DEVELOPMENT OF PASTA USING JACKFRUIT SEED FLOUR, BROKEN RICE FLOUR AND BANANA FLOUR

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PROJECT REPORT

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DECLARATION

We hereby declare that this project report entitled **"DEVELOPMENT OF PASTA USING JACKFRUIT SEED FLOUR, BROKEN RICE FLOUR AND BANANA FLOUR"** is a bonafide record of project work done by us during the course of project 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.

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DEDICATED TO TEACHERS AND FRIENDS

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SYMBOLS AND ABBREVIATIONS

%	percentage
^{o}C	degree centigrade
a_w	water activity
BRF	broken rice flour
i.e	that is
cm	centimeter
DSF	defatted soy flour
et al	and others
FP	fish powder
g	gram
g/cm^3	gram per centimeter cube
g/g	gram/gram
GDP	gross domestic product
GFP	gluten free pasta
H	hour
JSF	jack fruit seed flour
Kg	kilo gram

m	meter
m.c	moisture content
min	minute
ml	milli liter
mm	milli meter
N	newton
Ppm	part per million
RDS	rapidly digested starch
Rpm	rotation per minute
RS	resistant starch
WPC	whey protein concentrate
w/v	weight by volume
w/w	weight per weight

INTRODUCTION

CHAPTER I

INTRODUCTION

Fruit and vegetable processing sector is one of the largest sectors in India in terms of production, growth, consumption and export. A by-product is a secondary product derived from manufacturing process. It is not the primary product or service being produced. A by-product can be defined as the ‘output from a joint production process that is of minor net realizable value (NVR) and quality when compared to the main products’.

Jackfruit (*Artrocarpus heterophylus*) is a popular fruit of tropics and grown widely in India. The edible bulb of jackfruit is usually consumed, 10-15% of total fruit weight is considered as its seed weight. Though seeds are rich in carbohydrates and proteins, they are occasionally used as minor supplements but are mostly wasted. Significant quantities of jackfruit seed are generated as waste product in jackfruit processing industries. It is thus significant and even essential to find applications for the seeds.

Broken rice is a grade of rice consisting of grains broken in the milling process. Milling rice or paddy produces around 50% brown rice and approximately 16% broken rice, 20% husk, 14% bran and meal. Broken rice has similar energy content to intact rice. Very small broken rice is called 'brewers' rice', as use by brewers is the traditional industrial use. Due to the different size and shape of the grains, broken rice has a different, softer texture from "unbroken" rice. Broken rice is also used to make starch which is used as laundry starch and in foods, cosmetics and textile manufacture.

Banana flour is a powder traditionally made of green bananas that is often used as a gluten free replacement to wheat flour or as a source of resistant starch, which has been promoted by certain dieting trends such as paleo and primal diets and

by some recent nutritional research. Gluten free alternative to wheat based flours for those suffering from celiac disease and those who choose a gluten free diet. Gluten is a proteinaceous material that can be separated from flour when the starch and other minor components of the flour are removed by washing out under running water. The resulting gluten contains approximately 65% water. On a dry matter basis, gluten contains 75-86% protein, the remainder being carbohydrate and lipid, which are held strongly within the gluten protein matrix. Gluten contains the protein fractions glutenin and gliadin. The former is a rough, rubbery mass when fully hydrated, while gliadin produces a viscous, fluid mass on hydration. Gluten, therefore, exhibits cohesive, elastic and viscous properties that combine the extremes of the two components.

Celiac disease (CD) is a permanent intolerance to gluten. Those who suffer from celiac disease manifest anomalies of the intestinal mucosa with partial or total atrophy of the villi following the consumption of food containing gluten. Therefore this pathology is often correlated with a mal-absorption of several important nutrients, including iron, folic acid, calcium and vitamins. The only way to overcome the celiac disease is to consume only gluten free products. The measure of celiac disease is increasing and seriously affecting the health of individuals. With the increasing awareness there exists a greater scope for gluten free products. The gluten free products market represents one of the most prosperous markets in the field of food and beverages in the immediate future.

Gluten free products like pasta and cookies markets have increased in recent years. Pasta is also known as noodles or chowmein or vermicelli or macroni. These are all generic names of the same items. Pasta comes in different sizes and shapes like strings, alphabets, macroni, fancy shapes like shells, wheels, twists, butterflies or ribbons. Each pasta is complemented with variety of sauces, vegetables, olive oil, meat to add to the taste and eating methods of the consumer. It is accompanied with

assorted bread. Since the nutritional value of pasta is very high, it has become very popular among the young and old alike.

Pasta is a part of well-balanced diet. It is also 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 any number of dishes. Pasta may be divided into two broad categories, dried pasta (*pasta secca)* and fresh (*pasta fresca)*.

Most dried pasta is commercially produced via an extrusion process. Fresh pasta was traditionally produced by hand, but today many varieties of fresh pasta are also commercially produced by large scale machines. Both dried and fresh pasta come in a number of shapes and varieties, with 310 specific forms known variably by over 1300 names.

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 fiber requirement in every one cup portion.

Extrusion has been used to process cereal legume blends for many years. When heating and during the extrusion process the macromolecules in food ingredients lose their native, organized tertiary structure and form a viscous plasticized material. At the end of the die, fast vaporization of the water present in food takes place, leading to structural reorganization and producing a series of textural products. Among these pasta is the product made by extrusion. Extrusion of a mixture, instead of only the cereal portion would ensure a nutritious precooked blended product with the elimination of prolonged cooking. So a product enriched with these raw material viz. jackfruit seed flour, banana flour and rice flour will

ensure a food which is safe to consume, nutritious and ready to eat pasta with more or less, same textural characteristics as that of wheat based pasta.

In this background, a study was conducted in KCAET, Tavanur which encompasses the following specific objectives;

` 1. To standardize the composition of pasta prepared from jackfruit seed, Banana flour, Rice flour and Atta

2. Quality evaluation of the developed pasta

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

This chapter gives general information on jackfruit seed, banana flour and broken rice flour, its chemical composition and its effect on quality of end products. Research done on these aspects were reviewed and discussed in detail under the following topic.

2.1 Pasta

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 any number of dishes. Pasta may be divided into two broad categories, dried pasta (*pasta secca)* and fresh (*pasta fresca).*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.

Bidingmeyer *et al.* (1987) evaluated nutritional and functional characteristics of protein-fortified pasta from sweet potato. The objective of this study 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, WPC, DSF and 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 RDS and the highest 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: 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.

Torben *et al.* (2005) 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 this work was to evaluate the effect of extrusion, lamination and lamination under vacuum on physico-chemical properties of selected fresh pasta. The water status of fresh pasta was slightly affected by the shaping process.

Satterlee *et al.* (1979) evaluated the physico-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 (0.0) % 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.

Sindayikengera *et al.* (2006) made an evaluation on pasta from organic jasmine rice. The aim of the study was to utilize the organic agricultural produce considering environmental awareness, natural balance and biological diversity. 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% fibers respectively. The study of shelf life of pasta at room temperature for 3 months showed that the product color 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.

Malcolmson *et al.* (1993) conducted a study on chemical composition, amino acid profile and metabolizable energy value of pasta refusals, and its application in broiler diets in response to feed enzyme The apparent dry matter digestibility was significantly ($P<0.01$)different among the three feedstuffs with the highest values obtained for the pasta refusals. Similarly, the apparent nitrogen retention was different ($P<0.001$) among the feed ingredients with the more negative values allocated to the cocks on maize samples. The average AME_n values of maize, wheat, and pasta refusals samples were determined to be 14.1, 12.6, and 15.5 MJ kg−1, respectively. The highest ADWG values were observed for the chickson 400 g kg−1pasta refusals-containing diets supplemented with 1000 U kg−1xylanase.Dietary inclusion of pasta refusals in the expense of wheat significantly ($P < 0.05$) improved feed conversion ratio (FCR) during grower period. In addition, dietary supplementation of at least 500 U kg−1xylanase improved FCR values during both 7–35 ($P < 0.01$) and7–49 ($P < 0.05$) d periods

Stephenson (1983) made evaluation on Manufacture and characterization of pasta made with wheat flour rendered gluten-free using fungal proteases and selected

sourdough lactic acid bacteria. It was found that wheat flour, which was rendered gluten-free by sourdough lactic acid bacteria fermentation and fungal proteases, was used for manufacturing experimental gluten-free pasta (E-GFp), according to a traditional process with low temperature drying cycle. Chemical, technological, structural, nutritional and sensory features were characterized and compared with those of commercial gluten-free (C-GFp) and durum wheat pasta (C-DWp). As shown through immunological analyses, the residual concentration of gluten of the hydrolyzed wheat flour was below 10 ppm. E-GFp showed rapid water uptake and shorter optimal cooking time compared to the other pastas.

2.2 Extrusion process

Lakshmi *et al.* (2013) developed pasta products using refined wheat flour, semolina, green gram, black gram, cheese flavor 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 and fish in the ratio of 32.5 : 32.5:10:5:20.

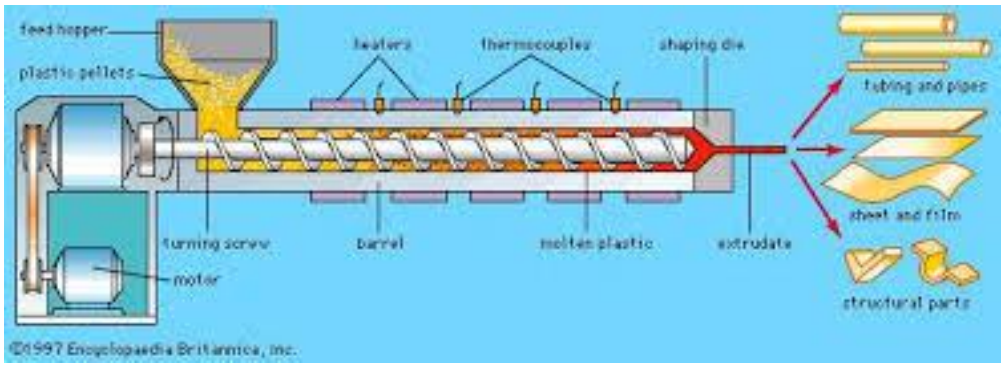

Fig 2.1: Pasta maker

Sudhadevi (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.

Cabrera *et al.* (2012) conducted a study on molecular rearrangement in extrusion processes for the production of amaranth-enriched, gluten free rice pasta. The high firmness of rice- only pasta is due to the elevated content of starch in rice flour, and to starch retro gradation in the extrusion- cooking process. The addition of amaranth flour increases the amount of protein and fiber that act synergistically in decreasing the extent of retrograded starch. Antagonistic and synergistic relationships have been reported between fiber and other food components (mainly starch and protein) and have been related to restricted water movement during the cooking of pasta products. Thus, the decrease in firmness of fiber enriched pasta may be associated with a decrease in starch swelling and gelatinization.

2.3 Jackfruit seed

Abedin *et al.* (2012) studied on the nutritive composition of jackfruit seeds; showed protein content was ranged from 13-18%. Crude fiber content of seed varied from 1.56-2.60%. jackfruit is a good source of many mineral contents like N, P, K, Ca, Mg, S, Zn, Cu etc. starch content in seed was found from 12.86- 17.90%.

10-15% of total fruit weight is considered as its seed weight. The seeds are nutritious and important source of diet. They are boiled or roasted and eaten like chestnuts, or cooked as some local dishes (Rajeswari *et al*., 2013). The seeds are also marketed in canned as in boiled form like the beans, in brine and in tomato sauce (Morton, 1987). Seed flour, which is high in protein and carbohydrate and has good water and oil absorption abilities, is used as an alternative for wheat flour to reduce calorie intake (Prakash *et al.,* 2009; Tulyathan *et al.,* 2002.). Jackfruit seeds are a

good source of starch (22%) and dietary fiber (3.19%) (Guria *et al.,* 2006). Jackfruit seed contains lignans, isoflavones, saponins, all phytonutrients and their health benefits are wide-ranging from anticancer to antihypertensive, anti-aging, antioxidant, antiulcer, and so on (Fardet, 1998).

Boiled jackfruit seeds are very tasty and nutritious snacks, jackfruit seeds, which taste like chestnuts, appeal to all taste. They may be boiled or roasted and eaten or boiled and preserved in syrup like chestnuts. Bobbio *et al.* (1978) reported protein, crude lipid, and carbohydrate contents of jackfruit seeds as 31.9%, 1.3%, and 66.2%, respectively. The protein content reported was very high probably, because the seeds were reported to have been collected from fruits of various trees and no variety was reported. Kumar *et al.* (1988) also reported on the composition of seeds from 2 varieties of jackfruit. Protein, crude lipid, and carbohydrate content were 17.8% to 18.3%, 2.1% to 2.5%, and 76.1%, respectively. There have been few studies on jackfruit seeds. Bobbio *et al.* (1978) reported some physicochemical properties, such as pasting characteristics of jackfruit seed starch. Kumar *et al.* (1988) studied the proximate compositions of 2 varieties of jackfruit seeds and reported considerable biochemical differences between them. The starch content of the seed increased with maturity and different locations gave different seed contents (Rahman *et al.,* 1999).Jackfruit seed flour has great potential in the food industry, especially as thickener and binding agent in various food systems (Samatarini *et al.,* 2007). Some functional properties of jackfruit seed flour and its protein digestibility was reported by Singh *et al.* (2007).The fresh seed contains crude proteins (606 g), fat (0.4 g), carbohydrates (38.4 g), fiber (1.5 g), ash (1.25 to 1.50 g), and moisture (51.6 to 57.77 g) (Morton, 1987). Information on food value per 100 g of edible portion of dried seed is scarce. The presence of anti-nutritional factors such as tannin and trypsin inhibitors has been reported, resulting in digestive ailment when eaten raw (Morton, 1987).

Narayana (1984) made an analytical study on jackfruit seed flour and its incorporation in pasta. It was found out that jackfruit seeds make-up around 10 to 15% of the total fruit weight and have high carbohydrate and protein contents, dietary fiber, vitamins, minerals and phytonutrients. To increase the shelf life, jackfruit seed flour is a better option, so that the analysis had done. Jackfruit seed flour (JSF) was a cheap source of protein (13.49%), ash (2.47%) and carbohydrate (70.73%). The calorific value was 357.665 kcal/100g. It was also rich in potassium (6466 ppm), magnesium (4582 ppm) and sodium (8906 ppm). High water absorption capacity (2.91 ml/g), oil absorption capacity (0.884 ml/g) and bulk density (0.873 g/ml) were recorded for JSF. It had a least gelation capacity of 17%. The addition of JSF at different proportions (5%, 10%, 15% and 20%) to the pasta increased the nutrient content and textural properties. 10% JSF substituted pasta has got the maximum consumer acceptability.

2.4 Banana

Bananas are mainly produced in tropical and sub tropical developing countries. According to the FAO India are the largest producers of banana. Bananas are a very delicate commodity for economic, social, environmental and political reasons. Starch is the main component of unripe banana, corresponding to 60‑80 g/100 g (dw) of the fruit, a percentage range similar to that of corn or potatoes.

2.5 Banana flour

Banana flour is a powder traditionally made of green bananas that is often used as a gluten free replacement to wheat flours. Banana flour is generally produced with green bananas that are peeled, chopped, dried, and then ground. This process can be completed traditionally by hand where the bananas are sun dried, dried in an oven, or a residential food dryer and then either ground in a mortar and pestle or with a mechanical grinder. The green banana process requires 8–10 kg of raw green bananas

to produce 1 kg of banana flour. It is being marketed as gluten free alternative to wheat based flours for those suffering from celiac disease and those who choose a gluten free diet.

Menezes *et al.* (2010) made an evaluation of chemical composition and nutritional value of unripe banana flour. It was found that the unripe banana flour (UBF) presented a high amount of total dietary fiber (DF) (56.24 g/100 g), which consisted of resistant starch (RS) (48.99 g/100 g), fructans(0.05 g/100 g) and DF without RS or fructans (7.2 g/100 g).The contents of available starch (AS) (27.78 g/100 g) and soluble sugars (1.81 g/100 g) were low the main phytosterols found were campesterol (4.1 mg/100 g),stigmasterol (2.5 mg/100 g) and β-sitosterol (6.2 mg/100 g). The total polyphenol content was 50.65 mg GAE/100 g. The content of Zn, Ca and Fe and mineral dialyzability were low.UBF exhibited undamaged starch granules and low energy value. Mineral, phytosterols, available carbohydrate and total polyphenol contents were low in UBF, but with moderated antioxidant activity. In conclusion, the carbohydrate profile of UBF indicates that it has characteristics of a potential functional ingredient.

2.6 Broken rice flour

Broken rice is a grade of rice consisting of grains broken in the milling process. On milling *Oryza sativa*, commonly known as Asian rice or paddy rice, produces around 50% brown rice then approximately 16% broken rice, 20% husk, 14% bran and meal. Further grains break before and after milling in transport. Mechanical separators are used to separate the broken grains from the whole grains. Broken rice may or may not have lower fiber and nutrient content, but generally has similar energy content to intact rice. Very small broken rice is called 'brewers' rice', as use by brewers is the traditional industrial use. Due to the different size and shape of the grains, broken rice has a different, softer texture from "unbroken" rice. Broken

rice is also used to make starch which is used as laundry starch and in foods, cosmetics and textile manufacture.

Bussakorn *et al.* (2005) conducted a study on physiochemical properties, proximate composition, and cooking qualities of locally grown and imported rice varieties. It was observed that. 'Black rice' variety had the highest protein content (8.16%) with lowest fat content (0.07%). Between the various rice varieties investigated, thousand kernel weight varied between 16.97-19.43 g, length/breadth (l/b) ratio was between 2.09-3.75, while bulk density varied between 0.81-0.86 g/ml. Amylase content was highest (27.71%) in white rice (local, medium grain type) with lowest recorded for brown rice variety (3.36%). Results on minimum cooking time showed it to range between 10 to 31.67 minutes with the brown rice cooking the slowest. The water uptake ratio ranged between 2.33 to 3.95 and was low in glutinous rice (2.33), while gruel solid loss (range from 3.17 to 6.43) was lowest in Basmati rice variety (3.17%). The minimum cooking time was found to be negatively correlated with amylase content (r = -0.97). A positive correlation was recorded for both amylase content and l/b ratio in relation to elongation of cooked rice. These results highlight cooking and physiochemical properties of rice to be strongly dependent on their amylase content. Results generated in this study might be able to provide vital information's on identifying 'superior quality of rice' marketed in Penang, based on their proximate composition as well as on their physiochemical and cooking properties.

2.7 Properties

Sumolwongwaisri *et al.* (1982) studied the extrusion cooking and bio-conservation of cereals and reported that at typical high temperatures and pressure prevailing in HTST extrusion cooking an water activity (a_w) approximately 1 may be reached even at well below 20% moisture, explaining the high degree of cooking

obtainable during extrusion cooking of cereal based materials at very low moisture level.

Bulk density was determined by taking the flour sample in a measuring cylinder filled up to a certain mark the initial volume and initial weight of the sample were recorded then the flour samples were given equal tapping and final volume was recorded, the bulk density of the sample was calculated from the data thus obtained.

Water absorption capacity was evaluated following method with minor modification. 1gm of flour was dissolved in 25 ml of distilled water and vortexed thoroughly and centrifuged at 2500 g for 10 min. The residue obtained up on decanting the soluble fraction was weighed. The water absorption capacity was expressed in ml of water absorbed by 1gm of flour or in % (v/w) (Abbey *et al.,*2010).

The JSF has a swelling power of 5.264. 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.

Chandakmnuan and Sangsomebunyasak (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 practical perspectives, empirical methods are suggested as alternative to fundamental technique, especially to food scientists and food manufactures interested in predicting consumer perception of texture.

MATERIALS AND METHODS

CHAPTER III
MATERIALS AND METHODS

This chapter deals with the methodologies used to perform the preparation of samples, blending of prepared flours, extrusion of jack fruit seed flour, banana flour, rice flour and atta blended in different proportions. The chapter also describes the standardized method to carry out the physical, textural and sensory tests to analyze the qualities of the developed pasta.

3.1 Raw Materials

Raw materials selected for the study were jackfruit seed, Nendran banana, broken rice and atta. The raw materials were collected from local market.

3.1.1 Jackfruit seed

Jackfruit seed is a byproduct obtained from jackfruit. Seed is collected and sun dried to moisture content of 6% (Rajeshwari *et al.,*2013). Outer white cover is removed by using knife and is sliced into small pieces with brown skin. Seed is then dried in a tray dryer at 65±5°C. Dried seed is then milled in a hammer mill to a mesh size of 40 and Packed in LDPE.

3.1.2 Banana

Raw banana is collected from the market. Peeling is done by using knife and is sliced into small size by using slicer. Banana is then dried in tray dryer at 65±5°C milled in hammer mill to a mesh size of 40 and packed in LDPE, (Menezes *et al.,*2010)

3.1.3 Rice flour

Brown rice is collected from farm and is cleaned in water, tray dried. After sun drying, rice is milled by using hammer mill to a mesh size of 40. Rice flour is packed in LDPE and stored Bussakorn *et al.,*(2005).

3.2 Composition of Pasta

Pasta of 9 different combination and a control was made according to the proportions sited in table 3.1

Table 3.1 composition of pasta

Samples	**Atta**	**Jackfruit seed powder**	**Banana flour**	**Rice flour**
Sample 1	50%	25%	12.5%	12.5%
Sample 2	40%	30%	15%	15%
Sample 3	30%	35%	20%	15%
Sample 4	30%	40%	20%	10%
Sample 5	25%	40%	25%	10%
Sample 6	20%	50%	15%	15%
Sample 7	15%	40%	35%	10%
Sample 8	5%	50%	35%	10%
Sample 9	0%	45%	45%	10%
Control	100%	0%	0%	0%

3.3 Pasta

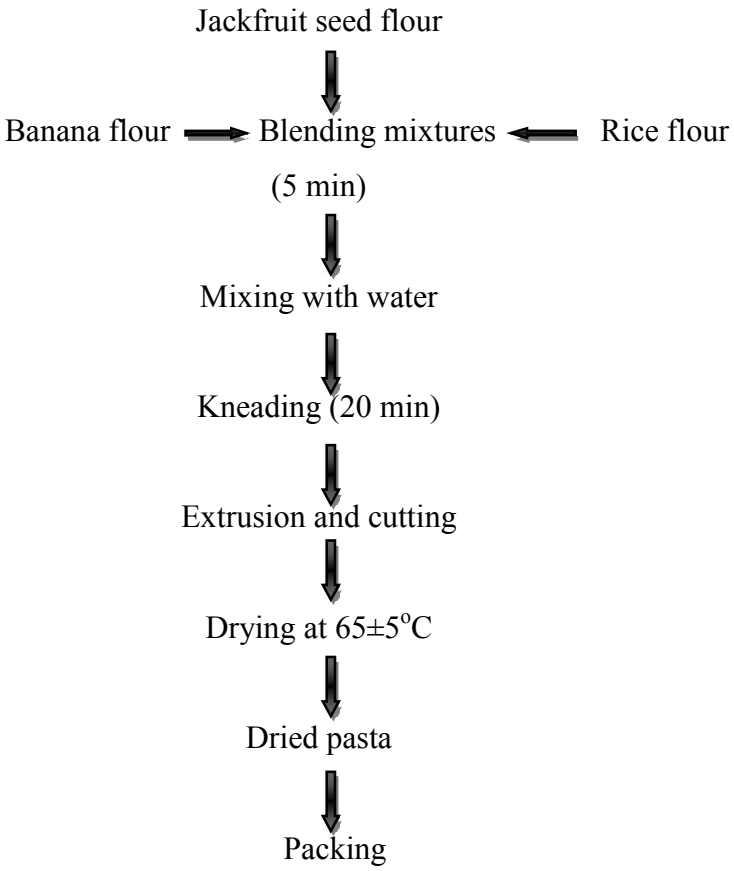

Fig 3.1 . flow chart for pasta making

3.3.1 Pasta Maker

A pasta maker or Pasta machine is a medium sized kitchen tool designed to simplify the process of rolling and cutting egg noodles, or other kinds of dough to make fresh pasta. Some machines have inbuilt cutters where the sheet can be passed through a cutter and separated into strips of the appropriate.

Unlike an extrusion type pasta maker, the manual type has a crank attached or in most cases, slots for a crank on the side. The crank turns a series of rollers, some

interlocking to cut, and others just to flatten. An adjuster wheel on one side controls the distance between the flat crank roller wheels. There are typically two sets of cutting wheels, each with its own slots for the crank. One set is very finely spaced for cutting spaghetti; the other is spaced at about 5 mm. The pasta making machine is shown in Plate 3.2, this is an Italian made machine, Dolly with a capacity of 2 kg.

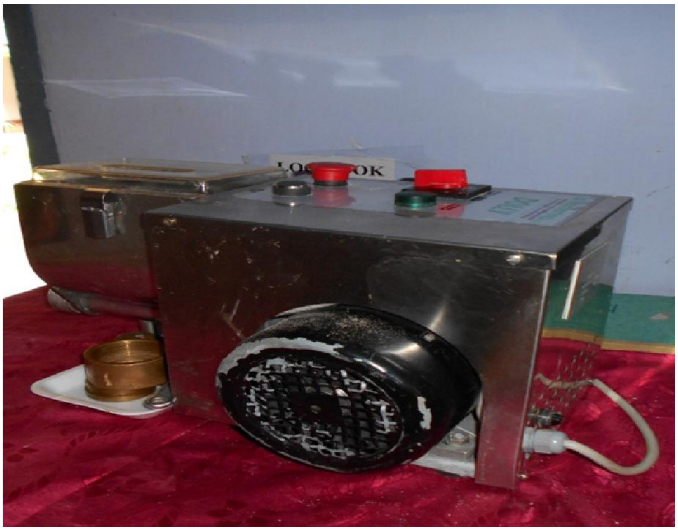

Plate 3.2: Pasta maker

This machine essentially consists of a single screw placed within a channel or cage along with a die and a mixture. The screw inside the barrel is being rotated by an electric motor present within the pasta maker. It carries out a cold extrusion process.

3.3.2 Preparation of pasta

Pasta was prepared from different composition of flour by using pasta making machine. Raw materials (Atta, jackfruit seed flour, banana flour and rice flour) were weighed using weighing balance and mixed well. Then the samples were blended with 30% water and kneaded for 2-3 minutes to obtain unleavened dough. This mixture is then fed into the pasta making machine through the feed inlet at the top, after fixing the extruder screw and blender. Then a die of desired shape was fixed at

the outlet where the pasta will extrude out. The machine was switched on and allowed 5minutes to get proper blending followed by extrusion of long strips of pasta through the die. These strips were made into small pieces manually and dried at a temperature of 65±5^{0}C in tray dryer to a moisture content of 19% (Abedin *et al.,* 2012). Then it is packed and in LDPE covers and sealed for further quality analysis.

Plate 3.1: Formulated pasta sample

3.3.3 Standardization of composition of pasta

The percentage composition of the developed pasta is standardized based on three parameters predominant in determining the quality characteristics. Composition with 100% atta was taken as control. Textural characteristics, physical properties and sensory qualities were considered. All experiments were conducted in triplicates and average values are reported.

3.4 Quality Evaluation

Pasta was prepared according to the above mentioned procedures and quality evaluation was conducted. The following quality parameters of dried pastas were evaluated.

3.4.1 Texture

Instrumental analysis of texture in food provides fast and relatively inexpensive access on product characteristics and consumer acceptance. For the experiment the pre prepared samples were taken and put in the texture analyzer.

Three replications of each sample was kept in Polypropylene cover for evaluation. The texture analyzer (TA.XT plus texture analyzer, stable micro systems Ltd.) (Plate 3.3) was operated with a 5 Kg load cell.

Plate 3.3:Texture analyser

Pasta firmness was determined by AACC (10-50) standard method and force required for each sample was recorded, by making settings shown in table 3.2.

Table 3.2 Technical specification of texture analyser

Test speed	5mm/sec
Distance	30mm
Probe	AACC 1mm flat percex knife blade(A/LKB)
Mode	Measure force in compression
Acquisition ratio	400pps

3.4.2 Bulk density

Bulk density is the measure of expansion that has occurred as a result of extrusion. The density was obtained by taking the weight of the 2cm samples that filled a specific volume (Ocloo *et al.,*2010) and calculated using the formula:

$$\text{Bulk density} = \frac{\text{weight of the sample}}{\text{volume of the container}} \quad \text{.....} \quad (3.1)$$

3.4.3 Water activity

Water activity (a_w) is a measurement of the energy status of water in a system. The concept of water activity is of particular importance in determining product quality and safety. It predicts safety and stability with respect to microbial growth, chemical and biochemical reaction rates and physical property. The water activity of the developed extrudates was measured using a standard water activity meter (Aqua Lab water activity meter). The powder extrudates were placed in a prepared sample cup by making sure the cup is entirely within the chamber. Then load the sample into the instrument, the readings were noted (Abedin *et al.,* 2012).

Plate 3.4 water activity meter

3.4.4 Swelling power

1gm sample was mixed with 10ml distilled water in centrifuge tube and heated at 80˚C for 30 mnts with continuous shaking. The suspension was centrifuged at 1000xg for 15 minutes (Abbey *et al.,*2010). The supernatant was decanted and the weight of the pate was noted. The swelling power was calculated using the equation:

$$\text{Swelling power (g/g)} = \frac{w_2\text{-}w_3)\times 1}{w_1} \quad \ldots\ldots\ldots \quad (3.2)$$

Where,

w_1: weight of the sample

w_2: weight of the centrifuge tube with sample

w_3: weight of the centrifuge tube with swollen material

3.4.5 Water absorption capacity

1gm ground extruders was weighed into 25 ml graduated conical centrifuge tube and about 10 ml of water added. The suspensions were allowed to stand at room

temperature (30±2˚C) for 1hr. The suspension was centrifuged at 200 xg (2000 rpm) for 30 minutes (Abbey *et al.,*2010). The volume of water on the sediment was measured and the water absorbed expressed as percent water absorption based on the original sample weight.

3.4.6 Crude fibre

For estimating crude fibre about 5 g of the dried sample (W) was ground and boiled with 200 ml H_2SO_4 for 30 minutes. The sample was then filtered through muslin cloth and washed with hot water for 2-3 times. The residue obtained was boiled with 200 ml NaOH and filtered through muslin cloth again and washed with 25 ml of 0.225 N H_2SO_4, 350 ml of water and 25 ml alcohol. Then the residue was transferred to ashing dish (W_1) and dried for 2 hr at 130±2ºC. Weight of the dish and and the residue (W_2) were taken after cooling in the desiccators. Again the dish was ignited for 30 minutes at 600±15ºC and weighed after cooling (W_3) (Ocloo *et al.,*2010).

$$\text{Crude fibre content (\%)} = \frac{(W_2-W_1)-(W_3-W_1)}{W} \quad \ldots\ldots\ldots\ldots \quad (3.3)$$

3.4.7 Colour

Product color is a strong indicator of thermal history within the extruder. Hunter lab color flex meter (plate 3.5) was used for measurement of color. It works on the principle of focusing the light and measuring the energy reflected from the sample across the entire visible spectrum. For color measurement extruded samples were ground to pass a 100 mesh U.S sieve. Measurements displayed in L, a and b values represents light- dark spectrum. 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.,*(2010)).

It was determined using the formula:

$$\Delta E = [(l^* - l_o^*)^2 + (a^* - a_o^*)^2 + (b^* - b_o^*)^2]^{1/2}$$

Where, ΔE – Variation from other sample

l^* – black to white of sample

l_0^* - black to white of control

a^* - green to red of sample

a_o^* -green to red of control

b^* - blue to yellow of sample

b_o^* - blue to yellow of control.

Plate 3.5: Hunter lab colorimeter

3.4.8 Carbohydrate by anthrone method

Materials used were 2.5 N HCl, anthrone reagent: dissolve 100 mg anthrone in 100 ml of ice cold 95% sulphuric acid. Prepare fresh before use and standardize glucose: dissolve 100 mg in 100 ml water. Working standard: 10 ml of stock diluted to 100 ml distilled water. Store refrigerated after adding a few drops of toluene.

100 mg of the sample was taken in a boiling tube and was hydrolyzed by keeping it in a boiling water bath for three hours with 5 ml of 2.5 N-HCl and cooled to room temperature. Then it was neutralized with solid sodium carbonate until the effectiveness ceases. After that it was made up to volume to 100 ml and centrifuged. Supernatant was collected and 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of the working standard was taken and '0' serves as blank. Volume was made up to 1 ml in all the tubes including sample tubes by adding distilled water. 4 ml of anthrone reagent was added to each of the tubes and was heated for 8 minutes in a boiling water bath. Then it was cooled rapidly and the green to dark green colour at 630 nm was read. After that a standard graph was plotted with the concentration of the standard on the X-axis and the absorbance on the Y-axis. From the graph the amount of carbohydrate present in the sample tube was calculated.

Calculation

$$\text{Amount of carbohydrate present in 100mg of the sample} = \frac{\text{mg of glucose} \times 10}{\text{Volume of test sample}} \quad \text{……..(3.4)}$$

3.4.9 Estimation of crude protein

Protein is the most essential nutrient present in many food crops. The major element present in the protein is nitrogen, which generally constitutes 16% 0f the total make up. Determination of the nitrogen content is the easiest way to compute the crude proteins using Kjeldahl digestion tubes on Kjeldahl apparatus. The crude protein content was obtained by multiplying the total nitrogen content by a factor of

6.25 and estimated according to the procedure given by the (AOAC official methods of analysis 2008, Moorthy *et al.,* 2002).

$$\text{Protein (\%)} = \frac{\text{(Titre value-Blank value)} \times \text{Normality of HCl} \times 14.007 \times 6.25 \times 100}{\text{Weight of the sample}} \quad \text{.....(3.5)}$$

3.4.10 Sensory evaluation

Sensory evaluation, the scientific discipline used to evoke measures to analyze and interpret reactions to those characteristics of food as they are perceived by the sense of sight, smell, taste, touch and hearing. The final criterion of food quality is human evaluation; the value of objective measurements must be evaluated by their correlation with sensory measurements. For the pasta product with different compositions the sensory evaluation was carried out by a heterogeneous population consisting of people. They ranked the samples according to overall flavor, taste, texture and acceptability of the prepared pasta on a 5 point hedonic scale. Cooked pasta delicacy obtained using standard ingredients in equal proportion were served to the sensory panel. The specimen score card is shown in Appendix IV.

RESULTS AND DISCUSSION

CHAPTER IV
RESULTS AND DISCUSSION

This chapter deals with the results obtained and discussion of the experiments conducted on extruded pasta from jackfruit seed flour, banana flour and rice flour blended in different proportions. Quality analyses of the selected extrudates with objective and subjective parameters are also discussed.

4.1 Standardisation of the composition of the pasta

Using the raw materials, JSF, banana flour, broken rice flour and atta nine different combination of pasta and a control of 100% atta were prepared by the standard procedure mentioned in section 3.3.2. and different quality evaluations were conducted.

4.2 Quality Evaluation

Qualities such as texture, color, crude fibre, water activity, water absorption capacity, bulk density, swelling power and sensory evaluations were conducted and the following results were obtained.

4.2.1 Texture analysis

The texture properties of the extrudates were determined by measuring the peak force and breaking force by the methodologies described as per section 3.2.2.2. Textural properties are described in terms of firmness. The results of these textural properties are tabulated in table 4.1.

Table 4.1: Texture analysis of treatments

Treatments	Firmness (N)
Control	10.437
Sample 1	11.036
sample 2	12.022
Sample 3	13.38
Sample 4	13.738
Sample 5	14.497
Sample 6	14.810
Sample 7	15.540
Sample 8	16.418
Sample 9	17.878

From the above values we can conclude that Sample 9 has the most acceptable firmness. The JSF substituted pasta had lesser stickiness as it has higher fibre content than atta. Addition of JSF has increased the firmness of the pasta compared to that of control. Similar results were obtained for the studies conducted by (Albi *et al.,*2007).

4.4 Bulk density and Water activity a_w

Bulk density is considered expansion in all directions and was determined using the methodologies as per 3.4.2. Though higher bulk density indicates high mass per unit volume, expansion during the extrusion process is a desirable characteristic of the extruded product. The bulk density of the treatments is given below.

The water activities of the extrudates were determined by methodologies explained in section 3.4.3. Food stability usually decreases with increase in water activity. Products with low a_w, signify safe for consumption. Water activity of treatments is shown in table 4.2.

Table 4.2: Bulk density and water activity of treatments

Treatments	Bulk density gm/cm^3	Water activity
Control	0.78	0.73
Sample 1	0.811	0.594
Sample 2	0.65	0.637
Sample 3	0.64	0.621
Sample 4	0.54	0.645
Sample 5	0.77	0.591
Sample 6	0.71	0.747
Sample 7	0.67	0.608
Sample 8	0.54	0.615
Sample 9	0.73	0.54

Bulk density is a measure of heaviness of a flour sample. It is important for determining packaging requirements, material handling and application in wet processing in the food industry. The JSF could be used as a thickener. Albi *et al,*(2007) reported from his studies that bulk density of JSF incorporated pasta is 0.80 g/cm^3 which is comparable with our formulated pasta.

The values in the above table show that sample1, sample5 and sample 9 has the lowest water activity. Food stability increases with decrease in water activity. Product with low a_w, signifies safe for consumption, so this property is considered as a critical control point (Linko *et al.,* 1982).

4.5 Swelling power and Water absorption capacity

Swelling power is a measure of hydration capacity, being 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.

Water absorption capacity of the sample was calculated as per the methodologies explained under section 3.4.5. Water absorption capacity was found and mentioned below. Protein in jackfruit seed consist of more hydrophilic sub unit structure which can bind more water.

Table 4.3 : swelling power and water absorption capacity of treatments

Treatments	Swelling power gm/gm	Water absorption capacity ml/gm
Control	5.8	0.8
Sample 1	5.5	0.6
Sample 2	6.9	0.7
Sample 3	7	0.9
Sample 4	6.1	1.0
Sample 5	5.9	1.5
Sample 6	7.7	1.1
Sample 7	6.2	1.5
Sample 8	6.3	1.4
Sample 9	6.1	1.3

From the values obtained it is found that sample 5 has the most acceptable swelling power. Albi *et al.*(2007) also concluded that pasta containing JSF has a swelling power of 5.264.

Highest water absorption capacities were found for sample 5, sample 7, sample 8 and sample 7. Ocloo *et. al.* (2010) reported that the water absorption capacity for the jackfruit seed flour was 0.9 ml/g. Water absorption capacity describes flour, water association ability under limited water supply. The disparities observed were attributed to the method used as well as the varietal differences. The results showed that the flour has a good ability to bind water and suggests that JSF could be used in bakery industry.

4.6 Crude fibre

The crude fibre determination of the extrudates was done with methodologies explained under section 3.2.2.7. The percent crude fibre of the all treatments was found to be 2% and that of control was found to be 1%.

Crude fibre value of 2.36% was also reported by Tulyathan *et. al.* (2002) in JSF incorporated pasta.

4.7 Colour

Colorimeter uses three values 'L', 'a' and 'b' to describe the precise location of a colour inside a three dimensional visible color space. The Hunter Lab 'L', 'a' and 'b' values were shown in table 4.4

Table 4.4 colorimeter reading

Samples	L	A	b	ΔE
Control	58.68	5.38	16.48	11.33
Sample 1	54.61	6.03	16.80	12.43
Sample 2	53.50	6.23	16.98	13.2
Sample 3	57.70	5.53	16.90	14.8
Sample 4	55.40	6.75	19.09	15.2
Sample 5	49.92	6.48	15.88	16.5
Sample 6	46.68	9.01	19.66	17.66
Sample 7	51.77	8.93	21.86	19.3
Sample 8	52.88	7.57	20.50	23.86
Sample 9	69.85	3.71	17.49	0

From the values obtained from hunter lab colorimeter it was found that sample 1 and sample 5 have colour comparable to that of the control.

4.8 Carbohydrate

The major component of the flour was carbohydrate. The carbohydrate content of the optimized sample was found to be 67g. The high carbohydrate content gives better water and oil absorption capacity, textural and sensory quality apart from being an energy source.

4.9 Protein

The protein was estimated by using the method mentioned in section (3.4.9).The protein content of the standardised mix was found to be 2.83g and that of the control sample was found to be 2.72g.

4.10 Sensory evaluation

For better acceptability and sustained marketing of the optimized pasta, various sensory parameters such as appearance, colour, flavour, taste and overall acceptability were considered (Anton and Luciano, 2007). After considering the above parameters it was concluded that sample1, sample 5 and sample 9 had the better results. So, these samples along with control were kept for sensory evaluation. The result of the sensory evaluation using 5 point hedonic scale is depicted in figure.

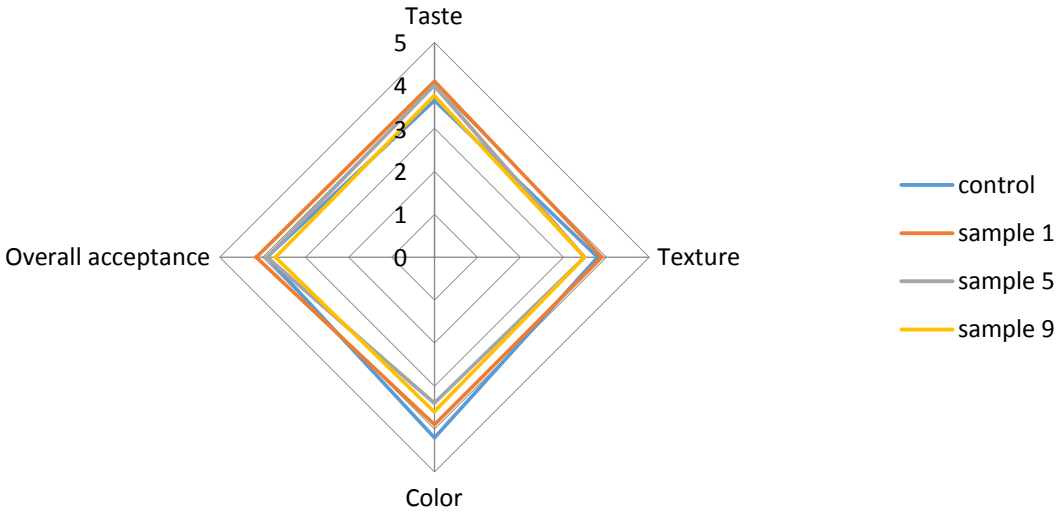

Fig 4.1: Sensory evaluation graph

From this graph it may be concluded that the sample1, had the maximum score for all the characters via taste, texture, colour and overall acceptance. Therefore the sample 1 maybe considered superior when compared to other samples.

SUMMARY AND CONCLUSION

CHAPTER V
SUMMARY AND COCLUSION

Jackfruit seed make up 10-15% of total weight of jackfruit. It is rich in carbohydrate and protein, but significant quantities of jackfruit seed are generated as waste product in jackfruit processing industries so it's essential to find application for these seeds. Broken rice is a grade of rice consisting of grains broken in the milling process but has a similar energy content to intact rice. Banana flour is a powder traditionally made of green bananas that is often used as a gluten free replacement. Therefore pasta was developed using the above mentioned ingredients, with all properties similar to that of commercially available pasta. The major objectives were standardization of mix and study the physical, functional and proximate analysis of the product.

The mix blend was standardized with 9 sets of proportion of JSF, BRF, banana flour and wheat as shown in Table 3.2.2. The product with 100% Atta was taken as control. The blend was prepared and extruded in laboratory model extruder. The product obtained were packed and analyzed.

By considering the properties such as bulk density, water activity, texture, colour, water absorption capacity, swelling power, crude fiber, and sensory evaluations standardization of mix was carried out. After considering the above mentioned properties it was found that sample with 50% Atta, 25% JSF , 12.5% rice flour and 12.5% banana flour was concluded to be optimum. This is considered to be superior. This sample showed water absorption capacity of 0.5ml/gm, water activity of 0.914 and bulk density of 3.5 gm/cm^3. This sample has an appealing colour and firmness of 11.036 N. Crude fiber content of 2% with swelling power of 6.2 gm/gm was also found to be optimum in the case of sample 1. Based on results of sensory

evaluation sample 1 with JSF 25%, Atta 50%, banana flour and Broken rice flour each of 12.5% was standardized. The product developed was nutritionally rich texturally superior and safe for long term storage.

Plate 5.1 sample 1

REFERENCE

CHAPTER VI

REFERENCE

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APPENDICES

APENDIX I

Table: Functional properties of JSF

Indices	Values
Water absorption capacity (%)	25.00 ± 1.67
Fat absorption capacity (%)	17.00 ± 1.37
Foaming capacity (%)	25.34 ± 0.02
Foam stability (%)	33.00 ± 0.01
Swelling power (g/g)	4.77

APENDIX II

Table: Materials composition of JSF

Minerals	Values (mg/kg)
Calcium	3087 ± 166
Magnesium	3380 ± 388
Iron	130.74 ± 12.37
Zinc	< 0.01
Potassium	14781 ± 256
Manganese	1.12 ± 0.11
Copper	10.45 ± 0.89
Sodium	60.66 ± 2.01

APENDIX III

Table: Physicochemical properties of JSF

Indices	Values (% dry matter)
Moisture	6.09 ± 0.01
Crude fat	1.27 ± 0.01
Ash	2.70 ± 0.02
Protein	13.50 ± 0.06
Fibre	3.19 ± 0.01
Carbohydrate	79.34 ± 0.06
Energy(kcal/100 g)	382.79 ± 1.20
Ph	5.78 ± 0.01
Titratable acidity (as lactic acid)	1.12 ± 0.03
Bulk density (g/cm)	0.80 ± 0.02

APPENDIX IV

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 the panelist

ABSTRACT

CHAPTER VIII
ABSTRACT

Jackfruit (*Artrocarpus heterophylus*) is a popular fruit of tropics and grown widely in India. Significant quantities of jackfruit seed are generated as waste product in jackfruit processing industries. Though seeds are rich in carbohydrates and proteins, they are occasionally used as minor supplements but are mostly wasted. Broken rice are main by-products of milling industry, broken rice has a similar energy content to intact rice. Banana flour is often used as a gluten free replacement to wheat flours or as a source of resistant starch. Gluten free alternative to wheat based flours for those suffering from celiac disease and those who choose a gluten free diet. Therefore, utilizing of these ingredients can benefit a lot to human health. Thus a conclusion was reached to utilize these ingredients to make gluten free pasta.

Raw materials were collected and pre-treatments were done. Pastas of ten different compositions were extruded and the sample 1 was found to be optimum by evaluating different properties such as moisture content, colour, texture, crude fiber, water absorption capacity, swelling index, bulk density and water activity.