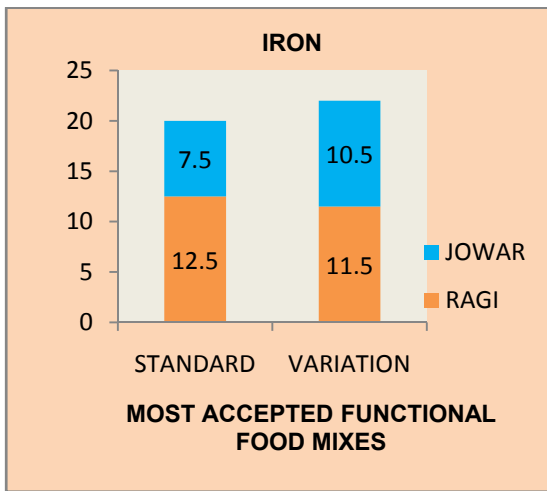
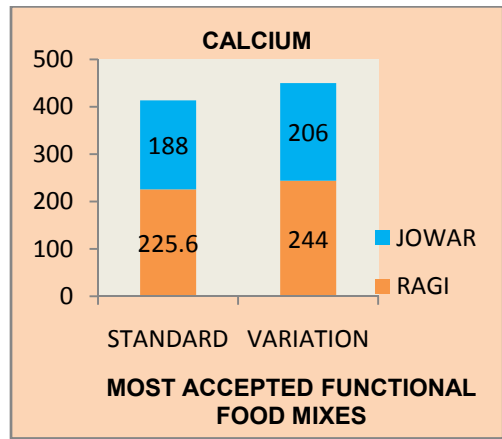
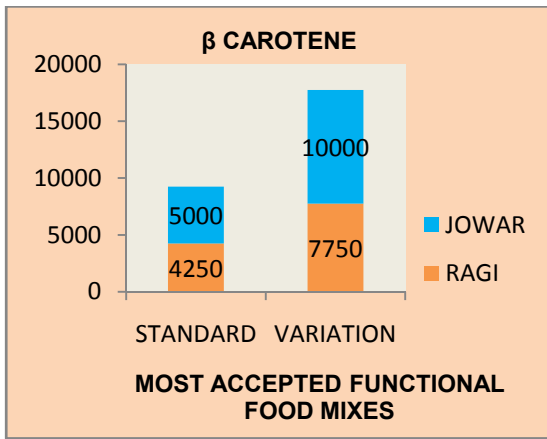
PROXIMATE COMPOSITION OF THE MOST ACCEPTED PRODUCTS PREPARED FROM FUNCTIONAL FOOD MIXES



Standard- functional food mix **V2-10% DLP**

FIGURE 7

**PROXIMATE COMPOSITION OF THE MOST ACCEPTED PRODUCTS
PREPARED FROM FUNCTIONAL FOOD MIXES**



Standard- functional food mix V2-10% DLP

FIGURE 8

VITAMINS AND MINERALS COMPOSITION OF THE MOST ACCEPTED PRODUCTS PREPARED FROM FUNCTIONAL FOOD MIXES

C. COST ANALYSIS OF MOST ACCEPTED FUNCTIONAL FOOD MIXES

Table XII reveals the data for cost calculation of the most accepted ragi based functional food mixes incorporated with 10 per cent incorporation of drumstick leaves powder.

TABLE-XII
COST CALCULATION OF RAGI BASED FUNCTIONAL FOOD MIXES

S.NO	Raw materials	Weight (g)	Amount (Rs)	Weight (g)	Amount (Rs)
1.	Ragi	450	20.50	45	2
2	Green gram whole	250	25.00	25	2
3	Roasted bengal gram	100	8.00	10	1
4	Ground nut	100	11	10	1
5	Drumstick leaves powder	100	50.00	10	5
	TOTAL	1000g (1Kg)	R.s 114.50	100 g	R.s 11.50

From the above table, it was found that the cost of ragi based functional food formulation was Rs 11.50 per 100g.

Table XIII reveals the data for cost calculation of the most accepted jowar based functional food mixes incorporated with 10 per cent incorporation of drumstick leaves powder.

TABLE-XIII

**COST CALCULATION OF JOWAR BASED FUNCTIONAL FOOD
MIXES**

S.NO	Raw materials	Weight (g)	Amount (Rs)	Weight (g)	Amount (Rs)
1.	Jowar	450	13.50	45	1
2	Green gram whole	250	25.00	25	2
3	Roasted bengal gram	100	8.00	10	1
4	Ground nut	100	11	10	1
5	Drumstick leaves powder	100	50.00	10	5
	TOTAL	1000g (1Kg)	R.s 107.50	100 g	R.s 10.50

From the above table, it was found that the cost of jowar based functional food formulation was Rs 10.50 per 100g.

Tables XII and XIII depicts that the formulation of ragi and jowar based functional food mixes developed in the present study were economically feasible to all categories of people since it included ingredients from the basic five food groups. The incorporation of green leafy vegetables namely drumstick leaves provided richness in terms of variety, taste, colour and nutrient content. Thus the study proved that the formulation is not only economical but also rich in nutrient content.

From the foregoing results, it may be revealed that it was feasible to prepare functional food mixes based on ragi and jowar .The organoleptic evaluation of the recipes prepared from the developed functional food mixes showed that all the recipes namely adai, laddu, puttu and sevai were acceptable in terms of appearance, colour, flavour, taste, texture and doneness. All the four recipes were most acceptable using the variation II

incorporated with drumstick leaves powder at 10 per cent level. Further analysis of the ragi and jowar based functional food mixes variation II when analysed for nutrient content, were found to be rich sources of macro and micro nutrients. Further studies may be conducted on shelf life and phytochemical constituents

V SUMMARY AND CONCLUSION

The term functional food was first introduced in Japan in 1980's which refers to processed foods containing ingredients that aid specific body functions in addition to being nutritious. In recent years, cereals and its ingredients are accepted as functional foods and nutraceuticals because of providing dietary fibre, proteins, energy, minerals, vitamins and antioxidants required for human health. Functional properties of foods and food products decide the application of foods in different physiological state. Though India has attained food security and is the largest producer of grains, vegetables, the post harvest losses occurring are uncountable. The loss of vegetables are 30-40 per cent in different stages that is from harvesting to processing. The loss of food can be diverted for the production of processed foods rich in macronutrients and micronutrients in the form of functional food mixes. The underutilized millets like ragi and jowar are used to formulate functional food mixes as a solution to the problems related to malnutrition.

With this background, the present study entitled "**Development and Evaluation of Functional Food Mixes Using Ragi and Jowar**" was undertaken. The objectives of the study are to develop functional food mixes using ragi and jowar and evaluate its acceptability and nutrient content. The ingredients used for the formulation of functional food mixes were ragi, mung bean, roasted Bengal gram and peanuts in the ratio of 55:25: 10:10 as standard formulation. Instead of ragi, jowar was used to prepare another formulation in the same ratio. Apart from the standard mix, three combinations of ragi and jowar mixes made by incorporation of dehydrated drumstick leaves powder at 5, 10 and 15 per cent levels. These variations (I, II, III) and the standard mixes were used to prepare the various products like laddu, uthiri puttu, adai and sevai.

The organoleptic evaluation of the recipes prepared with functional food mixes was carried out by semi-trained panel members. Using a five point numerical score card, sensory evaluation was done. The score card of the scale ranged from a maximum score of 5 to a minimum score of 1 for each recipe. The criteria evaluated for each recipe was appearance, colour, flavor, taste, texture and doneness. Results of the organoleptic evaluation of the

recipes prepared from ragi and jowar based formulations proved that variation II incorporated with 10 per cent level of drumstick leaves powder was most acceptable. Hence the formulation was chosen for nutrient analysis using standard AOAC procedures.

The salient findings of the study are:

- The organoleptic evaluation of adai prepared from ragi based mix for overall acceptability showed that variation II obtained a mean score of 26.2 ± 0.2 followed by standard (25.1 ± 0.35), variation I with 25.2 ± 0.28 scores and variation III with 24.5 ± 0.39 scores.
- The organoleptic evaluation of recipe laddu prepared from ragi based standard mix and variations I, II and III showed that in terms of scores obtained for overall acceptability, standard obtained 26.6 ± 0.27 scores followed by variation I with 25.5 ± 0.18 scores, variation II with 25.5 ± 0.16 scores and variation III with 25.5 ± 0.36 scores.
- The organoleptic evaluation of recipe puttu prepared from ragi based standard mix and variations I, II and III showed that in terms of scores obtained for overall acceptability, standard obtained 28.2 ± 0.25 scores followed by variation I with 27 ± 0.39 scores, variation II with 28.1 ± 0.23 scores and variation III with 25.9 ± 0.53 scores.
- The organoleptic evaluation of recipe sevai prepared from ragi based standard mix and variations I, II and III showed that in terms of scores obtained for overall acceptability, standard obtained 28.7 ± 0.17 scores followed by variation I with 27.9 ± 0.16 scores, variation II with 28.2 ± 0.13 scores, variation III with 27.5 ± 0.22 scores.
- The organoleptic evaluation of recipe adai prepared from jowar based standard mix and variations I, II and III showed that in terms of scores obtained for overall acceptability, variation II obtained 25.5 ± 0.31 scores followed by standard with 25.5 ± 0.18 scores, variation I with 24.5 ± 0.34 scores and variation III with 24.5 ± 0.4 scores.
- The organoleptic evaluation of recipe laddu prepared from jowar based standard mix and variations I, II and III showed that in terms of scores obtained for overall acceptability, standard recipe obtained 28.0 ± 0.20 scores followed by variation I with 25.9 ± 0.40 scores, variation II with 26.4 ± 0.33 scores and variation III with 25.5 ± 0.52 scores.

- The organoleptic evaluation of puttu prepared from jowar based standard mix and variations I, II and III showed that in terms of scores obtained for overall acceptability, standard recipe obtained 28.30 ± 0.21 scores followed by variation I with 28.2 ± 0.33 scores, variation II with 28.3 ± 0.22 scores and variation III with 28.2 ± 0.17 scores.
- The organoleptic evaluation of recipe sevai prepared from jowar based standard mix and variations I, II and III showed that in terms of scores obtained for overall acceptability, standard obtained 28.7 ± 0.17 scores followed by variation I with 27.9 ± 0.16 scores, variation II with 28.2 ± 0.13 scores, variation III with 27.5 ± 0.22 scores.
- The results of acceptability trials revealed that recipes prepared using variation II that is incorporated with 10 per cent level of drumstick leaves obtained a maximum score 28.3 when compared to others.
- The analysis of proximate composition reveals that the ash content ranged from 4 to 10g/100g of mix, with the highest moisture content 10g/100g mix for standard ragi based functional food mix. The moisture content ranged from 5 to 10g/100g with the highest moisture content of 10g/100g mix for standard ragi based functional food mix. This was within the permitted levels prescribed by CFTRI.
- The energy content ranged from 370- 409 k cal/100g with the highest energy content 409k cal/100g mix for standard jowar based functional food mix.
- The carbohydrate content of ragi and jowar based functional food mix standard and 10 per cent incorporation of drumstick leaves powder were 62,58g/100g mix and 50,46g/100g respectively. The protein content ragi and jowar based standard mix and variation II with 10 per cent incorporation of drumstick leaves powder were 8.1,10.5g/100g and 9.2,10.7g/100g mix respectively.
- The fat content ranged from 4 to 8g/100g mix with the highest fat content 8g /100g mix for jowar based functional food mix incorporated with 10 per cent drumstick leaves powder. The crude fibre content of ragi and jowar based standard mix and incorporation with 10 per cent drumstick leaves powder were 4, 2g/100g mix and 2.2, 2g/100g mix respectively.

- Beta carotene values were more for the entire drumstick leaves incorporated functional food mix. Also, calcium, iron, phosphorus and vitamin C values were better than the rest of the functional food mixes.
- The beta carotene values of ragi and jowar based standard mix were 4250,5000 mcg /100g and variation II with 10 per cent incorporation of drumstick leaves powder 7750,10000 mcg/100g respectively. The calcium values of ragi and jowar based standard mix and variation II with 10 per cent incorporation of drumstick leaves powder were 225.6, 188g/100g and 244,206g/100g mix respectively.
- The iron content ranged from 7.5 to 12.5 mg /100g of mix, ragi and jowar based standard mix were 12.5,7.5mg/100g of mix and variation II with 10 per cent incorporation of drumstick leaves powder were 11.5,10.5 mg/100g of mix respectively. The phosphorus values of ragi and jowar based standard mix were 240,260 mg /100g of mix and variation II with 10 per cent incorporation of drumstick leaves powder the values were 360 and 320 mg/100g respectively.
- The vitamin C content ranged from 18.8 to 22.8 mg /100g. Vitamin c obtained in ragi and jowar based variation II with 10 per cent incorporation of drumstick leaves powder.
- The cost calculation of the food formulations showed that the cost of ragi based formulations ranged from Rs 100- Rs 115 per kg for variation II. The cost of jowar based formulations ranged from Rs 100 to 107.50 per kg

The salient findings of the study revealed that it was feasible to prepare functional food mixes using ragi and jowar along with other locally available functional ingredients. Standard mix and drumstick leaves powder incorporated variations I , II and III were used to prepare recipes namely adai, laddu, puttu and sevai .Organoleptic evaluation revealed that all the recipes were acceptable especially those prepared from variation II. Nutrient analysis of functional mixes (variation II) incorporated with drumstick leaves powder at 10 per cent level and standard mix revealed that variation II was nutrient dense .In terms of cost, the food mixes were low cost and affordable by families of all socio-economic strata.

The recommendations of the study are:

- Incorporation of underexploited foods in development of functional food mixes
- Studies on phytochemical analysis of the developed functional food mixes
- In vitro availability of micronutrients from the developed formulations
- Shelf life study of the developed functional food formulations

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APPENDIX I

NUMERICAL SCORE CARD

S.NO	SENSORY CHARACTERISTICS	SCORE	VARIATION-1	VARIATION-2	VARIATION-3
1.	APPEARANCE Excellent Very good Good Fair Poor	5 4 3 2 1			
2.	COLOUR Olive green Greenish brown Brownish green Light brown Brown	5 4 3 2 1			
3.	FLAVOUR Like extremely Like moderately Neither like nor dislike Dislike moderately Dislike extremely	5 4 3 2 1			
4.	TASTE Excellent Very good Good Fair Poor	5 4 3 2 1			
5.	TEXTURE Soft Semi soft Wobbly Hard Very hard	5 4 3 2 1			
6.	DONENESS Cooked Partially cooked Over cooked Burned Not cooked properly	5 4 3 2 1			

APPENDIX-II

THE ESTIMATION PROCEDURES FOR NUTRIENT CONTENT

1. Determination of Moisture Content

Aim:

To determine the moisture content of the given food sample and calculate the percentage of moisture content.

Principle:

Estimation of moisture is one of the most often performed determinations in food analysis. Moisture is lost when food is heated not much higher than the temperature of boiling water or by allowing to stand overnight over dehydrating agent or by heating over vacuum.

Apparatus:

Low flat-bottomed dishes, asbestos, analytical balance, weight box, tongs, desiccators and electric oven.

Procedure:

Heated a pair of weighing bottles at 100⁰ c in an oven and labeled A and B. Placed on an asbestos sheet for 2 minutes and then transferred them to a desiccators where they remained for half an hour. Recorded their weights in an analytical balance repeated this procedure till two successive weights obtained were constant (with maximum difference of 0.0002g).

Weighed definite amounts of food materials (2g) in each dish and placed in an electric oven thermostatically controlled at 100- 150⁰c. Heated for a stipulated time (2 hours), cooled in a desiccators for half an hour and weighed. This was also weighed till successive weightings showed no further loss.

Precautions needed:

1. Handle the bottles always with a clean pair of tongs.
2. Always keep the oven closed.
3. Do not expose the bottles to atmospheric air to avoid the change of atmospheric moisture getting in.
4. Check for the appropriate placement of the lid of the desiccator.
5. Avoid placing a dish in a desiccator for more than half an hour.
6. Keep the door of the analytical balance shut.
7. Take care of the food sample for its purity. i.e free from non-edible impurities.

The loss of weight equals the moisture present in the sample. The loss of weight divided by the weight of the original sample multiplied by 100 gives the percentage of moisture.

2. Determination of ash content**Aim:**

To determine the ash content of the given food sample.

Principle:

By continuous heating, the substance gets charred which can be used for the determination of minerals presents.

Apparatus:

Porcelain crucible, Clay pipe triangle, Muffles furnace, Desiccators, Weighing balance, Asbestos sheet.

Procedure:

About 5 g of the sample was weighed accurately into a tarred platinum or porcelain crucible (which had previously been heated to about 600⁰c and cooled). The crucible was then placed on a clay pipe triangle and heated over a low flame till

all the material was completely charred, followed by heated in a muffle furnace for about 3-5 hours at 600⁰c. The crucible was then cooled in a desiccator and weighed.

To ensure completeness of ashing heated in a muffle furnace for half an hour, cooled and weighed. This was repeated till two consecutive weights were the same and ash was almost white or greyish white in colour.

Result:

The ash content of food sample is ----- g of ash contain.

3. Determination of Fibre content

Aim:

To determine the fibre content of the given food sample.

Principle:

The term “crude fibre” ordinarily meant in agriculture and food analysis is the organic residue consisting largely of cellulose, that is left after other carbohydrates and proteins have been removed by successive treatment with boiling acids and alkalis. The crude fibre obtained in this way is not cellulose but contains distinct properties of hemicelluloses, and nitrogenous substances. These however are not sufficient to prevent the results from being reasonably accurate and comparable.

Apparatus:

Weighing balance, Beaker, Glass rod, Funnel, Muslin cloth, Burner and Wire gauze.

Reagents:

1. 0.255N Sulphuric acid: 0.9 ml of Sulphuric acid in 99.1ml water.
2. 0.313N Sodium hydroxide: 0.8g Sodium hydroxide in 99.2ml water.
3. Ether
4. Alcohol

Procedure:

5g of the sample was weighed into a 500ml beaker and 200ml of boiling 0.255N sulphuric acid was added. The mixture was boiled for 30 minutes keeping the volume constant by adding water at frequent intervals (a glass rod inserted in the beaker helps smooth stirring and boiling). At the end of the period, the mixture was filtered through a muslin cloth and the residue was washed with hot water till free from acid. The mixture was then transferred to a beaker containing 200ml of boiling 0.313N sodium hydroxide. After boiling for 30 minutes (keeping the volume constant as before) the mixture was filtered through a muslin cloth. The residue was washed with hot water till free from alkali following by washing with some alcohol and ether. It was then transferred into a crucible, dried overnight at 80-100⁰c and weighed. The crucible was heated in a muffle furnace at 600⁰c for 2-3 hours. Cooled and weighed again. The difference in the weight represents the weight of the fibre.

Results:

100g of sample contains ----- of fibre.

4. Estimation of total carbohydrate by anthrone method**Aim:**

To estimate the amount of total carbohydrate present in the given food sample.

Principle:

Carbohydrates are hydrolyzed into simple sugar using dilute hydrochloric acid. In hot acidic medium glucose is dehydrated to hydroxyl methyl furfural. This compound forms with anthrone, a green colour with an absorption maximum at 630nm.

Reagents:

1. 2.5mIN HCL
2. Anthrone reagents: Dissolved 200mg anthrone in 100ml of ice cold H₂SO₄, prepared fresh before use.

3. Stock standard: dissolved 100mg glucose in 100ml of water.
4. Working standard: 10 ml of stock standard solution is diluted with 100ml distilled water. Stored refrigerated after adding a few drops of toluene.

Procedure:

1. Weigh 100mg of sample into a boiling tube.
2. Hydrolyse by keeping it in boiling water bath. Boiled for 3 hours with 5ml 2.5N HCL and cool to room temperature.
3. Neutralize it with solid sodium carbonate until effervescence ceases.
4. Make up the volume to 100ml and centrifuge. Collect the supernatant and 0.5ml and 1 ml aliquots for analysis. Prepared the standard by taking 0.0, 0.2, 0.4, 0.6, 0.8 and 1ml of the working standard '0' serves as blank.
5. Make up the volume to 1ml in all the tube including the sample tubes by adding distilled water.
6. Then added 4ml of anthrone reagent and heat to 8 minutes in boiling water bath. Cool rapidly and read the green to dark green colour at 630nm.
7. Draw a standard graph by plotting concentration of the standard on the x axis versus absorbance on the y axis. From the graph calculate the amount of carbohydrates present in the sample tube.

Result:

Amount of carbohydrate present in 100ml of the food sample is

5. Estimation of Nitrogen

Aim:

To determine the amount of nitrogen present in the given sample.

Principle:

The given sample is digested with concentrated sulphuric acid in a macrokjeldahl flask when nitrogen gets converted to ammonium sulphate. Ammonia is liberated by the action of strong alkali in a macrokjeldahl steam distillation apparatus. This nitrogenous substance is converted to ammonium

borate by absorbing 2% boric acid is titrated against N 70 sulphuric acid. The volume of acid required to bring the test sample to the colour of the blank of the blank gives the equivalent to the ammonia.

Reagents:

1. N/70 Sulphuric acid
2. 40% Sodium Hydroxide
3. 2% Boric acid(in warm water)
4. Digestion mixture: A mixture of copper sulphate and potassium sulphate in the ratio of 2:98
5. Concentrated Sulphuric acid
6. Mozazaga indicator: A mixture of bromocresol green and methyl red indicator in 95% alcohol in the ratio of 4:1 (80 mg and 20 mg in 100 ml of alcohol).

Procedure:

1. 0.5 g of the sample was taken into the digestion flask. To this added 15ml of concentrated sulphuric acid and a pinch of digestion as a catalyst. Kept at boiling gently over a heating mantle.
2. After digestion, the flask was cooled and the contents were transferred to a 100ml of standard flask and made upto the mark with distilled water.
3. The whole apparatus was washed with distilled water and allowed to back suck.
4. 10ml of boric acid was taken in a conical flask. A drop of indicator was added to it and kept under the condenser.
5. The tip of the condensor was well below the liquid.
6. 5ml of the digested blank was added into the distillation chamber through the funnel. Then added 10 ml of 40% of NaOH. Washed the funnel with 2-3ml of distilled water.
7. Closed the tap and the steam was generated.
8. Steam entered the distillation chamber and drove all the ammonia which is in turn absorbed by boric acid.

9. Solution was pinkish white in colour, turned blue.
10. Steam was passed for 5min and then the conical flask was lowered and the tip of the condensor washed.
11. The boric acid solution containing the liberated ammonia was titrated against N/70 H₂SO₄.
12. The end point was the appearance of pale permanent pink colour.
13. Between each estimation, the apparatus was washed.
14. The experiment was repeated to get concordant values.

RESULT:

The nitrogen content in 100g of food sample is..... mg

6. Determine of Fat content

Aim:

To determine the fat content of the food stuff.

Principle:

Ether extraction of the crude fat in vegetable products is carried out in a continuous extractor that is an apparatus in which the ether, after dissolving a portion of the fat of the materials and discharging into the extraction flask, is volatilized, condensed and again allowed to act on the material. The steps in the process are repeated continuously and automatically until the extraction is complete.

The soxhelt extraction used depends on the intermittent action of a glass syphon. The ether gradually condenses into the extraction tube containing the material until it rises to top when it is discharged into the extraction flask.

Reagent:

Petroleum ether (60-80° c boiling point).

Procedure:

The soxhlet flask was weighed to consecutive concordant weights. 2g of the moisture free sample was packed into an extraction thimble and placed in an extractor which was fixed into a soxhlet flask. Poured sufficient amount (150ml) of petroleum ether so as to permit syphon action. The thimble and the contents were allowed to soak in ether for 24 hours. The entire set up was kept over an electric water bath and the extractor was connected to the condenser. The nozzle of the condenser was always plugged with moistened cotton. The temperature was maintained at 60⁰c. A steady stream of water in the condensor was maintained. The ether evaporated rose up but owing to the condensor arrangement, it fell back into the condensor extractor. When the extractor got filled with ether, it was siphoned back into the flask. This went on till the ether that got collected in the extractor was free from any yellow colour indicating the presence of fat. The soxhlet flask was then disconnected and ether was evaporated in a water bath maintained at 60⁰c. When the ether in the flask was evaporated, the flask was weighed again to get concordant values. From the difference in weight, the fat content was calculated.

Result:

The fat content of 100g of sample contains=

7.Estimation of calcium

Aim:

To estimate the amount of calcium present in the given sample.

Principle:

Calcium is determined by the precipitating it as calcium oxalate and titrating the oxalate solution in dilute sulphuric acid against standard potassium permanganate.

Apparatus:

Beaker, Burette, Pipette flask and Standard flask.

Reagents:

1. AMMONIUM OXALATE (4%):

Ammonium oxalate was dissolved in 200ml of distilled water till it was saturated.

2.0.01 N OXALIC ACID:

0.063g oxalic acid crystals were weighed and dissolved in 100ml of distilled water.

3. 0.01 N KMNO_4 :

0.316g of KMNO_4 was dissolved in 1000ml of distilled water.

4. Strong Ammonia

5. Glacial Acetic Acid

6. 2N Sulphuric Acid

5.5 ml of sulphuric acid was dissolved in 94.5ml of distilled water.

Procedure:

Ash from the ignited sample was dissolved in hydrochloric acid and made upto the 100ml with distilled water. 10ml of the ash solution was pipette out in a conical flask and 90ml distilled water was added to it. Added 2 drops of methyl red indicator. It was made strongly alkali by adding ammonia and kept for boiling 20ml of saturated ammonium oxalate was added to the solution 10 ml each time to ensure complete precipitation directly. When it was hot, a few drops of acetic acid were added to render the medium acidic. The precipitate was allowed to settle overnight. The next morning the solution was filtered with What man No:40 filter paper. The precipitate was washed first with ammonical water and then with hot water several times until it was free from chloride. To test it 5ml of washing was collected, in a test tube and a drop of calcium chloride solution was added. The washing was continued til there

was no precipitate with silver nitrate or calcium chloride solution. The filter paper was collected in a flask by making a hole in the filter paper. To this 2ml of 2N sulphuric acid was added. This solution was heated to 60° - 80° C and when still hot was titrated against N/100 potassium permanganate solution. From the volume potassium permanganate solution used up the milligram of calcium present in 100g of sample was calculated.

RESULT:

100g of sample contains ----- milligram of calcium.

8. Estimation of Iron

Aim:

To estimate the amount of iron present in 100g of the given food sample.

Principle:

The food sample is oxidized with ignition or oxidation. Iron as ferric iron reacts with ammonium thiocyanate or with potassium thiocyanate to give ferric thiocyanate which is red in color. The color which is a measure of the concentration is measured colorimetrically.

Apparatus:

Volumetric flask, Test tubes, Klett, Pipettes.

Reagents:

1. Stock iron solution: Dissolved 0.0702gm (70.2mg) of reagent grade crystalline ferrous ammonium sulphate (Mohr's salt) in 100ml of water.
2. Working standard: prepared a working standard solution in a 100ml volumetric flask by adding 10ml of the stock solution and diluted to the mark with distilled water.
3. Saturated potassium per sulphate solution: stock 7 to 8g of reagent grade potassium per sulphate in 100ml of water in a glass stoppered flask. The

undissolved crystals settled to the bottom and compensate the loss by decomposition.

4. 3N Potassium thiocyanate: Dissolved 146g of reagent grade potassium thiocyanate in water and diluted to 500ml with water filtered if turbid . Added 20ml of pure acetone to improve the keeping quality. Deterioration will be evident from the rapid fermentation of a yellow color in the blank. Stored in brown bottles.

Procedure:

2g of the sample was ashed by ignition. When ashing had been completed 5ml of hydrochloric acid was added and made up to 100 ml in a volumetric flask. Took different aliquots of the standard solution (1ml-5ml) to corresponding to 10-50 gamma in a series of the test tube. Added 1ml of 30% H₂SO₄, 1ml of potassium persulphate and 1.5ml of potassium thiocyanate to all the test tubes. This was made up to 10ml with water. A blank was prepared by adding the reagents except the standard or the unknown solution. Allowed the colour to develop for 20 minutes and the intensity was read at 530-540μ filters in the colorimeter.

Result:

100g of sample contains ----- milligram of iron.

9.Estimation of phosphorus

Aim:

To estimate the amount of phosphorous present in the given sample.

Principle:

When the ash solution is treated with ammonium molybdate, phosphomolybdic acid is formed. Phosphomolybdic acid is reduced by the addition of 1, 2,4 amino naphthol sulphonic acid reagent to produce a blue colour which is apparently a mixture of oxides of molybdenum. The intensity of the colour developed is the measure of phosphorous present.

Apparatus:

Measuring cylinder, Klett, Test tubes and Pipette.

Reagents:**1. Molybdate solution No 1:**

Dissolved 25g of reagent grade ammonium Molybdate I in about 200ml of water. In one litre volumetric flask 500ml of 10N sulphuric acid was added. The molybdate solution was added and dilute with water to one litre. This solution is stable indefinitely.

2. Molybdate solution No.II:

Dissolved 25g of reagent grade ammonium Molybdate II about 200ml of water. In one litre volumetric flask, 300ml of 10N sulphuric acid was added and was dilute with water to one litre. This solution is stable indefinitely.

3. ANSA:

195ml of 15% sodium bisulphate solution was placed in a glass stoppered cylinder. 0.5g of 1, 2, 4 ANSA (amino naphthol sulphonic acid) was added followed by 5ml of 20% sodium sulphite. Put the stopper and shook until the powder was dissolved. If the solution was not complete, added more sodium sulphite, 1ml at a time with shaking but avoided excess. This solution was transferred to a brown glass bottle and stored in the refrigerator.

4. Stock standard phosphorus solution:

35.1mg of pure potassium dihydrogen phosphate is weighed and dissolved in water. Added 10ml of 10N sulphuric acid and made upto 100ml with water. 5ml of the solution contains 0.4mg of phosphorus. Prepared a working standard containing 8 gamma of phosphorus in 1 ml of the solution by making up 5ml of the standard solution to 50ml with water.

Procedure:

0.1ml of the ash solution was taken in two test tubes. 1ml of molybdate II and 0.4ml of 1,2,4, amino naphthol sulphonic acid were added and the volume was made upto 10ml with distilled water. To 1ml, 2ml, 3ml,4ml and 5ml of standard solution, 1ml of molybdate I solution and 0.4ml of ANSA were added and made upto 10ml. All the tubes containing 10ml of the solution were mixed well and allowed to stand for 15 minutes. Simultaneously, a blank was prepared by mixing 8.6ml of

water, 1ml of molybdate II and 0.4ml of ANSA. The colour developed was read in the colorimeter using red filter of wavelength 660 millimicrons.

Result:

100g of the foodstuff contains= of phosphorus.

10. Estimation of vitamin 'c' by dye method

Aim:

To estimate the amount of vitamin c present in the given sample.

Principle:

Vitamin c is a good reducing agent and it reduces the dye 2,6 dichlorophenol indophenol. In this reaction the ascorbic acid itself is oxidized to dehydro ascorbic acid. In the absence of interfering substances, the capacity of the extract of the sample to reduce a standard solution of a dye as determined by titration is directly proportional to the vitamin C content. Oxalic acid is not only used to reduce the pH of the extracting medium, thereby establishing the vitamin C but also forms complexes with metals eg. Copper thereby preventing the catalytic oxidation of vitamin.

Apparatus:

Centrifuge, centrifuge tubes, mortar and pestle, beakers, pipette, 100ml standard flask, burette and funnel.

Reagents:

1. 2,6 Dichlorophenol indophenol dye: Dissolved 42mg of bicarbonate and 52mg of 2, 6 dichlorophenol indophenol in about 50ml of water. This was diluted to 200ml, filtered, and stored in the refrigerator.

2. 4% Oxalic acid: Dissolved 4g oxalic acid in 100ml distilled water .

3. Standard ascorbic acid: Dissolved 100mg of pure ascorbic acid crystals in 100ml of 4% oxalic acid.

Standardization of the dye:

Pipette out 10 ml of the standard ascorbic acid solution into a beaker and then added 25ml of oxalic acid. From this solution pipetted out 5ml into a conical flask and placed in an ice container and the contents were titrated against the dye in the burette. The end point was the appearance of pink colour which persisted for 30 seconds. The amount of dye consumed is equivalent to the amount of ascorbic acid present.

Procedure:

5g of the sample was weighed and soaked in 40% oxalic acid for 10 mts. This was then ground in a mortar and transferred to centrifuge tubes adding more oxalic acid. The solution was centrifuged and the supernatant clear liquid was transferred to a 100ml standard flask. Repeated the extraction with oxalic acid for three or four times. All the supernatants were collected in the same standard flask and this was finally made up to the mark with acid.

The dye was taken in a micro burette and titrated against 5ml of the extract in a beaker. The end point was the appearance of pink color which persisted for 30 sec. The titration was repeated till concordant values were obtained.

Result:

100g of food sample contain ----- mg of ascorbic acid.

11. Estimation of carotene (beta carotene)

Aim:

To estimate the amount of carotene in 100g of food sample.

Principle:

Carotene present is extracted with petroleum ether and the intensity of the color of the colour of the extract is compared with that of the standard solution using a colorimeter

Reagent:

1. Stock standard solution: 1mg of the standard carotene was weighed and made up to 10ml with petroleum ether.
2. Working standard: 2ml of the stock standard was taken and made up to 50 ml with petroleum ether.
3. 95% ethanol
4. 85% ethanol
5. Petroleum ether (40 to 60)

Procedure:

The given sample was pulverized with 95% ethanol .the suspension was refluxed for about half an hour in a boiling water bath. The clear supernatant was filtered, diluted with 20 ml of 85% ethanol. Extracted the solution repeatedly with petroleum ether using 20 ml portion every time and the extraction was done for 3 or 4 times . Carotene was extracted in the petroleum ether pooled the ether extracts and made up to 100ml with ether.

Take different volumes of standard carotene solution 2 to 8ml corresponding to 40 to 160 μg . The volumes of all solution were made up to 8ml with petroleum ether. The extract was considered to be unknown .8 ml of the made up extract was taken for the experiment .The color developed was read at 540 μg in a colorimeter.

Precautions:

No water should be used throughout the experiment either for rinsing or for makeup only petroleum ether should be used.

Result:

100g of food stuff contain ----- μg of carotene