DEVELOPMENT AND QUALITY EVALUATION OF NUTRACEUTICAL PASTA

By,
ANJALI K U

KISHORE JOHNSON

SANAL JOSEPH

PROJECT REPORT

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DECLARATION

We hereby declare that this project report entitled **"DEVELOPMENT AND QUALITY EVALUATION OF NUTRACEUTICAL PASTA"** is a bonafide record of project work done by us during the course of study and that the report has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Anjali K U (2012-06-004)

Kishore Johnson (2012-06-008)

Sanal Joseph (2012-06-011)

CERTIFICATE

Certified that this project report, entitled, **"DEVELOPMENT AND QUALITY EVALUATION OF NUTRACEUTICAL PASTA"** is a record of project work done jointly by Ms. Anjali K U, Mr Kishore Johnson and Mr Sanal Joseph under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, associate ship or other similar title of any other University or Society.

Dr. Sudheer K P

Associate Professor
Dept. of F& APE
K.C.A.E.T, Tavanur

Place: Tavanur

Date:

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Kishore Johnson

Sanal Joseph

DEDICATED TO THE FOOD ENGINEERING PROFESSION

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CHAPTER I
INTRODUCTION

Nowadays the production and consumption of expanded ready to eat (RTE) & ready to cook (RTC) products through extrusion cooking has notably increasing worldwide. Eating patterns are changing; snack foods play very important roles in the diet of the modern consumer. Many consumers do not have time to prepare traditional meals and lacks proper knowledge of cooking. After work they prefer a meal readily available. The extrusion technology has a pivotal role in the snack and ready to eat breakfast food industry. History shows that the first application of the use of a cooking extruder in the food industry was in producing an expanded cornmeal based snack in a single screw extruder. Single screw extruders were first used in 1940's, since twin screw extruders were not developed for the food industry until the early 1980's (Harper.1981). However, twin screw extruders are rapidly becoming the extruders of choice in the food industry.

Consumers are increasingly interested in foods containing healthy ingredients. According to Marchylo and Dexter (2001), pasta has an excellent nutritional profile, being a good source of complex carbohydrates and a moderate source of protein and vitamins. Besides being easy to prepare and a very versatile food, pasta has a relatively long shelf life when it is stored appropriately. It is also considered an adequate vehicle for food supplementation with minerals, proteins, and many other valuable healthy components (Borneo & Aguirre, 2008).

Pasta is a staple food in many countries. It is commonly used to refer to the variety of pasta dishes. Typically pasta is made from unleavened dough of durum wheat flour mixed with water and formed into sheets or various shapes, then cooked and served in several dishes. Pasta may be divided into two broad categories, dried pasta (*pasta secca)* and fresh (*pasta fresca).* Pasta is commercially produced by an extrusion process. Fresh pasta was traditionally produced by hand, but today many varieties of fresh pasta are commercially produced by large scale machines.

Pasta is an excellent source of complex carbohydrates, which provide a slow release of energy. Unlike simple sugars that offer a quick, yet fleeting boost of energy, pasta helps sustain energy. Pasta is very low in sodium and is cholesterol free. Per cup, enriched varieties provide a good source of several essential nutrients. Whole wheat pasta can provide up to 25% of daily fibre requirement in every one cup portion.

In order to increase the nutritional quality of pasta made from wheat flour, many studies have investigated the addition of ingredients such as amaranth leaf meal, wakame, and germinated *Cajanus cajan* seeds, among others (Borneo & Aguirre, 2008). Pasta, with its origin in Italy has gained wide popularity as a convenient and nutritionally palatable, low glycemic food. The pasta products have been fortified with supplements from various high-protein sources to improve their nutritional properties. The object of this research is to evaluate the pasta with dietary fibre using drum stick pulp, elephant yam, purple yam and ragi flour.

The fortified pastas were evaluated in relation to biochemical composition, cooking properties, textural characteristics and nutritional characteristics. Thus, the underutilized vegetables with high nutritive value can be utilized for the preparation of pasta with improved nutritional properties.

Finger millet also known as ragi in India is one of the important cereals occupies highest area under cultivation among the small millets. Finger millet is comparable to rice with regard to protein (6-8%) and fat (1-2%) and is superior to rice and wheat with respect to mineral and micronutrient contents. It is a major source of dietary carbohydrates for a large section of society. Additionally ragi has enormous health benefits and also a good source of valuable micro-nutrients along with the major food components. In order to develop the value added food products based on ragi, that can able to enrich the nutritional value and also beneficial for good health is the current need for the wellbeing of the society (Maria *et al*., 2014).

Yams are mainly grown for direct human consumption and are marketed as fresh produce in all the growing regions. Most of the world production of yam is from Africa (about 96%) with Nigeria alone accounting for nearly 75% of the total world production. Both purple and elephant yam are rich in antioxidants.

Yams, the tubers of *Dioscorea* spp., are important staple foods in many tropical countries. One piece of yam tuber weighs several kilograms, which is an amount exceeding the capacity of ordinary families to consume in a relatively short period of time. Fresh yams are difficult to store and are subject to deterioration during storage. Because yams are regarded as health foods and not staple foods in oriental countries, it is feasible to develop a stable form of yam products to fulfil the health food market. Since flours can be easily stored for long period of time and conveniently used in manufacturing formulated foods or capsules for consumption, dried yam flour is worth developing (Yen-Wenn *et al*., 2007).

Amorphophallus paeoniifolius known as elephant foot yam is a highly potential tropical tuber crop of *Araceae* family. It is an important tuber crop of tropical and sub-tropical countries because of its yield potential and culinary properties. It is not only used as vegetables but recently several value added products like pickles, dried cubes, chips, thickening agents etc are also made and they are gaining popularity. Preparation of osmodehydrated slices from fresh corm and bread from flour of *Amorphophallus paeoniifolius* corm which has been a good source of both carbohydrate and protein (Anuradha Singh and Neeraj Wadhwa. 2014).

Moringa oleifera (Family: Moringaceae, English: drumstick tree, Sanskrit: shrigru) has been an ingredient of Indian diet since several centuries. People in India have been using it as an item of their daily food for nearly 5000 years. *Moringa oleifera* is cultivated almost all over the country and its leaves and fruits are used as vegetables. Almost all parts of the plant have been utilized in traditional medicine practices. In addition to its compelling water purifying powers and high nutritional value, *M. oleifera* is very important for its medicinal value. Various parts of this plant such as the leaves, roots, seed, bark, fruit, flowers and immature pods act as cardiac and circulatory stimulants, possess antitumor, antipyretic, antiepileptic, anti inflammatory, antiulcer, antispasmodic, diuretic, antihypertensive, cholesterol lowering, antioxidant, anti-diabetic, hepatoprotective, antibacterial and antifungal activities, and are being employed for the treatment of different ailments in the indigenous system of medicine, particularly in South Asia (Mangale *et al*. 2012).

Corn flour or maize starch is the starch derived from the corn (maize) grain. The starch is obtained from the endosperm of the corn kernel. Corn starch is a popular food ingredient used in thickening sauces or soups, and is used in making corn syrup and other sugars. Corn starch is used as a thickening agent in liquid-based foods (e.g., soup, sauces, gravies, custard), usually by mixing it with a lower-temperature liquid to form a paste or slurry. It is sometimes preferred over flour alone because it forms a translucent mixture, rather than an opaque one. As the starch is heated, the molecular chains unravel, allowing them to collide with other starch chains to form a mesh, thickening the liquid (Zeng *et al.* 2011).

Atta is Indian wheat flour used to make most South Asian flatbreads, such as chapati, roti, naan and puri. Most atta is milled from the semi-hard wheat varieties, also known as durum wheat that comprises 90% of the Indian wheat crop, and is more precisely called durum atta. Hard wheat have a high content of gluten (a protein composite that gives elasticity), so dough made out of atta flour are strong and can be rolled out very thin. Indian wheat is mostly Durum wheat, which are high in protein but less in "bread forming gluten" so the bread when baked with this flour does not rise as well and tends to be dense (Ndife and Abbo, 2009).

Guar gum is economical because it has almost eight times the water-thickening potency of cornstarch; only a very small quantity is needed for producing sufficient viscosity. Thus, it can be used in various multiphase formulations as an emulsifier because it helps to prevent oil droplets from coalescing, and/or as a stabilizer because it helps to prevent solid particles from settling. Guar gum is a viscosifier with very favorable rheological properties. It has a really useful ability to form breakable gels when cross-linked with boron. This makes it extremely valuable for hydraulic fracturing (J C Brown & G Livesey. 1994).

Thus incorporation of these underutilized vegetables into a corn and ragi based pasta could serve to provide a healthy and ready to cook food especially to the nutritionally compromised section of the society.

Considering the above facts, a work was undertaken in KCAET, Tavanur with the following specific objectives;

- Standardization of the pre treatments and drying process of vegetables used for nutraceutical pasta.
- Optimization of feed composition to make nutraceutical pasta by minimizing maida content and maximizing ragi content.
- To study the physical and engineering properties of millet based nutraceutical pasta by examining the changes in the cooked & uncooked samples of pastas of different combinations.

CHAPTER II

REVIEW OF LITRATURE

This chapter gives general information on nutraceutical ingredients of pasta, its chemical composition and its effects on quality of end products. Research done on these aspects were reviewed and discussed in detail under the following topic.

2.1 Pasta

Pasta is a staple food in many countries. According to Marchylo and Dexter (2001), it has an excellent nutritional profile. In order to increase the nutritional quality of pasta made from wheat flour, many studies was investigated the addition of ingredients (Borneo & Aguirre, 2008; Prabhasankar *et al*., 2009).

Gopalakrishnan *et al.* (2011) evaluated nutritional and functional characteristics of protein-fortified pasta from sweet potato. The objective of his work was to enhance the utilization of sweet potato as a low glycaemic food, mainly through its use in the development of high protein pasta. Among three protein sources, whey protein concentrate (WPC), defatted soy flour, and fish powder (FP), WPC gave high quality pasta with strong starch-protein net-work formation, as evidenced from scanning electron microscopic studies and low *in vitro* starch digestibility. Protein nutritional quality was also high for WPC-fortified sweet potato pasta, with very high scores for lysine and leucine as well as high essential amino acid index and calculated protein efficiency ratio. Fractionation of starch showed that the WPC-fortified sweet potato pasta had the lowest rapidly digested starch (RDS) and the highest resistant starch (RS) content, indicating its potential as a low glycaemic food.

Stephano and Marco (2009) evaluated the chemical and physical characteristic of cooked fresh egg pasta sample obtained using two different production methodologies; viz; extrusion and lamination. The extruded pasta were tougher than the sheet rolled pasta, absorbed more water during cooking and released more total organic matter in the rinsing water. The result obtained showed that the extrusion process led to higher furosine content than sheet rolled processes.

Carini *et al.* (2002) reported that fresh pasta is a very common food in Italy and it can be produced by subjecting semolina-water dough either extrusion or lamination to obtain the desired shape. The objective of their work was to evaluate the effect of extrusion, lamination and lamination under vacuum on physico chemical properties of selected fresh pasta. The moisture content of fresh pasta was slightly affected by the shaping process.

Agnesi *et al.* (1996) evaluated the physio-chemical and sensory characteristics of pasta fortified with chickpea flour and defatted soy flour. Effects of fortification of pasta with the combination of chickpea flour and defatted soy flour at different levels were assessed on the nutritional, sensory and cooking quality of the pasta. The fortification of durum wheat semolina was done by the combination of chickpea flour and defatted soy flour at levels containing only semolina as control, 10.6%, 14.10%, 18.14% respectively. A novel legume fortified pasta product was successfully produced and it was observed as the concentration of legumes was increased, the cooking time also increased. The cooking quality of the pasta was enhanced by steaming. On the basis of cooking and sensory quality, pasta containing 14% chickpea flour and 10% defatted soy flour resulted in better quality and nutritious pasta.

Nomjit *et al.* (2009) made an evaluation on pasta from organic jasmine rice. It was determined that the product needed 200 g organic jasmine rice flour, 50 g organic wheat flour, 12.5 g organic tapioca flour, 110 g organic chicken egg, 11 g organic olive oil, 5 g salt and 70 g water. To manufacture dry pasta, the dough was kneaded, made into pasta sheet in pasta machine, simmered in boiling water and dried at 60°C in a hot air oven for 6 h. After that, the nutritive value was determined. It was found that pasta from organic jasmine rice contained 85.4% carbohydrates, 8.4% fat, 3.0% of moisture, 2.0% proteins and 1.1% fibres. The study of shelf life of pasta at room temperature for 3 months showed that the product colour had not changed. However, the moisture and water contents increased slightly. For total microbial and yeast count, it was found that the product was meeting the food safety levels.

2.2 Extrusion

Food extrusion is a form of extrusion used in food processing. It is a process by which a set of mixed ingredients are forced through an opening in a perforated plate or die with a design specific to the food, and is then cut to a specified size by blades. The machine which forces the mix through the die is an extruder, and the mix is known as the extrudate. The extruder consists of a large, rotating screw tightly fitting within a stationary barrel, at the end of which is the die.

Extrusion enables mass production of food via a continuous, efficient system that ensures uniformity of the final product. Food products manufactured using extrusions usually have high starch content. These include some pasta, breads (croutons, bread sticks, and flat breads), many breakfast cereals and ready-to-eat snacks, confectionery, pre-made cookie dough, some baby foods, full-fat soy, textured vegetable protein, some beverages, and dry and semi-moist pet foods (Dias *et al*., 2009).

Cold extrusion could produce parts with good surface finish, high strength due to strain hardening, improved accuracy, and high rate of production. However, the process requires higher pressure and tools are subjected to higher stresses. Proper lubrication is necessary for preventing seizure of tool and work piece. Phosphate coated billets are lubricated with soap. Hot extrusion can be employed for higher extrusion ratios. Inhomogeneous deformation can occur due to die wall chilling of the billet. Metal may get oxidized. The oxide layer can increase friction as well as the material flow. Glass is used as lubricant for hot extrusion. Molybdenum disulfide or graphite is the solid lubricants used in hot extrusion. Canned extrusion using thin walled cans made of copper or tin is usually used for extruding highly reactive metals and metal powders.

Extrusion is done with relatively dry materials to plasticise food mass, to reduce microbial load, denature enzymes, gelatinise starch, and polymerise proteins and most importantly texturise the end product into a desirable form. Harper (1981) emphasised the importance of extrusion cooking over conventional cooking methods because of versatility, efficiency and economy of space and labour. Transport of material through single screw extruders depends largely on friction at the barrel surface. Material flows forward (drag flow) owing to the action of screw and to a lesser extent, backwards along the barrel (pressure flow and leakage flow) (Harper and Jansen, 1985).The screw has a number of sections, including a feed section to compress particles in to a homogenous mass, a kneading section to compress, mix and shear the plasticized food and in high shear screws, a cooking section (Leszek and Zuilichem, 2011). Pressure flow is caused by the build-up of pressure behind the die and by material movement between the screw and barrel. Slipping can be minimised by special groves on the inside of the barrel

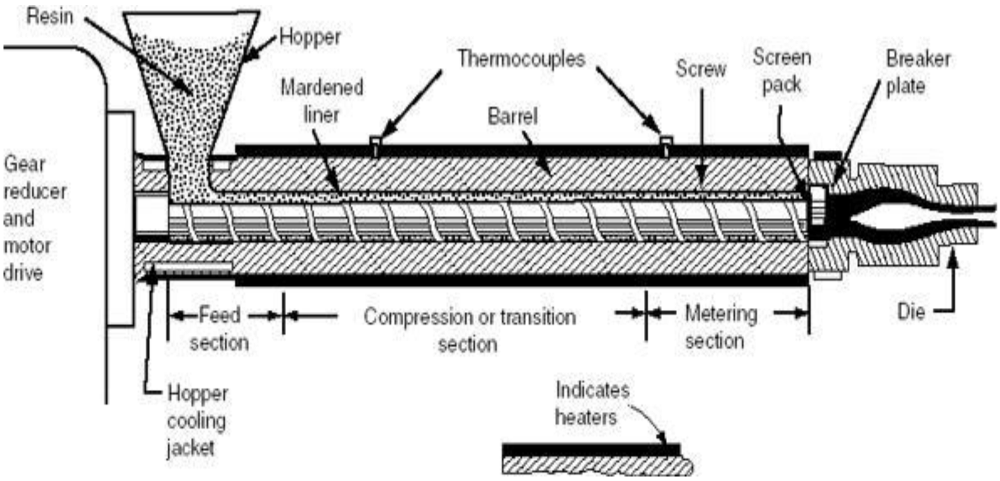

Fig. 2.1 Single screw extruder (Ref: Fellows, 2000)

Single screw extruders have lower capital and operating costs and require less skill to operate and maintain than twin screw machines (Fellows, 2000). Ever since extrusion involves simultaneous mixing, kneading and cooking, it causes a large number of complex changes to a food, including hydration of starches and proteins, homogenization, gelation, shearing, melting of fats, denaturation or re-orientation of proteins, plastification and expansion of the food structure. For many years the empirical knowledge of extruder operators outstripped scientific theory of the sequence and nature of these interactions and their effects. The two factors that most influence the nature of the extruded product are the rheological properties of the food and the operating conditions of the extruder. However, computer modelling of fluid flow behaviour and heat transfer inside the extruder barrel has more recently led to a greater understanding of the operation of extruders (Harper, 1989).

Extrusion technology has gained in popularity due to following reasons (Fellows, 2000)

- *Versatility* - A very wide variety of products are possible by changing the ingredients, the operating conditions of the extruder and the shape of the dies. Many extruded foods cannot be easily produced by other methods.

- *Reduced costs* - Extrusion has lower processing costs and higher productivity than other cooking or forming processes. Some traditional processes, including manufacture of cornflakes and frankfurters, are more efficient and cheaper when replaced by extrusion.

- *High production rates and automated production* - Extruders operate continuously and have high throughputs. For example, production rates of up to 315 kg/h for snack foods, 1200 kg/h for low-density cereals and 9000 kg/h for dry expanded pet foods are possible.

- *Product quality* - Extrusion cooking involves high temperatures applied for a short time and limited heat treatment therefore retains many heat sensitive components.

- *No process effluents* - Extrusion is a low-moisture process that does not produce process effluents. This eliminates water treatment costs and does not create problems of environmental pollution.

A study on physico chemical characteristics, nutritional quality and shelf life of pearl millet based extrusion cooked supplementary foods was done by Sumathi *et al.* (2007). The cold and cooked paste viscosity, the melt energy and also the carbohydrate digestibility of the extrudates indicated that the products were precooked and were of ready-to-eat nature. The millet was blended with grain legumes (30%) and also with defatted soy (15%) separately and extruded to prepare ready-to eat nutritious foods suitable as food supplements to children and mothers. The foods based on the millet and legumes and also the millet and soy contained 14.7% and 16.0% protein with

2.0 and 2.1 protein efficiency ratio values, respectively. The shelf-life of the foods was about 6 months in different flexible pouches at ambient storage conditions.

Lakshmi *et al.* (2013) developed pasta products using refined wheat flour, semolina, green gram, black gram, cheese flavour and fish mince with a lab scale extruder. Acceptability studies on the pasta products were conducted initially and at the end of the storage period that is, two months at laboratory level by panel of judges using a 5 point hedonic scale. Among the different blends studied, the most acceptable pasta was the product made with combination of refined wheat flour + semolina + black gram dal + cheese flavor + fish.

Chaiyakul *et al.* (2009) studied the effect of extrusion conditions on physical and chemical properties of high protein glutinous rice-based snack and came to conclusion that high protein nutritious snack obtained from glutinous rice flour; vital wheat gluten and toasted soy grits even at increased feed moisture and reduced barrel temperature. The conditions providing high expansion, low bulk density, and low shear strength of extruded snack were resulted at feed moisture of 20 g/100 g wb and 180˚C.

Sudha devi (2012) reported the development of pasta products using different small millets namely, little, fox tail, kodo, proso and barn yard using wheat flour as binder. Sensory evaluation of various products indicated that the pasta extruded from the formulation proso is to wheat flour was best in terms of its quality.

2.3 Raw materials

2.3.1 *Drumstick*

Moringa oleifera is the most widely cultivated species of a monogeneric family, the Moringaceae that is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan. Moringa trees have been used to combat malnutrition, especially among infants and nursing mothers. Leaves can be eaten fresh, cooked, or stored as dried powder for many months without refrigeration, and reportedly without loss of nutritional value. Moringa is especially promising as a food source in the tropics because the tree is in full leaf at the end of the dry season when other foods are typically scarce. The benefits for the treatment or prevention of disease or infection that may accrue from either dietary or topical administration of Moringa preparations (e.g. extracts, decoctions, poultices, creams, oils, emollients, salves, powders, porridges) are not quite so well known.

Mangale *et al*. (2012) studied the effects of *Moringa oleifera* (Drumstick) seed as natural Absorbent and Antimicrobial agent for River water treatment. Its seeds act as a natural coagulant, flocculent, absorbent for the treatment of drinking water. It reduces the total hardness, turbidity, acidity, alkalinity, chloride after the treatment. It also acts as a natural antimicrobial active against the micro-organisms which is present in the drinking water and decrease the number of bacteria. If we can use combined *Moringa oleifera* seed powder and chlorine it can give best results and the water can be suitable for drinking.

2.3.2 *Elephant yam*

Amorphophallus paeoniifolius known as Elephant foot yam is a highly potential tropical tuber crop of Araceae family. Amorphophallus is a good source of energy, sugar, starch, proteins as well as minerals Average nutritional profile contains Starch (11-28%), sugar (0.7-1.7%), protein (0.8-2.60%), fat (0.07-0.40%) mean energy value (236-566.70KJ/100g). The most abundant macro mineral is potassium (327.83 mg/100 g), Phosphorus (166.91 mg/100g), calcium (161.08 mg/100 g) and iron (3.43 mg/100g). Macro mineral and soluble oxalate ranges between different Varieties: K (230-417 mg/100 g), P (120- 247 mg/100g), Ca (131-247 mg/100g), Fe (1.97-5.56 mg/100 g), Mn (0.19-.65 mg/100 g), Zn (0.12-1.92 mg/100g) & Soluble oxalate (6.65-18.50 mg/100g). The mean soluble oxalate content (13.53 mg/100g) was safe from the viewpoint of accumulation of urinary oxalate leading to kidney stones (Anuradha Singh and Neeraj Wadhwa. 2014).

2.3.3 *Purple yam*

Dioscorea which is commonly known as yam and a large genus in the family *Dioscoreaceae* is one of the staples in many tropical countries. Yam is widely grown in many West African countries. Some yams are used as medicines in oriental countries to prevent diarrhoea and diabetes. *Dioscorea* family or yam tuber consists of about 600 species which are around 50-60 species cultivated or food and medicine (Yen-Wenn *et al*., 2007)

Araghiniknam *et al*. (1996) reported that the tuber contains allantoin, a cell-proliferant that speeds the healing process. The tuber is also anthelmintic and digestive. It is used internally in the treatment of poor appetite, chronic diarrhoea, asthma, dry coughs, frequent or uncontrollable urination, diabetes, and emotional instability. It is applied externally to ulcers, boils and abcesses. Zava *et al*. (1998) reported that the roots of most, if not all, members of this genus contain diosgenin. This is widely used in modern medicine in order to manufacture progesterone and other steroid drugs. Harijono *et al*. (2013) studied the physical-chemical properties of purple and yellow water yam tubers that have been tabulated in table 2.1 and 2.2.

Table 2.1: Difference in physical properties of purple and yellow water yam tubers

PHYSICAL	**PURPLE**	**YELLOW YAM**
Colour of the peel	Dark brown	Light brown
Tuber shape	Slightly	irregular
Texture of the peel	Rough	Rather smooth
Many little mucous	Many mucous	Rather mucous
Presence or absence of	Little hair	Rather hair
Colour of the flesh	Purple	Light yellow
Texture of the flesh	smooth	Rather smooth

Source**:** Harijono *et al*. (2013)

Table 2.2: Chemical composition of purple and yellow water yam

COMPONENT %	PURPLE YAM	YELLOW YAM
Water	78.12	87.75
Ash	0.69	0.81
Protein	1.69	1.58
Fat	0.97	0.47
Carbohydrate	18.53	9.39
Crude fiber	1.46	1.17
Soluble fiber	3.23	3.28
Insoluble fiber	36.06	51.45

Source**:** Harijono *et al*. (2013)

2.3.4 *Ragi*

Ragi is rich in calcium, iron, protein and some rare nutrients such as methionine. Also digests easily from infancy through old age and its nutrients are highly absorbed. Ragi is an ideal food after an infant reaches at least 6 months of age .major portion of ragi is carbohydrate, around 80% .the fat percentage is quite less which is good. Ragi also has some good number of essential amino acids which are essential for human body (Shukla & Srivastava, 2014). Some of them are valine, methionine, isoleucine, threonine, and tryptophan. Millets also contains B vitamins, especially niacin, B6 and follic acid calcium, iron, potassium, magnesium and zinc. Finger millet is well comparable and even superior to many cereals in terms of mineral and micronutrient contents. Its major use as food has remained only in the area where it is cultivated and to the traditional preparations (Amadou *et al*., 2011).

Millets are most recognized nutritionally for being a good source of minerals magnesium, manganese and phosphorus. Research has linked magnesium to a reduced risk for heart attack and phosphorus is important for the development of body tissue and energy metabolism. Millets are also rich in phytochemicals, including phytic acid (Shashi *et a*l., 2007), which is believed to lower cholesterol, and phytate, which is associated with reduced cancer risk. Thus, millets are strategic in terms of their food, nutritional and livelihood security and their role in local agro-ecosystems (Joshi *et al.*, 2008). Patil and Sawant (2012) studied the nutrition facts of ragi and compared it with other grains it has been tabulated in table 2.3 and 2.4.

Table.2.3 Ragi nutrition facts (comparison)

CONTENTS (GRAMS)	BROWN RICE	WHEAT	MAIZE	RAGI
Energy (K Cal)	362	348	358	336
Carbohydrate	7.9	11.6	9.2	7.7
Protein	7.9	11.6	9.2	7.7
Fibre	1.	2.2	2.8	3.6

Source: Patil and Sawant (2012)

Table 2.4 Ragi nutrition facts

CONTENT	AMOUNT	CONTENT	AMOUNT
Carbohydrate	72.6 mg/dl	Valine	413 mg/dl
Protein	7.7 mg/dl	Phenylalanine	325 mg/dl
Fiber	3.6 mg/dl	Isoleucine	275 mg/dl
Fat	1.3 mg/dl	Threonine	263 mg/dl
Calcium	350 mg/dl	Methionine	194 mg/dl
Iron	3.9 mg/dl	Tryptophan	191 mg/dl
Niacin	1.1 mg/dl	Lysine	181 mg/dl
Thiamine	0.42 mg/dl	Cystine	163 mg/dl
Riboflavin	0.19 mg/dl	Leucine	594 mg/dl

Source: Patil and Sawant (2012)

2.3.5 *Corn flour*

Zeng *et al. (*2011) studied the Functionalities and relationships between raw and extruded maize flour blends. The extruded flour had higher water absorption and water solubility indices, and had no differential scanning calorimetry endotherm. In starches from raw flour, a bimodal distribution of the chain length was found by gel permeation chromatography while in the extruded starches only one fraction was observed. The dough quality of 60%

raw and 40% extruded flour mixture was found to be better than with other mixture proportions

2.3.6 *Atta*

The Atta flour found in commerce varies in fiber content from near 0% to 12%. Whole meal (US whole wheat) atta is obtained from grinding complete wheat grains. It is creamy brown in color and quite coarse compared to other types of flour. Traditionally, atta is made by stone grinding, a process that imparts a characteristic aroma and taste to the bread. The high bran content of whole meal atta makes it a fiber rich food. This may help to regulate blood sugar as well have other health benefits. The temperatures attained in a *chakki* (mill or grinder, traditionally from stone), produced by friction, are of the order of 110–125˚C. At such high temperatures, the carotenes present in the bran tend to exude the characteristic roasty smell, and contribute to the sweetness of the atta (Ndife and Abbo, 2009).

The various quality control parameters for the atta industry are ash content, moisture content, acid insoluble ash, water absorption, alcoholic acidity, granulation profile, damaged starch and gluten content.

Recently, consumer's awareness of the need to eat high quality and healthy foods known as functional foods, that is, foods which contain ingredients that provide additional health benefits beyond the basic nutritional requirements, is increasing. Jideani and Onwubali (2009) reported that the development and consumption of such functional foods not only improves the nutritional status of the general population but also helps those suffering from degenerative diseases associated with today's changing life styles and environment. The whole wheat flour has been shown by many researchers to be a rich source of these functional ingredients such as fibre, phytochemicals, minerals, essential amino acids that are located in the bran and fat soluble vitamins contained in the germ of the whole wheat grain (Dewettinck *et al*., 2008).

2.3.7 *Gaur gum*

Gaur gum also calles guaran is a galactomannan. It is primarily the ground endosperm of guar beans. The guar seeds are dehusked, milled and screened to obtain the guar gum. It is typically produced as a free-flowing, off-white powder. Chemically Gaur gum is a polysaccharide composed of the sugars galactose and mannose. The backbone is a linear chain of β 1,4-linked mannose residues to which galactose residues are 1,6-linked at every second mannose, forming short side-branches. Guar gum, as a water-soluble fiber, acts as a bulk-forming laxative, so is claimed to be effective in promoting regular bowel movements and relieving constipation and chronic related functional bowel ailments, such as diverticulosis, Crohn's disease, colitis and irritable bowel syndrome. Guar gum has been considered of interest in regard to both weight loss and diabetic diets. It is a thermogenic substance by J C Brown & G Livesey (1994). Moreover, its low digestibility lends its use in recipes as filler, which can help to provide satiety, or slow the digestion of a meal, thus lowering the glycemic index of that meal.

2.4 Physical Properties

2.4.1 *Colour characteristics*

Iwe *et al*., (2000) studied on the effect of extrusion cooking of soy–sweet potato mixtures on browning index of extrudates and showed the effect of processing variables such as feed composition, screw speed and die diameter. Response surfaces for the parameters were generated using a second degree polynomial. Increase in feed composition and screw speed increases browning index, but decreases die diameter and feed composition increases browning index.

Cemalettin and Mustafa (2010) performed modelling the effects of processing factors on the changes in colour parameters of cooked meatballs for studying the simultaneous effects of processing variables such as fat (10-30%), wheat bran (5- 15%) and NaCl (0-2%) on the colour changes (L, a, b, whiteness index, saturation index, hue-angle, total colour difference and browning index) of cooked beef meatballs. The results showed that the processing variables had a significant effect on the colour parameters. L and whiteness index values of meatballs were decreased by the wheat bran addition. The ‘b’ and saturation index values were increased by fat addition. ∆E value was decreased by the wheat bran addition. Increase in the fat content increases the browning index values and salt addition showed an inverse effect.

2.4.2 ***Texture Analysis***

Anton and Luciano (2007) studied the instrumental texture evaluation of extruded snack foods. Texture evaluation of extruded snacks is a complex subject, where the combination of the techniques involves sensory, instrumental and microstructure analysis. From a practical perspective, empirical methods are suggested as alternative to fundamental techniques, especially to food scientists and food manufacturers interested in predicting consumer perception of texture.

The high shear stress and temperature seem to favor the formation of a strengthened starchy network, involving the majority of starch macromolecules (as exhibited by its low cooking loss and pasting viscosity) with a positive effect on the texture of cooked pasta in terms of high consistency parameters. A similar behaviour was also found by Wang *et al*., (1999) who investigated the suitability of pea flour for pasta-making using a twin-screw extruder: pasta obtained by extrusion-cooking exhibited superior firmness, flavour and texture after cooking, compared to pasta-products prepared from the same flour using a conventional extruder.

Agulera *et al*., (1984) studied on the air classification and extrusion of navy bean fractions and reported that the increase in hardness coincided with an increase in expansion of the extrudates. This property which is a physical quantification of the textural properties was not significantly different for all extrudates under concern (Amir.gull *et al.*, 2015). They also reported that a similar trend for pure corn, where increases in extrusion temperature gave more expanded and softer products.

2.4.3 *Elongation*

Zhu & Khan (2002) reported that gluten has viscoelastic behaviour in which gliadin and glutenin fractions represent viscous and elastic behaviour, respectively. Variation in protein content alone is not responsible for the differences in dough properties and suitability for end-products amongst the cultivars

Peri *et al*. (1983) reported that the expanded volume of cereal is due to the starch content. Zhu & Khan, (2002) studied the relationship between amylase content and extrusion-elongation properties of corn starches. Corn starch upto 70% amylose contents were extrusion cooked at different temperatures of 130 to 160°C and moisture contents of 0 to 50% (db). The product quality measures of elongation, shear strength and bulk density were studied in relation with the starch amylase content.

2.5 Cooking characteristics

2.5.1 *Optimum cooking time*

Pastificio *et al.* (2011) concluded in a study in which durum wheat was milled in order to obtain medium (M), medium coarse (MC) and coarse (C) semolinas with an average particle size of 275, 375 and 475 μm respectively. The three semolinas were characterized for their chemical and physical properties. The M semolina showed higher ash, protein and gluten content, a higher gluten extensibility but a lower gluten index and yellow colour than coarser semolinas. Spaghetti was produced with the three semolinas. Dried spaghetti were characterized for their diameter, hardness and colour and eventually tested for their cooking quality. Spaghetti from MC and C semolina showed higher optimum cooking time (OCT) than spaghetti from M semolina. Cooking time being equal, the weight and diameter increase was higher in spaghetti from coarser semolinas. Within OCT, the hardness of spaghetti from MC and C semolina was higher than that of spaghetti from M semolina. The high OCT and hardness (before OCT) of the semi-cooked pasta obtained from MC and C semolina could be useful in two-step cooking processes in which pasta is pre-cooked and cooled before the final cooking step.

2.5.2 *Solid loss*

Bhaskaran *et al*. (2011) conducted a study in which statistical analysis revealed a highly significant difference in the total solids loss between the control and the noodles enriched with SMP, as well as the combination of SMP and WPC. The total solid loss in gruel increased as the level of substitution increased (Khan *et al*., 2013). The increase in loss due to enrichment may be related to gluten dilution and protein solubility fraction of wheat germ. The results were in conformity with Olfat *et al*. (1993) and Fayed *et al*. (1993). The total solids loss was higher in the noodles substituted with SMP when compared to WPC. This may be attributed to the compact structure of WPC and the porous nature of the SMP enriched noodles. Total solids loss in gruel increases as the level of substitution increases. It was also found that, the loss of total solids was higher in noodles supplemented with skim milk powder compared to whey protein concentrate and a combination of SMP and WPC. Similar effects on cooking losses have been reported for pasta products incorporating non-durum ingredients such as seaweed (Prabhasankar *et al*., 2009), dietary fibre (Tudorica *et al*., 2002), banana flour (Ovando *et al*., 2009).

2.5.3 *Swelling power*

Swelling power is a measure of hydration capacity, because the determination is a weight measure of swollen starch granules and their occluded water (Rickard *et al*., 1992). Food eating quality is often connected with retention of water in the swollen starch granules (Albi Abraham and Jayamuthunagai., 2014). The low swelling power of starches might be attributed to the presence of a large number of crystallites formed by the association between long amylopectin chains. Crystallite formation increases granular stability, thereby reducing the extent of granular swelling (Miao et al., 2009). Swelling volume of starch was affected by amylose content and the structure of amylopectin (Sasaki and Matsuki, 1998)

2.6 Sensory

Jing *et al*. (1991) reported on the effects of extrusion conditions on sensory properties of corn meal extrudates and found that temperature and moisture had a significant effect on the flour aroma of extrudates. Increasing the temperature and decreasing the moisture resulted in a marked increase in toasted corn taste probably related to the chemical reactions in corn meal during extrusion cooking. Screw speed has less effect on toasted corn taste. The chemical reactions responsible for toasted corn aroma were probably also responsible for toasted flavour. The denseness of extrudates affected significantly the barrel temperature during extrusion and by the interaction between temperature and screw speed. At low temperature with decreasing screw speed, increases denseness of extrudates. Thus the crispness of the extrudates was related to the denseness of the extrudates.

Hanne *et al*. (2005) studied on the sensory quality of extruded oat, stored in light and darkness in packages with different oxygen transmission rates (including the use of an oxygen absorber), which was evaluated after 3 months of storage at 38˚C and 10 months of storage at 23˚C. To reduce the costly and time consuming shelf life and packaging evaluation, the possibility of reducing the number of sensory attributes to be analyzed and to accelerate shelf life testing was studied. The intensity of oat odour, paint odour and crispiness were found to describe the main differences among the samples. By increasing the temperature from 23 to 38˚C for samples stored in darkness, packaging evaluation tests for extruded oat might be performed in approximately one third of the time. Changes in headspace oxygen concentration in the packages due to oxygen consumption were in agreement with the sensory changes in the oat.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the methodologies used for the preparation of samples, blending of prepared flours, experiments on extrusion of elephant yam, purple yam, drum stick and ragi flour blended in different proportions. The chapter also describes the standardized methods to carry out the physical, textural and sensory tests to analyze the engineering qualities of the developed nutraceutical pasta.

3.1 Raw Materials

Raw materials selected for the study are elephant yam, purple yam, drum stick, ragi, maida and corn flour and these were procured from the local markets.

3.2 Preparation of samples for Extrusion

Good quality elephant yam, purple yam, drum stick were collected from the market. These materials were then washed with water to remove the surface dirt. It was then peeled using a knife and washed again with running water. Then it was sliced into small pieces and blanched for 2 minutes. Drying was carried out at 60°C for 6 hours. Tempering was done before drying again at 60°C for 2 hours. The dried product was then powdered, sieved and stored. The flowchart for standardisation of vegetables is given in figure 3.1.The various proportions of ingredients used in each treatment has been shown in table 3.

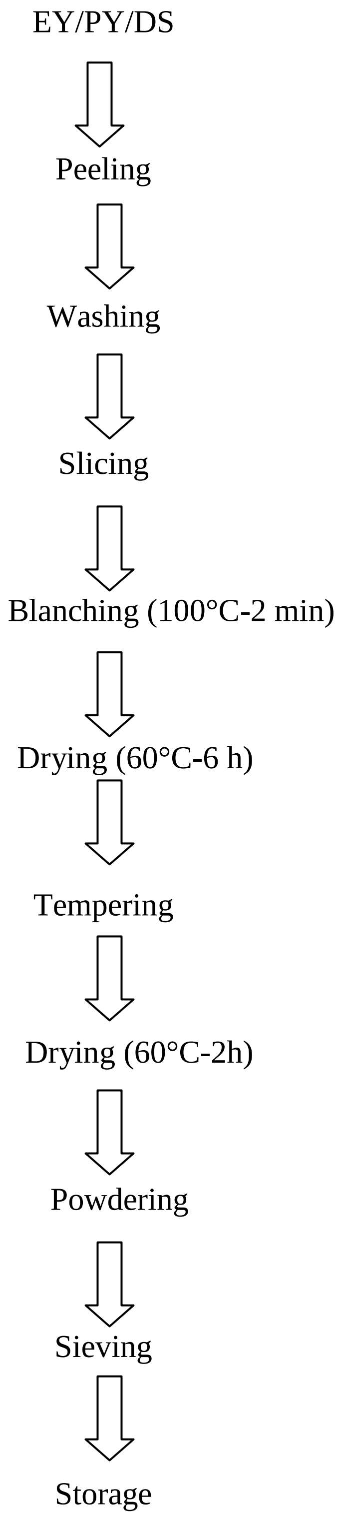

Fig 3.1 Flowchart for standardisation of vegetables

Table 3.1: Various proportions of ingredients used under each combination

Sample	Ingredients (%)							
	M	**EY**	**PY**	**DS**	**R**	**A**	**CF**	**G**
1	30	2	18	5	45	-	-	-
2	10	2.5	48.5	5	34	-	-	-
3	-	3.5	55	6.5	35	-	-	-
4	-	5	55	5	25	10	-	-
5	-	5	55	5	25	-	10	-
6	-	5	48	5	40	-	-	2

3.3 Extrusion process

The blends were extruded in a single screw La monferrina extruder (Model Dolly, Italy) (Plate 3.1). The screw zone of the extruder can be divided into five sections. The first section allows the flour to get uniformly mixed inside the extruder. The second cooking section consists of a flat plate through which the ingredients get heated up to the required temperature. The third section consists of a rotating screw with pressure variance in which the particles of the blend are brought together. The fourth section contains an extruder die with the required size to enable puffing of the product and the fifth section is the cutting section where the expelled extrudates are sliced to specific length.

Plate 3.1: Single screw extruder

Plate 3.2: Screw of extruder

3.4 Experimental procedure

The different blends of Elephant yam flour, Purple yam flour, Drum stick flour, Maida, Ragi, Corn flour, Atta, Gaur gum in different compositions were mixed well by the addition of water. Kneading of the mix was carried out in the pasta maker for 30 minutes. After thorough mixing, extrusion was carried out. Organoleptic qualities of the processed pasta were analysed using standard engineering properties including physical, textural and sensory assessments.

3.4.1 Flow chart for the production of NP

EYF + PYF + DSF + Ragi + Maida/CF/Atta/Guar gum

↓

Mixing (30 min)

↓

Conditioning with water

↓

Extrusion → Physical, Textural, Sensory

↓

Drying (60°C for 30 min)

↓

Cooking

↓

Nutraceutical Pasta

Fig 3.2 Flowchart for production of NP

3.5 Analysis of Physical and Engineering properties

3.5.1 *Colour*

Product colour is a strong indicator of the thermal history within the extruder. Hunter lab colour flex meter (made by: Hunter Associates Laboratory, Reston, Virginia, USA) (Plate 3.3) was used for the measurement of colour. It works on the principle of focusing the light and measuring the energy reflected from the sample across the entire visible spectrum. The colour meter has filters that relay on "standard observation curves" which define the amount of red yellow and blue colours.

This system uses three values viz. 'L*', 'a*' and 'b*' to describe the precise location of a colour inside a three-dimensional visible colour space. The colorimeter was calibrated against standard white and black tiles before each actual colour measurement. For each sample at least four replications performed at different positions and the mean values were taken. For colour measurements extruded samples were ground to pass a 100 mesh U.S sieve. Measurements displayed in L, a and b values represents light - dark spectrum with a range from 0 (black) to 100 (white), the green - red spectrum with a range from - 60 (green) to + 60 (red) and the blue - yellow spectrum with a range from - 60 (blue) to + 60 (yellow) dimensions respectively (Ali *et al*., 2008).

Plate 3.3 Experimental set up of Hunter lab colour flex meter

3.5.2 *Texture*

Instrumental analysis of texture in foods provides fast and relatively in expensive access on product characteristics and consumer acceptance. For the experiment, all extruded samples were dried until moisture content of 6% was reached which is ideal operating condition for the texture analyser. The texture analyser (TA.XT plus texture analyser, Stable micro systems Ltd.) (Plate 3.4) was operated with a 10 kg load cell and a sharp blade probe (55 mm wide, 40 mm high and 9 mm thick) used to find the peak force of extrudates in terms of parameters namely, hardness (N), toughness (N-s) and crispness (number of peaks) of extrudates (Jisha *et al*., 2010). The test speed was 0.17 mm/s and the distance between two supports was 30 mm. A force time curve was recorded and analysed by texture Exponent 32 software program (version 3.0).

Plate 3.4 Experimental set up of TA.XT plus texture analyser

3.5.3 *Elongation*

The percentage elongation of cooked and uncooked pastas was analyzed by using a digital vernier caliper (plate 3.5). Calibration was set 0.00 by pressing the set button. Initial length and width value were taken before cooking and the final measurements were taken after cooking of the samples. The percentage elongation was calculated by using the formula:

Percentage Elongation = (Initial – Final) /Initial× 100

Plate 3.5 Digital Vernier Caliper

3.2.4 *Optimum cooking time*

Optimum cooking time was measured using manual method by pressing the product between fingers periodically at 1 minute intervals. When the product was completely soft, the time was noted.

3.2.5 *Swelling power*

A known weight of 5 g of pasta was cooked in a glass beaker with 100 ml water for 20 min over a water bath maintained at 100°C. After cooking, the water was drained out. The cooked pasta was dried using filter paper to remove the excess moisture. The cooked sample was weighed. The Swelling power was calculated using the equation given below:

Swelling power = (Sample weight after cooking - Sample weight before cooking)/Sample weight before cooking

3.2.6 *Solid loss*

It was determined by cooking pasta in boiling water for 20 minutes. After cooking, the cooked materials were retained out. The whole filterate was transferred quantitatively into a pre weighed Petri dish. It was evaporated over a water bath followed by drying for 1 hour at 60°C. The Petri dish was again weighed with dried solids.

$$\text{Solid loss percentage} = (M_2 - M_1) \times 100/M_0$$

M_0 = Weight of pasta taken for cooking

M_1 = Weight of empty Petri dish

M_2 = Weight of Petri dish with dried solids after evaporation

3.2.7 *Sensory evaluation*

Sensory quality is a combination of different senses of perception coming into play in choosing and eating a food. Appearance, flavour and mouth feel decides the acceptance of the food. Sensory analysis was done by consuming the product by a sensory panel (Aneesa *et al.*, 2009). The sensory assessments were conducted from the selected six samples. Sensory characteristics of the extrudates were analyzed based on the appearance, colour, flavour and texture.

SENSORY EVALUATION CARD

Name of the panellist:-

Date:-

TREATMENT NO:	COLOR	TASTE	TEXTURE	OVERALL ACCEPTIBILITY

5-Like very much 4-Like 3-Neither like nor dislike 2-Dislike

1-Dislike very much Signature of panellist

Fig 3.3 Score card for sensory evaluation

CHAPTER IV

RESULTS AND DISCUSSION

This chapter deals with the results and discussion of the experiments conducted on extruded nutraceutical pasta from elephant yam, purple yam, drumstick pulp, maida, corn flour, atta and guar gum blended in different proportions.

4.1 Physical properties

4.1.1 *Colour*

The hunter lab colorimeter was used to analyse the samples, due to substitution of various flour levels, there was considerable difference in colour among the different sample levels. The lightness L* values of uncooked pastas decreased slightly from 28.16 to 37.05 than control (93.33) and that of cooked pastas were decreased slightly from 24.24 to 32.51 than the control (61.04). The a* values of both cooked and uncooked pastas were higher as compared to control (5.56 for cooked & 6.48 for uncooked). The decrease in L* value is may be due to the brownish colour imparted by the finger millet. Difference in the colour characteristics of all pasta samples may be attributed due to difference in the coloured pigments of different flours (Iwe *et al*. 2000). Carini *et al*., (2010) observed decreased L* value and drastically increased a* and b* values on addition of carrot based ingredients.

The colour values of the treatments were given below in terms of ‘L*’ ‘a*’ and ‘b*’in table 4.1.

Table 4.1 Hunter lab colorimeter values of cooked & uncooked samples

TREATMENTS	UNCOOKED			COOKED		
	L*	a*	b*	L*	a*	b*
Control	38.81	5.56	10.34	45.63	6.48	11.30
Sample 1	37.05	6.24	10.89	30.74	6.13	8.42
Sample 2	30.76	4.48	8.08	24.24	5.69	7.81
Sample 3	31.57	7.54	11.76	32.51	7.87	11.04
Sample 4	34.38	7.21	11.62	30.53	7.98	10.98
Sample 5	34.15	7.13	12.05	32.33	8.02	12.03
Sample 6	28.16	6.04	10.34	32.30	6.8	10.6

4.1.2 *Texture*

Textural evaluation is the main criteria to access the overall quality of cooked pasta. The textural properties of the extrudates were determined by measuring the peak force and breaking force by the methodologies described as per 3.8. The control cooked pasta had the best texture with firmness of 0.726N but for uncooked it has a firmness of 39.03N. The force required was higher (46.37N for uncooked & 0.7764N for cooked) for the samples containing atta (10%A+5%EY+55%PY+5%DS+25%R), this may be due to the strength offered by the gluten content in the atta makes it stronger than the other samples containing maida (35.07N for uncooked & 0.7472N). The next highest value of compression force was observed for the sample containing guar gum (38.07 for uncooked) this may be due to the binding property imparted by the natural gum (Wang *et al*. 1999). Variation in the texture of the pasta products may be attributed to the variation in the gluten strength as it reduced to the substitution of different flours (Amir.gull *et al*., 2015). Shukla & Srivastava (2014) also reported decrease in firmness of noodles incorporated with finger millet flour. The textural properties of the extrudates were determined by measuring the compression force it has been given below in table 4.2.

Table 4.2 Texture analyser values for cooked and uncooked samples

TREATMENTS	COMPRESSION FORCE (N)	
	UNCOOKED	COOKED
Control	39.03	0.726
Sample 1	35.0748	0.7472
Sample 2	35.85	0.6806
Sample 3	23.9	0.4666
Sample 4	46.37	0.7764
Sample 5	22.608	0.7308
Sample 6	38.07	0.742

4.1 .3 *Elongation*

The percentage elongation is higher (16.81% in length & 96.55% in width) for the sample containing maida (30%M+2%EY+18%PY+5%DS+45%DS) than the control sample (88.76% in length & 21.63% in width) and percentage elongation is lower (5.42 in length & 14.6 in width) for the sample containing corn flour (10%CF+5%EY+45%PY+5%DS+35%R). Further analysis shows that as the maida content decreases, the percentage elongation is also decreased (Zhu & Khan, 2002).

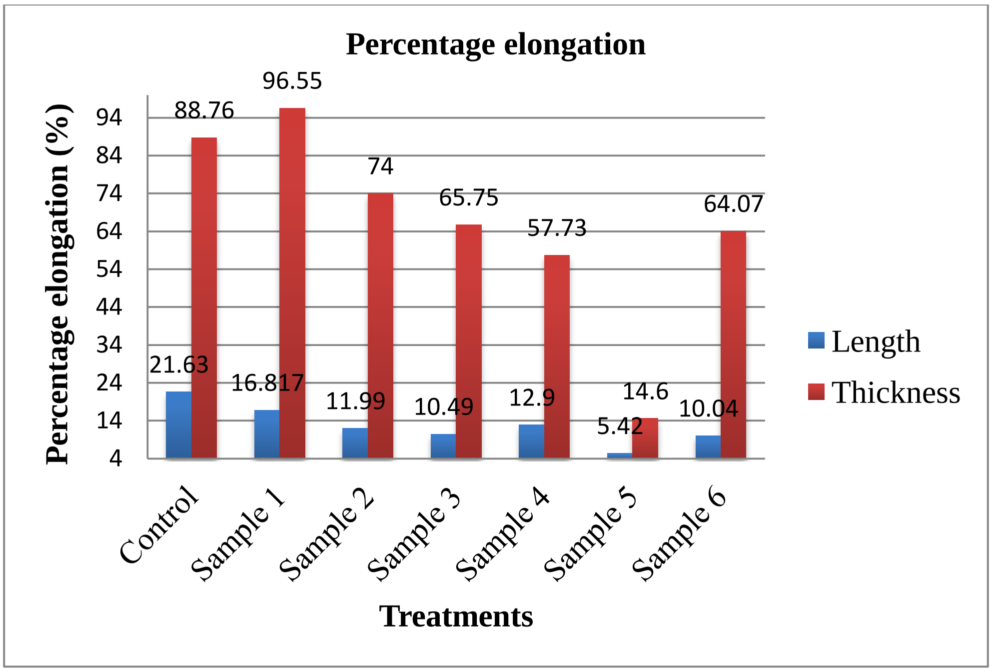

Fig 4.1 Percentage elongation of samples

4.2 Cooking qualities

4.2.1 *Optimum cooking time (OCT)*

Figure 4.2.1 reports the pasta cooking time evaluated in this study. Cooking quality parameters (OCT, swelling power and solid loss) were evaluated. It is observed that the OCT required for the control (14.3 min) is more followed by the samples consists of 10% maida (9 min) & 2% guar gum (8.2 min). This may be due to the increased atta content in control sample (Pastificio *et al.* 2011). The reason for the increased OCT is due to the presence of guar gum and decreased maida content which was further substituted by higher amount of purple yam required more cooking time (Khan *et al.*, 2013).

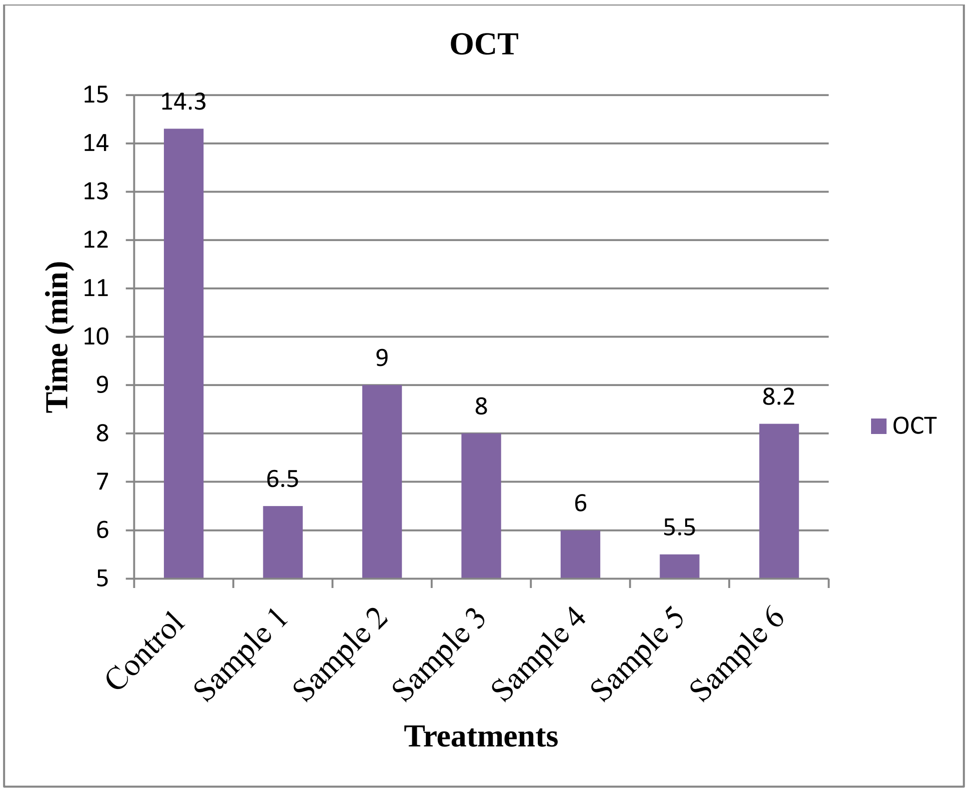

Fig 4.2 Optimum cooking time required for the samples

4.2.2 *Solid loss*

Cooking loss was calculated for an average time of 8.2 min (fig 4.3). Cooking loss is a measure of the amount of solid lost into the cooking water, is considered as an important factor. The total solid loss of control pasta was found to be 1.57% after 14.3 min of cooking. Solid loss gradually increased with the increased amount of PY and R from 0.88 to 1.57%. The increase in cooking loss observed can be attributed due to absence of gluten protein in these flours (Bhaskaran *et al*., 2011). Also since gluten protein network is responsible for retaining pasta physical integrity during cooking, a weaker structure leaches more solids from pasta samples into the cooking water increasing cooking residues (Khan *et al*., 2013). Similar effects on cooking losses have been reported for pasta products incorporating non-durum ingredients such as seaweed (Prabhasankar *et al*., 2009), dietary fibre (Tudorica *et al*., 2002), banana flour (Ovando *et al*., 2009).

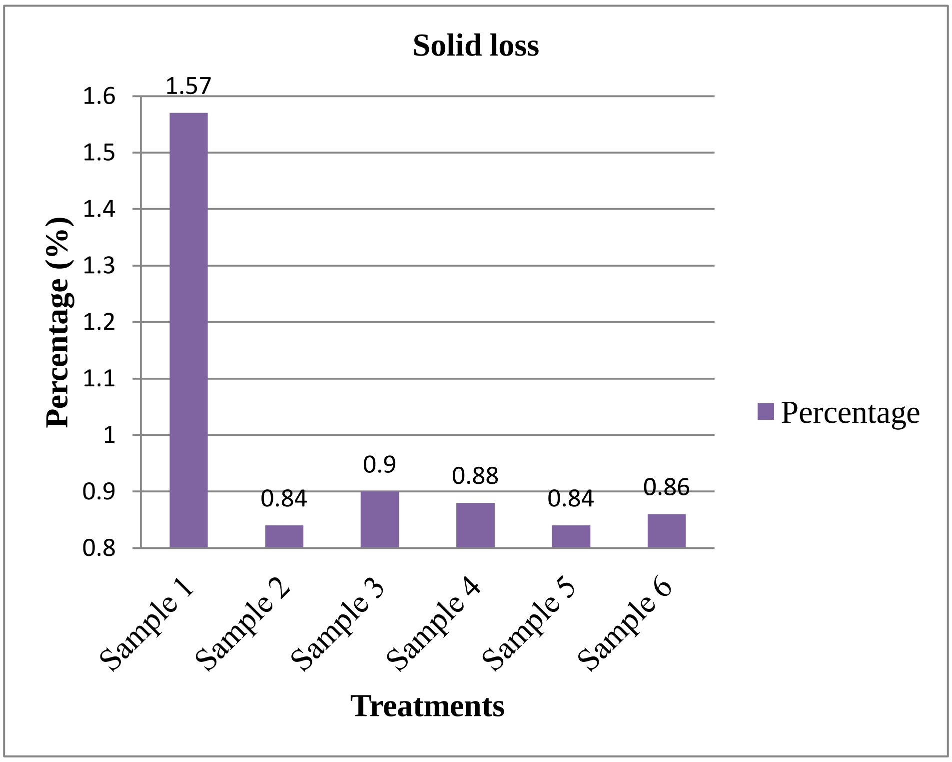

Fig 4.3 Total solid loss in samples

4.2.3 *Swelling power*

Swelling power is a measure of hydration capacity, because the determination is a weight measure of swollen starch granules and their occluded water. Food eating quality is often connected with retention of water in the swollen starch granules. Food eating quality is often connected with retention of water in the swollen starch granules (Rickard *et al*., 1992). Similarly, the swelling power for the control sample is seen more (1.42) followed by the compositions consist of 0% maida. Increased atta content increases the swelling power and as the maida content increases swelling power of the samples get decreased (Miao et al., 2009). Fig 4.4 shows the swelling power of the pasta samples.

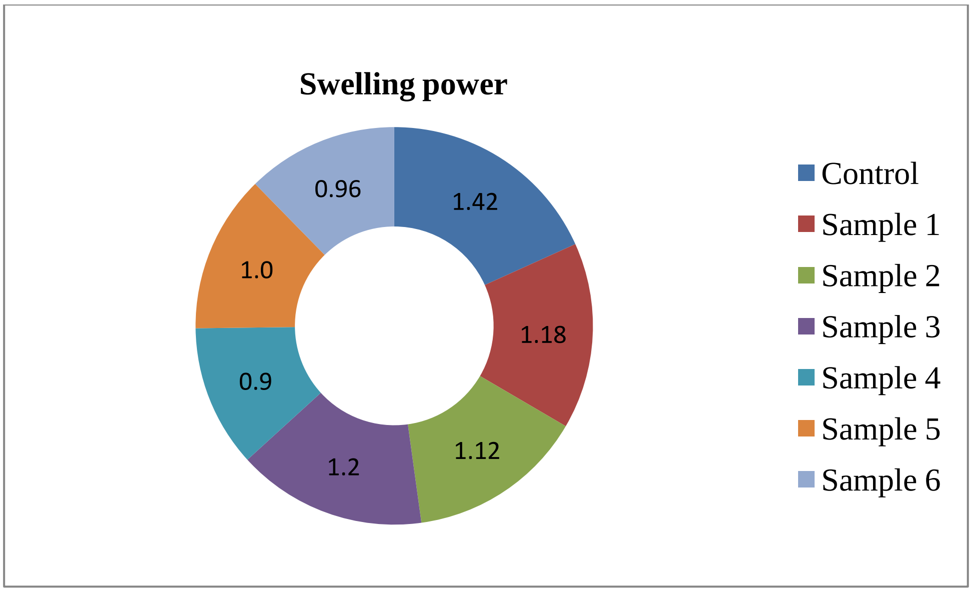

Fig 4.4 Swelling power of pasta samples

4.2.4 *Overall acceptability*

The success or failure of a new expanded food product is directly related to sensory attributes, where texture plays a major role (Iwe, 2000, Anton *et al.*, 2007). Sensory analysis represents the unique tool for determination of organoleptic properties of food using human senses, because it is highly correlated with the consumers' attitude (Jing *et al.*, 1991). At the same time the prepared samples of pasta were cooked and kept for sensory evaluation. The scores given for different treatments on different organoleptic traits namely, colour, taste, texture and overall acceptability were represented in 3.2.7

Sensory evaluation was carried out by a panel of 15 judges from the centre of excellence in post harvest technology by giving them a score card. Pasta samples were presented in a random order to each judge. The judges were asked to score different quality characteristics. The scores given for different treatments on different organoleptic traits namely, colour, taste, texture and overall acceptability are presented in fig 4.5, and texture of sample 6 was chosen as the best because of the presence of guar gum. It was observed due to the presence of the corn flour masking the taste of elephant yam, taste was found as best for the sample 5 (Agnesi *et al.*, 1996). The overall acceptability was higher for the sample 4 consists of atta followed by corn flour and guar gum. Based on the results from the analysis of cooking quality, colour, texture and sensory evaluation, it is recommended that 10% replacement level of Atta flour along with 25% finger millet flour and 55 % purple yam flour is the better to get the best product, which could be an alternate to the unhealthy pastas available in the market. Plate 3.6 shows the optimized sample. These products were packed in low density polyethylene packs (200 gauges) and the storage studies revealed that the products can store for six months without affecting the quality and cooking properties.

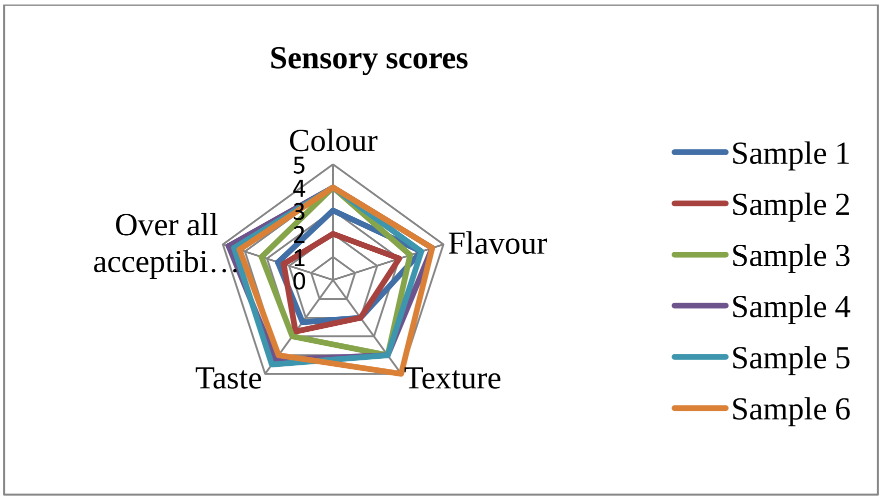

Fig 4.5 sensory scores of pasta samples

Plate 3.6 optimized sample

SUMMARY AND CONCLUSION

Food is consumed in combinations. The synergy between foods with other is vital not for taste and delight of eating but also for their high nutritional quality and health benefits. The modern trend for development of new food products aspires for complementary foods in order to fulfil the widening gap of food availability and nutritional security. Extrusion cooking is used for the production of expanded snack foods, modified starch ready-to- eat cereals, baby foods and pasta. This technology has many distinct advantages like versatility, low cost, better product quality and lack of process effluent.

Pasta should never remain as a luxury convenience food of the urban elite. It should also serve the purpose of the best nutritional alternative to the common man. Hence an economic functional pasta formulation has turned out to be the need of the hour.

Nutraceutical pasta was developed using flours such as yam flours, finger millet flour, and drum stick pulp flour as the main ingredients. The present work was carried out to investigate some of the physical and engineering properties of millet based nutraceutical pasta. Quality evaluation of the developed 6 pasta samples along with control was done for standard physical and engineering properties. By the analysis, optimized sample 4 (25% R + 55% PY + 5% DS+5% EY +10% A) is selected best based on colour, textural properties and sensory qualities. Further analysis including solid loss, percentage elongation and swelling power is done for the optimized sample 4.

The textural analysis showed a significant reduction in firmness for cooked pastas irrespective of the treatment combinations. The force required was higher for samples containing atta (for both cooked (0.7764 N) and uncooked pasta (46.37 N)). This could be due to the high strength offered by the gluten content in atta which makes stronger compared to millet based pasta (for both cooked (0.466 N) and uncooked (23.9 N)). The colour values showed a decrease in L* value (32.45) of ragi based pasta compared to other combinations for both cooked and uncooked samples. The expansion ratio after cooking showed a higher elongation (16.8%) for pasta containing corn flour and higher thickness (96.55%) was observed for millet based pasta. The OCT required for the sample containing corn flour was less (5.5 min) followed by the sample containing atta (6 min) compared to other treatments this may be due to lesser amount of maida. It is observed that the swelling for control (1.42) followed by the treatment with 0% maida and 30% maida this is due to high gluten content. Swelling power is less in the sample consist of guar gum (0.96) and atta (0.9). The solid loss is seen more in the control sample (1.57%) followed by the sample consist of 30% maida (0.9). Solid loss is lesser in the treatment consist of corn flour (0.82%). The overall acceptability was found to be higher in the treatment consist of atta flour followed by the sample consist of corn flour since the corn flour impart a pleasant taste, followed by the treatment consist of guar gum which gives a binding property to the pasta. The study concludes that the developed nutraceutical pasta incorporated with ragi (25%), purple yam (55%), elephant yam (5%), drum stick (5%) and atta (10%) not only ensure increase the acceptability but also increases the nutrition level. Hence nutraceutical pasta is recommended to consumers without any fear.

REFERENCES

Agnesi, E., Matsuo, J.E., and Dick, J.W 1996. The history of pasta, in pasta and noodle technology: Kreugar (ed). pp. 31-68.

Agulera, J .M., Crisafulli, E.B., Lusas, E.W. Uebersax, M.A., and Zabik, M.E. 1984. Air classification and extrusion of navy bean fractions. *J. Food.Sci.* 49: 543-46

Albi Abraham. and Jayamuthunagai, J. 2014. An analytical study on jackfruit seed flour and its incorporation in pasta. *Res. pharmaceutical, Biol.& Chemical. Sci.* 5 (2). 1597-1599

Ali, M., Shahin, R., Zahra, E.D., and Alireza, K. 2008. Kinetic models for colour changes in kiwifruit slices during hot air drying. *Wld. J. Agric. Sci*. 4 (3): 376-383

Amadou , I., Gbadamosi, O.S., and L. Guo-Wei. 2011. Millet-based traditional processed foods and beverages-A review. *Cereal Food World* 56 (3): 115–121

Amir gull., Kamlesh Prasadh., and Pradyuman Kumar.2015. Effects of millet flours and carrot pomace on cooking qualities, colour and texture of developed pasta.*LWT Food Sci. Technol.* 63. 470-474

Aneesa, E., Hridhya ,H., and Surya, S. 2009. Development and quality evaluation of ready to eat food from speciality rice and Nendran banana. B.Tech Project report, Kerala Agricultural University, Thrissur.

Anton, A. A. and Luciano, F. B. 2007. Instrumental texture evaluation of extruded snack foods. *Cienc Tecnol Aliment*. 5(4): 245-251.

Anuradha Singh. and Neeraj Wadhwa. 2014. A Review on multiple potential of aroid: *Amorphophallus paeoniifolius. Int. J. Pharm. Sci. Rev. Res.,* 24 (1): 55-60

Araghiniknam, M., Chung, S., Nelson-White, T., Eskelson, C., and Watson, R.R. 1996. Antioxidant activity of dioscorea and dehydroepiandrosterone (DHEA) in older humans. *Pharmacology Letters* 59, 147–157.

Baskaran1, D., Muthupandian, K., Gnanalakshmi1, K.S., Pugazenthi1, T. R., Jothylingam, S., and Ayyadurai, K. 2011. Physical properties of noodles enriched with whey protein concentrate (WPC) and skim milk powder (SMP). *J. Stored Products & Postharvest Res.* 2 (6). 127 - 130

Borneo, R. And Aguirre, A. 2008. Chemical composition, cooking quality, and consumer acceptance of pasta made with dried amaranth leaves flour. *LWT – Food Sci. Technol*, 41(10). 1748–1751.

Brown, J.C. and Livesey, G. 1994. Energy balance and expenditure while consuming guar gum at various fat intakes and ambient temperatures. *Am. J Clin Nutr.* 60 (6): 956-64.

Carini, E., Vittadini, C.E., Antoniazzi, F., and Viazzani, P. 2010. Effects of formulations on physicochemical properties & water status of nutritionally enriched fresh pasta. *Food Bioprocess Technol.*5.1642-1652

Cemalettin, S. and Mustafa, T.Y. 2010. Modelling the effects of processing factors on the changes in colour parameters of cooked meatballs using response surface methodology. *Wld. Appl. Sci. J.* 9 (1): 14-22

Chaiyakul, S., Jangchud, K., Jangchud, A., Wuttijumnong, P., and Winger, R. 2009. Effect of extrusion conditions on physical and chemical properties of high protein glutinous rice - based snack. *Food. Sci.Technol*. 42: 781-787.

Dewettinck, K., Van Bockstaele, F., Kuhne, B., Van de Walle., Courtens, T.,and Gellynck, X .2008. Nutritional value of bread: Influence of processing, food interaction and consumer perception. Rev. *J. Cereal Sci.,* 48: 243- 257

Dias V., Manolio, R.A., and Gomes, J.A. 2009. Storage stability of snacks with reduced saturated and trans fatty acids contents. *Ciencia e Tecnolgia Alimentos* 29 (3): 690-695.

Fellows, P.J. 2000. Food processing technology principles and practices. Wood head publishers, Cambridge.

Goplakrishnan., Jyothi., Menon., Renjusha., Padmaja., and Gowrikutty. 2011. Nutritional and functional characteristics of protein fortified pasta from sweet potato. *Food. Sci. Nutri*. 2. 990-996.

Hanne, L., Per, L.,and Marit, R. 2005. Sensory changes in extruded oat stored under different packaging, light and temperature conditions. *Food. Quality Preferences*. 16 (7): 573-584

Harijono., Teti Estiasih., Mulia, W., Apriliyanti, Asmak Afriliana., and Joni Kusnadi. 2013. Physicochemical and Bioactives Characteristics of Purple and Yellow Water Yam (*Dioscorea alata*) Tubers. *Int. J. Pharm Tech Research.* 5 (4). 1691-1701.

Harper, J.H. and Jansen, G. 1985. Production of nutritious precooked foods in developing countries by low cost extrusion technology. *Food. Rev. Int*. 1: 27-97

Harper, J.M. 1981. Extrusion of foods. Vol. 1. CRC Press, Raton, 17-19.

Harper, J.M. 1989. Food extruders and their applications in extrusion cooking. *Am.Ass. Cereal Chem.* 3: 1-15.

Iwe, M.O. 2000. Effects of extrusion cooking on some functional properties of soy-sweet potato mixtures using response surface analysis. *Pl. Food. Hum. Nutr.* 10: 169–184.

Jideani, V.and Onwubali, F . 2009. Optimisation of wheat-sprouted soybean flour bread using response surface methodology. Afr. *J. Biotechnol*., 8 (22): 6364-6373.

Jing, C., Florence, L.S., Rajesh, P., and Henry, D. 1991. Effect of extrusion conditions on sensory properties of corn meal extrudates. *J. Food. Sci*. 56 (1): 84-89.

Jisha, S., Sheriff, J.T., and Padmaja, G. 2010. Nutritional, functional and physical properties of extrudates from blends of cassava flour with cereal and legume flours. *Int. J. Food. Properties.* 13:1002–1011.

Joshi, A., Rawat, K., and Karki, B. 2008. Millets as religious offering for nutritional, ecological and economical security. *Comp. Rev. Food Sci. Food. Safety* 7:369-372.

Khan, L., Yousif, A., Johnson, S., and Gamlath, S. 2013. Effects of sorghum flour addition on resistant starch content, phenolic profile and antioxidant capacity of durum wheat pasta. *Food. Res. Int*. 54. 578-586.

Lakshmi, D.N., Aparna, K., and Kalpana, K. 2013. Utilisation of fish mince in formulation and development of pasta products. *J. Int. Food. Res*. 20 (1): 219-224.

Leszek, M. and Zuilichem, D.J. 2011. [on line]. Extrusion cooking technology: Applications, theory and sustainability. [14 Feb 2011]

Mangale ,S. M., Chonde, S. G., Jadhav A. S., and Raut, P. D. 2012. Study of *Moringa oleifera* (Drumstick) seed as natural absorbent and antimicrobial agent for river water treatment. *J. Nat. Prod. Plant Resour*. 2 (1): 89-100

Marchylo, B. A., & Dexter, J. E. 2001. Pasta production. In G. Owens. (Ed.), *Cereals processing technol.* Boca Raton, Boston, New York, Washington, DC: CRC Press. 109–130.

Maria de Lourdes Moreno., Isabel Comino., and Carolina Sousa. 2014. Alternative grains as potential raw material for gluten - free food development in the diet of celiac and gluten- sensitive patients. *Austin J. Food. Nutri. Fd. Sci* ; 2 (3): 9-15.

Miao, M., Zhang, T. and Jiang, B. 2009. Characterisations of kabuli and desi chickpea starches cultivated in china. *Food. Chemistry.* 113:1025-1032.

Ndife, J. and Abbo, E. 2009. Functional Foods: Prospects and Challenges in Nigeria. *J. Sci. Technol*., 1 (5): 1-6.

Nomjit Suteebut., Kasarin Petcharat., Duangkamol Tungsathitporn., and Duangrat Sae-tung. 2009. Pasta from organic jasmine rice. *As. J. Fd. Ag-Ind*. S349-S355.

Ovando, M.M., Sayago, A.S., Agama, A.E., Goni, I and Bello, P.I.A. 2009. Un ripe banana flour as an ingredient to increase the undigestable carbohydrates of pasta. *Food. Chem*. 113 (1). 121-126.

Pastificio Cav. and Giuseppe Cocco. 2011. Effect of semolina particle size on the cooking kinetics and quality of spaghetti. *Procedia Food. Sci.* 1. 1740–1745.

Patil, Y.R. and Sawant, R.S. 2012. A role of starch of Eleuesin corcana Gaertn (Ragi Satwa) in management of malnutrition. *Int. J. Pharm*. 3 (2): 287-290.

Peri, C., Barbieri, R., and Casiraghi, E.M. 1983. Physical, chemical and nutritional quality of extruded corn germ flour and milk protein blends. *J. Food. Techol*. 18: 53-60.

Prabhasankar, P., Ganesan, P., Bhaskar, N., Hirose, A., Stephan, N., and Gowda, L.R. 2009. Edible Japanese seaweed, wakame (*Udaria pinnatifida*) as an ingredient in pasta: chemical, functional & structural evaluation. *Food. Chem*. 115 (2). 501-508.

Rickard, J.E., Blanshard, J.M.E., and Asaoka, M. 1992. Effects of cultivar and growth season on the gelatinization properties of cassava (*Manihot esculenta*) starch. *J. Sci. Food. Agric*. (59) 53-58.

Sasaki, T. and Matsuki, J. 1998. Effect of wheat starch structure on swelling power. *Cereal Chem*. 75 (4): 525-529.

Shashi, B.K., Sharan, S., Hittalamani, S., Shankar, A.G., and Nagarathna, T.K. 2007. Micronutrient composition, antimicronutirent factors and bioaccessibility of iron in different finger millet (*Eleucine coracana*) genotype. Karnataka. *J. Agric. Sci*. 20 (3): 583-585

Shukla, k. and Srivastava, S. 2014. Evaluation of finger millet incorporated noodles for nutrition value and glycemic index. *J. Food. Sci. Technol.* 51 (3) 527-534.

Stephen and Marco. 2009. Chemical and physical characteristics of cooked egg pasta. *The Int. J. Nutri. Diet*. 42: 503-508.

Sudhadevi, G., Palanimuthu, V., and Arunkumar, P. 2012. Development of proso millet based cold extruder product. *J. Enviro and E*. 31 (1): 212-215.

Sumathi, A., Ushakumari, S.R., and Malleshi, N.G. 2007. Physicochemical characteristics, nutritional quality and shelf life of pearl millet based extrusion cooked supplementary foods. *Int. J. Food. Sci.Nutr*. 58 (5): 350-362.

Tudorica, C.M., Kuri, V., and Brennan, C.S. 2002. Nutritional and Physicochemical characteristics of dietary fiber enriched pasta. *J. Agri. Food .Chem*. 50 (2). 347-356.

Wang, N., Bhirud, P.R., and Tyler, R.T. 1999. Extrusion texturization of air-classified pea protein. *J. Food. Sci.* 64 (3): 509-514.

Yen-Wenn Liu., Huey-Fang Shang., Chung-Kwe Wang., Feng-Lin Hsu., and Wen-Chi Hou. 2007. Immunomodulating activity of discorin, storage protein of yam (*Dioscorea alata* CV Tainong No.1) tuber. *Food. Chem & Technol*. 45, 2312-2316.

Zava, D.T., Dollbaum, C.M., and Blen, M. 1998. Estrogen and progestin bioactivity of foods, herbs, and spices. *Proceedings of the Society for Experimental Biology and Medicine* 217, 369–378.

Zeng J., Gao H., Li G., and Liang, X. 2011. Extruded corn flour changed the functionality behaviour of blends. Czech *J. Fd. Sci*., 29: 520–527.

Zhu, J., Khan, K. 2002. Quantative variation of HMW glutenin subunits from hard red spring wheats grown in different environments. *Cereal Chem*. 79, 783–786.

DEVELOPMENT AND QUALITY EVALUATION OF NUTRACEUTICAL PASTA

By,
ANJALI K U

KISHORE JOHNSON

SANAL JOSEPH

ABSTRACT OF THE THESIS REPORT

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Kerala Agricultural University

Department of Food and Agricultural Process Engineering
Kelappaji College of Agricultural Engineering & Technology
Tavanur P.O.-679573Kerala, India

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ABSTRACT

Pasta by itself is a healthy nutritional diet, and has great scope as an ideal functional food if supplemented with additional health ingredients. Taking this context into consideration there is a need to develop nutraceutical pasta which explores different health ingredients that are compatible with the physiological characteristics of pasta.

A study was conducted on development of nutraceutical pasta by cold extrusion technique using lab scale DOLLY equipment. The samples were made by mixing ingredients ragi, drumstick, atta, corn flour & yams. The vegetables were further blanched, dried, powdered and mixed with pulverized cereal. The extruded pasta was dried in cabinet dryer at a temperature of 65°C for 30 min. The textural analysis using a texture analyzer showed that the force required was higher for samples containing atta (for both cooked (0.7764 N) & uncooked pasta (46.37 N)). This could be due to the high strength offered by the gluten content in atta which makes stronger compared to millet based pasta (for both cooked (0.466 N) & uncooked (23.9 N)). The colour values measured by hunter lab colour flex meter showed a decrease in L* value (32.45) of ragi based pasta compared to other combinations for both cooked and uncooked samples. The percentage elongation checked with a digital vernier caliper after cooking showed a higher elongation (16.8%) for pasta containing ragi and higher thickness (96.55%) was observed for millet based pasta. The OCT and solid loss for the optimized sample was less (5.5 min & 0.82% respectively). The overall acceptability was found to be higher in the sample 5 followed by the sample 4. It is observed that swelling power is less in treatment consists of corn flour. The study concludes that developed nutraceutical pasta incorporating ragi (25%), purple yam (55%), elephant yam (5%), drumstick (5%) and atta (10%) is a good substitute for commercial pasta.