DEVELOPMENT OF TENDER JACKFRUIT FLOUR BASED PASTA

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PROJECT REPORT

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DECLARATION

We hereby declare that this project report entitled **"DEVELOPMENT OF TENDER JACKFRUIT FLOUR BASED PASTA"** 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 OUR TEACHERS & FRIENDS

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SYMBOLS AND ABBREVIATIONS

%	percentage
°C	degree centigrade
a_w	water activity
i.e	that is
cm	centimetre
et al	and others
g	gram
H	hour
Kg	kilo gram
m	meter
m.c	moisture content
min	minute
ml	milli litre
N	newton
RS	resistant starch

INTRODUCTION

CHAPTER I

INTRODUCTION

Jackfruit is a tropical fruit that has been gaining popularity in recent years due to its unique taste, texture, and versatility. The fruit is also rich in nutrients, including vitamin C, potassium, and dietary fiber (Khan *et al.*, 2021). In addition, jackfruit has been found to have several health benefits, such as aiding digestion and promoting healthy skin. Jackfruit can be eaten fresh, cooked in a variety of dishes, or used as a natural sweetener in desserts. Its versatility and nutritional value make it a valuable addition to any diet.

Tender jackfruit is a versatile fruit that is commonly used in Southeast Asian cuisine. It is harvested when it is still young and green, before the seeds have fully developed. Tender jackfruit has a fibrous and meat-like texture that makes it an ideal substitute for meat in vegetarian and vegan dishes. Additionally, it is a rich source of dietary fiber, vitamins, and minerals. Tender jackfruit is low in calories, high in fiber, and a good source of vitamin C and potassium (Rana *et al.*,2018).

Tender jackfruit is a low glycemic index food that can be beneficial for diabetic patients (Rana *et al.*,2019). The glycemic index is a measure of how quickly carbohydrates in food are absorbed and raise blood sugar levels. Foods with a high glycemic index can cause blood sugar spikes, which can be harmful to diabetic patients. Tender jackfruit has a glycemic index of 50, which is considered low, and can help regulate blood sugar levels. It is also high in dietary fiber, which can slow down the absorption of carbohydrates and reduce blood sugar spikes.

Pasta is a versatile and popular food that can be a part of a well-balanced diet. It is a broad term used to describe a variety of dishes made from unleavened dough, typically consisting of durum wheat flour and water. The dough is then formed into sheets or various shapes, which are then cooked and served in a variety of ways. There are two main categories of pasta, dried pasta (pasta secca) and fresh pasta (pasta fresca). Dried pasta is usually produced commercially using an extrusion process, while fresh pasta was traditionally made by hand, but today, many varieties are also produced using large-scale machines. Both dried and fresh pasta come in a vast array of shapes and sizes, with over 1300 names used to describe the 310 specific forms.
Finger millet is a rich source of carbohydrates and comprises of free sugars (1.04%), starch (65.5%), and non-starchy polysaccharides (Malleshi *et al.*, 1986).

It is exceptionally rich in calcium (344 mg) compared to all other cereals and millets (eight-fold higher than pearl millet) and contains 283 mg phosphorus, 3.9 mg iron (Gopalan *et al*., 2009).

Cold extrusion is a novel processing technique that has gained significant attention in the food industry. It involves the use of high pressure to shape and mold raw materials without the need for heat, resulting in products with enhanced nutritional and sensory properties. Cold extrusion can be used to process a wide range of materials, including fruits and vegetables (Shelar *et al*.,2019).

Extruded products from tender jackfruit are a new and innovative way to use this nutritious fruit, and it has the potential to become a significant player in the plant-based food market. These products are not only healthy and nutritious but also environmentally sustainable, as jackfruit is a low input crop that requires minimal irrigation and fertilization. Tender jackfruit flour is gluten-free, high in fiber, and has a low glycemic index, making it an excellent option for those with celiac disease, diabetes, or those seeking to maintain healthy blood sugar levels. Additionally, it is rich in antioxidants, vitamins, and minerals, such as vitamin C, potassium, and magnesium, which can contribute to better overall health (Rana *et al.*, 2018). When used in pasta dough, tender jackfruit flour can provide a unique flavor profile and a slightly sweet taste, which can enhance the overall taste and nutritional value of the dish. By incorporating tender jackfruit flour into pasta dough, we can create a healthier, more nutritious, and delicious alternative to traditional pasta that can benefit our health in many ways.

Hence the study titled " Development of Tender Jackfruit based Pasta " is conducted in KCAET, Tavanur which encompasses the following specific objectives;

1. Development of nutritional tender jackfruit flour-based pasta.
2. Evaluation of various quality parameters of pasta.
3. Optimization of product parameter.

REVIEW OF LITERATURE

CHAPTER II
REVIEW OF LITERATURE

This chapter gives general information on tender jackfruit, wheat flour, ragi flour and 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 Tender Jackfruit

Jackfruit (*Artocarpus integrifolia* L.) is also known as jaca and breadfruit. It belongs to the family Moraceae. Jackfruit is cultivated in Asia, Central Africa, and South America. Jackfruits turn brown and deteriorate quickly after ripening. The fruit is used in ice cream, chutney, jam, jelly, and paste or canned in syrup. Ripe bulbs may be dried, fried in oil, and salted for eating like potato chips. A pectin extract can be made from the peel. Jackfruit is rich in vitamin A and minerals such as phosphorus, potassium, and calcium. The seeds are rich in vitamins B1 and B2 and can be dried and used as vitamin supplement. (Fernandes *et al*.,2011)

Khan *et al* (2021) observed that the fruit contains lignin's, flavones and saponins which have the properties of anti-cancer, anti-ulcer, anti-hypertensive and anti-aging. It contains immense medicinal values and also considered a rich source of carbohydrates, minerals, carboxylic acids, dietary fibre and vitamins such as ascorbic acid and thiamine.

2.2 Wheat flour

Wheat flour is composed of mainly carbohydrates, proteins, and fats with small amounts of vitamins and minerals. The quality of wheat flour depends on the protein content, gluten content, and other physical and chemical properties, which in turn determine its suitability for various food applications. (Nikoloudakis, 2017).

Various processing techniques, such as milling, fermentation, and extrusion, can significantly impact the quality and functionality of wheat flour. For example, milling can affect the particle size and distribution of the flour, while fermentation can affect the flavour, texture, and nutritional value of the final product (Arora *et al*., 2018).

Wheat flour is a good source of complex carbohydrates and dietary fibre, which are essential for maintaining digestive health and preventing chronic diseases such as diabetes and heart disease. Additionally, wheat flour contains vitamins and minerals, such as iron and B vitamins, which are important for overall health and well-being. (Abdel-Aal *et al*., 2013).

Wheat flour is used in a wide variety of food products, including bread, pasta, noodles, cakes, biscuits, and snacks. The functionality of wheat flour, such as its ability to form a dough or batter, and its rheological properties, make it suitable for a range of food applications. (Singh *et al*., 2015).

2.3 Millet Flour

Effect of millet flours and carrot pomace on cooking qualities, colour and texture of developed pasta was examined by Gull *et al.* (2015). They observed significant differences in the cooking quality characteristics, colour, and texture of the pasta treatments with an increase in the substitution level of millet flours and CPP.The control pasta had the lowest solid loss (7.66%), highest weight gain (33.93g/10g), and firmness (5.94 N), while the supplemented pasta showed an increased solid loss (10-24.40%), decreased weight gain (32.34-25.07 g/10 g), and firmness (4.24-2.14 N) with an increase in the substitution level of millet flours and CPP. Colour analysis showed a slight decrease in the L* value for all raw and cooked pasta treatments. Study found that the millet flours and carrot pomace used in this study could partially replace durum semolina in pasta with acceptable characteristics.

A study was done on the topic non-wheat pasta based on pearl millet flour containing barley and whey protein concentrate by Yadav *et al.* (2012). The study aimed to prepare non-wheat pasta using pearl millet supplemented with barley flour, whey protein concentrate (WPC), and carboxy methyl cellulose (CMC), and to optimize the levels of these ingredients using response surface methodology (RSM) following central composite rotatable design (CCRD). The results showed that barley flour and WPC had a significant positive effect on the lightness and a negative effect on the stickiness of the pasta, which improved the overall acceptability (OAA). CMC improved the textural attributes of the pasta, such as firmness and stickiness, and caused a significant reduction in solids losses in gruel.

Vijayakumar *et al*. (2010) studied on the topic Quality evaluation of noodles from millet flour blend incorporated composite flour. The study aimed to investigate the influence of a millet flour blend on the physical, functional, nutritional, cooking, and organoleptic characteristics of noodles prepared from a composite flour of millet flour blend, whole wheat flour, and soy flour. The results showed that the fibre and amylose/amylopectin ratio increased significantly ($p<0.05$) with an increase in the level of millet flour blend incorporation. The cooking time of the developed noodles from the composite flour (15-18 min) was significantly ($p<0.01$) higher than the cooking time of branded noodles (9.3 min). The mean overall organoleptic score of the developed noodles from the composite flour was in the range of highly acceptable criteria (20-25). By all means, the 20% level of millet flour blend incorporation was found to be acceptable.

2.4 Rice flour

Rice is a crop that provides food for approximately half of the world's population. Rice is a vital crop globally, accounting for over 21% of human caloric requirements and up to 76% of the calorific intake of Southeast Asian inhabitants (Zhao *et al*.,2020).

Approximately 90% of the dry weight of milled rice is starch (Cornejo-Ramírez *et al*., 2018). Starch is a polymer composed of D-glucose linked α-(1–4) and typically consists of two fractions: an essentially linear fraction called amylose and a branched fraction called amylopectin.

The ratio of amylose to amylopectin is vital for the structure, appearance, and eating quality of rice grains. The amino acid profile of rice reveals a high aspartic acid and glutamic content, with lysine being the limiting amino acid (Carcea *et al.*,2021).

Consumption of rice pasta is increasing also outside the traditional Asian markets, mostly because of health-related issues. Rice-based products are low in allergens and fat, easily digestible, and suited for gluten-free diets (Rosell *et al.*, 2008).

2.5 Pasta

Gopalakrishnan *et al.* (2011) evaluated Nutritional and Functional Characteristics of Protein-Fortified Pasta from Sweet Potato. This study aimed to improve the utilization of sweet potato as a low glycaemic food by developing a high-protein pasta. They used three different protein sources, including whey protein concentrate (WPC), defatted soy flour (DSF), and fish powder (FP), to determine which source would result in the highest quality pasta with strong starch-protein network formation and low in vitro starch digestibility. The results showed that WPC-fortified sweet potato pasta had the best quality, with strong starch-protein network formation and low in vitro starch digestibility. The protein nutritional quality was also high for this pasta, with very high scores for lysine and leucine, as well as high essential amino acid index and calculated protein efficiency ratio. Additionally, they fractionated the starch and found that the WPC-fortified sweet potato pasta had the lowest rapidly digested starch (RDS) and the highest resistant starch (RS) content. These findings suggest that this pasta has the potential to be a low glycaemic food. Overall, this study demonstrates that the use of WPC in sweet potato pasta can result in a high-quality product with potential health benefits.

Bresciani *et al.* (2022) aims to address two main objectives related to the pasta-making process. The first objective is to investigate the main challenges faced during the pasta-making process and highlight the processing variables that have the most significant impact on pasta quality. The second objective is to identify the unknown factors that affect the pasta-making process and require further study. The goal is to understand how each of these processing steps affects the final quality of the pasta and how they can be optimized to produce pasta with the desired characteristics.

Marti *et al.* (2010) evaluated a comparison between conventional pasta-making and extrusion-cooking on rice. This study aimed to investigate the effects of two different pasta-making processes (conventional and extrusion-cooking) on parboiled brown and milled rice flours. The study differentiated the two processes based on extrusion temperature, with the conventional extrusion at 50°C and the extrusion-cooking at 115°C. The cooking quality of the resulting pasta was evaluated based on weight increase solid loss into the cooking water, and texture analysis. The study found that pasta obtained from milled rice using the extrusion-cooking process had the best cooking behaviour. It gives importance of considering the processing conditions in pasta-making, as it can significantly affect the final quality of the product. The findings also suggest that the type of rice used can also play a role in the cooking behaviour of the resulting pasta.

Arcangelis *et al*. (2020) investigated on the production of gluten-free pasta made from buckwheat flour, either alone or in combination with maize and rice flours. They found that by using appropriate technologies and additives such as emulsifiers and stabilizers (monoglycerides of fatty acids, propylene glycol alginate, and/or flour of carob and guar), they were able to achieve excellent nutritional and cooking quality properties. The resulting pasta had a high protein and dietary fibre content, making it suitable for celiac patients. The researchers found that the use of a combination of 0.1% propylene glycol alginate and 0.5% monoglycerides of fatty acids, together with the gelatinization of mixed flour (buckwheat, maize, rice), resulted in pasta with the highest cooking quality and texture.

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 was 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 ferrozine 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 physic-chemical properties of selected fresh pasta. The water status of fresh pasta was slightly affected by the shaping process.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The chapter focuses on the methodologies employed for sample preparation, blending of different flours including tender jackfruit flour, ragi flour, rice flour, and wheat flour in various ratios, and the extrusion process. Additionally, it outlines a standardized procedure for conducting physical, textural, and sensory tests to evaluate the characteristics of the produced pasta.

3.1 Raw Materials

Raw materials selected for the study were tender jackfruit flour, rice flour, ragi flour and wheat flour. The raw materials such as rice flour, ragi flour, wheat flour was collected from local market and the tender jackfruit was collected from the instructional farm, KCAET Tavanur. They are then peeled off, sliced, dried and powdered to get tender jackfruit flour.

3.1.1 Tender Jackfruit flour

Tender jackfruit (*Artocarpus heterophyllus* L.) is the young, immature stage of the jackfruit. Tender 'varikka' jackfruit at harvest maturity of 60-80 days after fruit formation were collected from Instructional farm, Tavanur. The outer skin was removed and the remaining edible portion were sliced into thin pieces, dried to a moisture content of 5-10%. Tender jackfruit is dried in a tray dryer at 65±5°C (Arun *et al.*, 2015) for about 8-10 hours. Dried tender jackfruit pieces were then ground in a blender and packed in LDPE.

Remove the spiny regions

⬇

Slicing

⬇

Drying (65± 5°C)

⬇

Powdering

⬇

Packaging (LDPE)

Fig : 3.1 Flow chart for the prepartion

The flow chart for the preparation of tender jackfruit flour is given above figure 3.1. Different stages of flour preparation are shown in the figure 3.2


Raw jackfruit


Peeling


Slicing


Drying(65±5°C)


Powdering


Packaging (LDPE)

Fig 3.2 Stages Of Flour Preparation

Seven jackfruit of average size 23.3× 8.9 cm, was selected for flour preparation.The total weight of tender jackfruit was 10.55 kg, the weight of the removed peel was 4.06 kg,and the weight of sliced sample was 6.885 kg. After drying the dried sample were weighed about 1.065 kg.

3.2 Pasta

Pasta is a food product made from a dough consisting of flour, water, and often eggs, that is formed into various shapes and typically cooked by boiling. It is a staple food in Italian cuisine and is widely consumed in many other parts of the world. Pasta can be served with a variety of sauces, such as tomato-based sauces, cream-based sauces, and oil-based sauces, and can also be used as an ingredient in other dishes.

3.2.1 Pasta Maker

A pasta maker is a kitchen appliance that is designed to make homemade pasta quickly and easily. It typically consists of a hand-cranked or electric machine that rolls out the pasta dough and cuts it into the desired shape, such as spaghetti, fettuccine, or lasagne noodles.

Most pasta makers come with several different attachments to make different types of pasta shapes, and some models also include features for adjusting the thickness of the pasta dough. The machine usually has a metal or plastic body, with a set of rollers and cutters made from stainless steel or another durable material.

To use a pasta maker, we first mix together the dough ingredients and knead them until smooth. Then, we feed the dough through the rollers of the pasta maker, gradually adjusting the thickness settings as needed, until the desired thickness is achieved. Finally, we run the dough through the appropriate cutter attachment to make the desired pasta shape.

Overall, a pasta maker is a convenient tool for anyone who enjoys making homemade pasta, as it can save time and effort compared to rolling out the dough by hand. It also allows for greater flexibility in terms of pasta shapes and thicknesses, and can be a fun and rewarding way to experiment with different recipes and flavours.

Plate 3.1: Pasta maker

3.2.2 Preparation of pasta

Pasta was prepared from different composition of flour by using pasta making machine. Raw materials (wheat flour, tender jackfruit flour, ragi flour and rice flour) were weighed using weighing balance and mixed well. Then the treatments (total 300g) were blended with 38%

water and kneaded for 2-3 min 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 5 min 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°C in tray dryer to a moisture content of 8-9% (Abedin *et al*., 2012). Then it is packed and in LDPE covers and sealed for further quality analysis. The preparation of pasta is shown below in fig 3.3.

Tender jackfruit flour

↓

Ragi flour → Blending mixtures ← Rice flour or Wheat flour

(5 min)

↓

Mixing with water

↓

Kneading (20 min)

↓

Extrusion and cutting

↓

Drying at 65±5°C

↓

Dried pasta

↓

Packing

Fig: 3.3. Flow chart for pasta making

3.3 Standardizing the water content for pasta preparation

The recommended water content for pasta dough in the extrusion process can vary depending on various factors. However, a common range for water content in pasta dough during extrusion is around 30% to 40% (Czaja *et al.*, 2017).

We selected a flour composition (70% Wheat flour+ 10% Tender Jackfruit flour+ 20%Ragi flour). The required amount of the water content for the preparation of pasta was determined by taking a treatment and prepared at various water content (30%,33%,35%,38%). Standardized these treatments t_1, t_2, t_3 and t_4 based on their visual appearance and wastage of pasta during preparation.

Table 3.1: Standardizing the water content for pasta preparation

Treatments	Composition	Water content
t_1	70% Wheat flour+ 10% Tender Jackfruit flour+ 20%Ragi flour	30%
t_2	70% Wheat flour+ 10% Tender Jackfruit flour+ 20%Ragi flour	33%
t_3	70% Wheat flour+ 10% Tender Jackfruit flour+ 20%Ragi flour	35%
t_4	70% Wheat flour+ 10% Tender Jackfruit flour+ 20%Ragi flour	38%

3.3.1 Quality evaluation for standardizing water content for pasta preparation

Quality evaluation encompasses the assessment of the quality of different entities or processes, including products, services, systems, and individual performance. It involves the measurement and analysis of specific criteria to ascertain if something meets predefined standards or requirements. This process aims to determine the level of excellence and conformity to desired specifications.

To standardize the water content of different treatments for pasta preparation using the flour composition of 70% wheat flour, 10% tender jackfruit flour, and 20% ragi flour, we conducted experiments with different water content levels. The treatments, named t_1, t_2, t_3 and t_4 were prepared with water contents of 30%, 33%, 35%, and 38% respectively.

During the experiments, we visually examined the extruded pasta treatments and assessed their appearance, looking for factors such as colour, texture, and uniformity. Additionally, we evaluated the wastage of pasta during preparation.

3.4 Standardization of product parameter of tender jackfruit-based pasta

For standardization of product parameter with the above standardized water content we had prepared tender jackfruit and ragi based pasta. And the combination of the pasta is given below.

Table 3.2 Composition of pasta

Treatments	Wheat flour	Tender jackfruit flour	Ragi flour	Rice flour
T_1	70%	10%	20%	__
T_2	90%	10%	__	__
T_3	70%	__	30%	__
T_4	70%	30%	__	__
T_5	25%	25%	25%	25%
T_6	__	10%	20%	70%
T_7	__	10%	__	90%
T_8	__	__	30%	70%
T_9	__	30%	__	70%
T_{10}	35%	10%	20%	35%

3.5 Quality Evaluation of prepared pasta

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

3.5.1 Water activity

Water activity (a_w) is a crucial parameter in assessing the quality and safety of a product. It indicates the availability of free water in a system, which can affect microbial growth, chemical reactions, and physical properties. To determine the water activity of the extrudates developed in this study, a standard water activity meter (Aqua Lab water activity meter) was used. The extrudates were prepared as a powder and placed in a sample cup within the meter's chamber. After loading the sample into the instrument, the water activity readings were recorded. This method allowed for accurate measurement of water activity, which is essential in predicting the stability and safety of the extrudates. (Abedin *et al*., 2012).

Plate 3.2: Water activity meter

3.5.2 Swelling index

The water swelling index (%) of the pasta was measured using the procedure outlined by Cleary and Brennan (2006). Approximately 50g of dried pasta (W_1) was cooked, and the water was drained into a pre-weighed beaker. The cooked pasta was then gently dried on a cloth to remove any surface moisture, and the weight of the cooked pasta (W_2) was recorded.

$$\text{Swelling index} = \frac{W_2 - W_1}{W_1} \qquad \text{........(Eqn.,1)}$$

3.5.3 Water absorption

The water absorption (gg-I) of the pasta was assessed following the methodology outlined by Cleary and Brennan (2006). Water absorption refers to the percentage difference in weight between the cooked pasta and the uncooked pasta. The cooked pasta was rinsed with water, drained, and then weighed to determine the increase in weight. The water absorption was calculated as the final weight of the cooked pasta minus the weight of the raw pasta, divided by the weight of the raw pasta.

$$\text{Water absorption} = \frac{\text{Final weight of cooked pasta - Weight of raw pasta}}{\text{Weight of raw pasta}} \quad \text{……..(Eqn.,2)}$$

3.5.4 Expansion ratio

The expansion ratio of an extrudate is determined by calculating the ratio of the extrudate's diameter to the diameter of the die hole (Fan *et al*. in 1996). The expansion ratio can be calculated using the following equation:

$$\text{Expansion ratio} = \frac{\text{Diameter of extruded product (mm)}}{\text{Diameter of die hole (mm)}} \quad \text{……….(Eqn.,3)}$$

3.5.5 Cooking time

The cooking quality of pasta was assessed using the methodology described by Ojure and Quadri in 2012. Ten grams of pasta were cooked in 150 ml of boiling water in a covered beaker. To determine the cooking time (min), a piece of pasta was removed every 2 min and compressed between two glass slides. The pasta was considered optimally cooked when the centre became transparent or when they were fully hydrated.

3.5.6 Cooking loss

Cooking loss (%), which is a crucial indicator of pasta quality, was quantified following the procedure outlined by Debbouz and Doetkott (1996) as described by Padmaja (2015). After cooking, the drained water was collected and dried in pre-weighed petri dishes. The dishes were then placed in an oven at 105°C for overnight drying. The weight of the resulting dry residue was measured (W_2 g) to determine the cooking loss percentage.

$$\text{Cooking loss (\%)} = \frac{W_2 \times 100}{W_1}, \text{ where } W_1 \text{ is the initial weight of the pasta ……(Eqn.,4)}$$

3.5.7 Ascorbic acid

Ascorbic acid otherwise known as Vitamin C is antiscorbutic. It is water soluble and heat-labile vitamin. The principle used here is Ascorbic acid reduces the 2, 6-dichlorophenol indophenol dye to a colourless leuco-base. The ascorbic acid gets oxidized to dehydroascorbic acid. Though the dye is a blue coloured compound, the end point is the appearance of pink colour. The dye is pink colour in acidic medium. Oxalic acid is used as the titrating medium.

First pipette out 5ml of the working standard solution into a 100ml of conical flask. Then add 10ml of 4% oxalic acid and titrate against the dye (V_1 ml). End point is the appearance of pink colour which persists for a few minutes. The amount of dye consumed is equivalent to the amount of ascorbic acid. Extract the sample (0.5-5g depending on the sample) in 4% oxalic acid and make up to a known volume (100ml) and centrifuge. Then pipette out 5ml of this supernatant, add 10ml of 4% oxalic acid and titrate against the dye (V_2 ml) (Sadasivam, S and Balasubraminan, T ,1987).

Amount of ascorbic acid mg/100ml sample is calculated by the equation,

$$\text{Ascorbic acid (mg/100ml)} = \frac{0.5\text{mg} \times V_2\text{ml} \times 100\text{ml} \times 100}{V_1\text{ml} \times 5\text{ml} \times \text{Wt. of the sample}} \quad \text{.........(Eqn.,5)}$$

3.5.8 Moisture content

The moisture content refers to the amount of water present in the product. It is an important parameter that affects the quality, texture, and shelf life of a product. The moisture content of pasta can vary depending on various factors such as the ingredients used, the manufacturing process, and storage conditions.

To determine the moisture content of pasta, a sample of the pasta is typically taken and weighed(w_1). The sample is then dried using tray drier to remove all the moisture. After drying, the sample is weighed again to determine the weight of the dry matter(W_2). The moisture content is calculated by subtracting the weight of the dry matter from the initial weight of the sample and then expressing it as a percentage of the initial weight.

$$\text{Moisture content (\%)} = \frac{W_1 - W_2}{W_1} \quad \text{...... (Eqn.,6)}$$

Plate 3.3: IR moisture meter

3.6 Sensory evaluation

Sensory evaluation refers to the systematic assessment and analysis of products using human senses such as sight, smell, taste, touch, and hearing. It is a scientific approach used to measure and understand various sensory attributes, preferences, and perceptions associated with a product or experience**.** The panel members were requested to assess the treatments based on various sensory aspects, including its appearance, taste, colour, flavour, odour, texture, elasticity, adhesiveness, mouthfeel, and overall acceptability. The evaluation was conducted using a 9-point hedonic scale, following the specified order of preference, as presented below. It is important to note that the structure and design of the assessment scale referred to here have been outlined (Ranganna,1986).

- Like extremely -9
- Like very much -8
- Like moderately -7
- Like slightly -6
- Neither like nor dislike -5
- Dislike slightly -4
- Dislike moderately -3
- Dislike very much -2
- Dislike extremely -1

For the sensory evaluation the composition taken is listed below

$\mathbf{T_5}$ = 25% Wheat flour+ 25% Tender jackfruit flour+ 25% Ragi flour + 25% rice flour (water content 38%).

$\mathbf{T_2}$ = 90% Wheat flour+ 10% Tender jackfruit flour+ (water content 38%).

$\mathbf{T_7}$ **=** 90% Rice flour+ 10% Tender jackfruit flour (water content 38%)

Commercial pasta = Control

$\mathbf{T_{10}}$ = 35% Wheat flour+ 10% Tender jackfruit flour+ 20% Ragi flour+ 35% Rice flour (water content 38%)

$\mathbf{T_8}$ = 70% Rice flour+ 30% Ragi flour (water content 38%)

$\mathbf{T_9}$ = 70% Rice flour+ 30% Tender jackfruit flour (water content 38%)

3.8 Cost analysis

The cost analysis of optimally produced extrudates was conducted by considering fixed and variable cost. The cost estimation of extruded product was given in Appendix B.

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

This chapter presents the findings and discussion of the experiments carried out on extruded pasta using blends of tender jackfruit flour, wheat flour, ragi flour and rice flour in varying proportions. The quality analysis of the resulting extrudates is examined using objective and subjective parameters, providing a comprehensive evaluation of the pasta's characteristics. The discussion encompasses a detailed analysis of the experimental results.

4.1 Standardization water content

Based on section 3.3.1 the water content of pasta is optimized. The given figure shows the four treatments.

t_1– 30% Water content

t_2– 33% Water content

t_3– 35% Water content

t_4– 38% Water content

Plate 4.1: Pasta at different water content

Among the four-treatment taken, t_4 with water content 38% was taken as optimum. During the experiments, we conducted a visual examination of the extruded pasta treatments, assessing factors such as colour, texture, and uniformity, while also evaluating the amount of pasta wasted during the preparation process.

4.2 Quality Evaluation

Various quality parameters are

- Expansion ratio.
- Water activity.
- Water absorption capacity.
- Cooking time.
- Cooking loss.
- Swelling power.
- Ascorbic acid.
- Sensory evaluations.

The above-mentioned parameters were assessed in the conducted experiments. The obtained results for each of these quality attributes will be discussed in detail.

4.2.1 Water activity(a_w)

The water activities of the extrudates were determined using the methodologies described in section 3.5.1 It is generally known that food stability tends to decrease as water activity increases. Therefore, products with lower water activity (a_w) are considered safer for consumption. The water activity values for each treatment are presented in Appendix A (Table A.1). The data presented in the above-mentioned table indicate that treatments 6, 7 and 2 exhibit the lowest water activity values. It is well-established that food stability improves as water activity decreases. Products with lower water activity (a_w) are considered to be safer for consumption, making this property a critical control point (Linko *et al*., 1982).

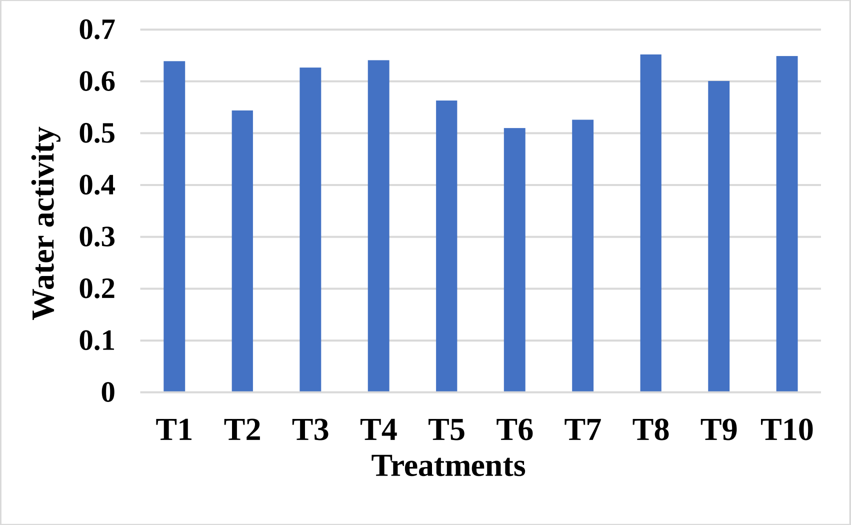

Fig 4.1 Graph showing water activity of different treatments

4.2.2 Swelling index

Swelling index of the treatments were determined using the methodologies as per 3.5.2. The swelling index of pasta refers to the increase in volume or size of the pasta during the cooking process. It is a measure of how much the pasta expands when cooked. The swelling index values for each treatment are presented in Appendix A (Table A.2).

A pasta with a higher swelling index generally absorbs more water during cooking, resulting in a softer and more tender texture. From the values obtained it is found that treatment 7 has the most acceptable swelling index (Swathi, 2019).

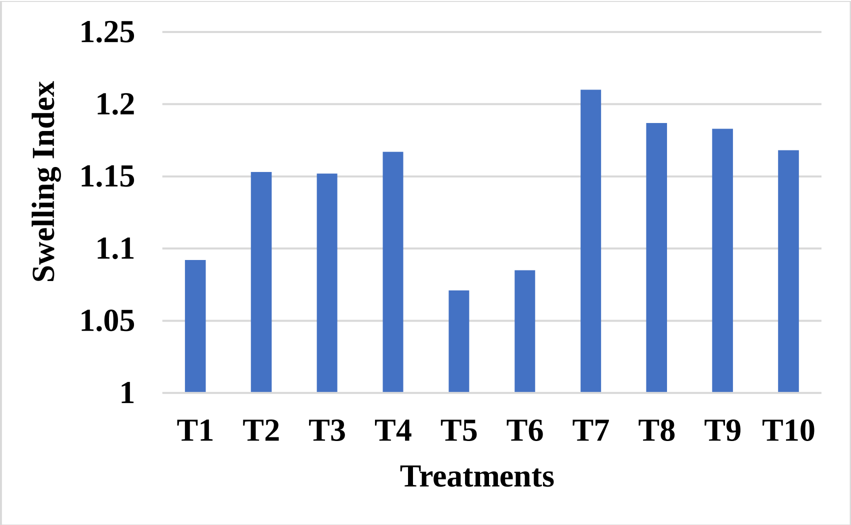

Fig 4.2 Graph showing swelling index of different treatments

4.2.3 Water absorption

The water absorption capacity of the treatments was determined following the methodologies described in section 3.5.3. The specific details of the procedure used to calculate the water absorption capacity are outlined in that section. By employing those methods, the water absorption capacity of the treatment was successfully determined. The water absorption values for each treatment are presented in Appendix A (Table A.3).

A pasta with higher water absorption is indicated by a porous texture, increased cooking time, expansion in size and a tender texture when cooked. Treatment 9 and 2 was found acceptable with respect to water absorption. (Swathi, 2019).

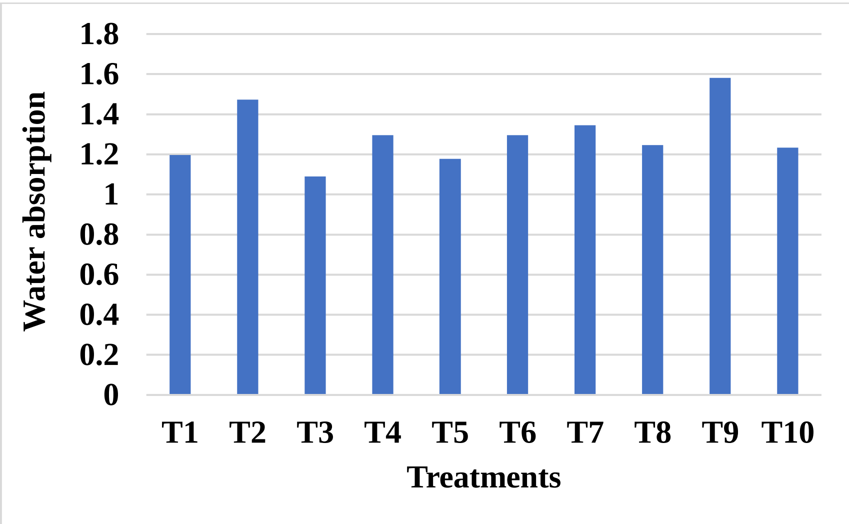

Fig 4.3 Graph showing water absorption of different treatments

4.2.4 Expansion ratio

The expansion ratio of extrudate is the calculated as 3.5.4. Three extruded samples were taken randomly and mean diameter was measured with a vernier calliper. The measured expansion ratio of 10 treatments is given below in Appendix (Table A.4). Based on the expansion ratio values obtained from the pasta treatments, it can be concluded that different treatments exhibit varying degrees of expansion during cooking. Among the treatments tested, treatment 6 (0.8719), treatment 9 (0.8410) and treatment 10 (0.8526) showed the highest expansion ratio**,** which indicates that these treatments absorb more water during cooking, resulting in a larger increase in size or volume. This can lead to a more tender and softer texture in the cooked pasta (Bouasla *et al.*, 2017).

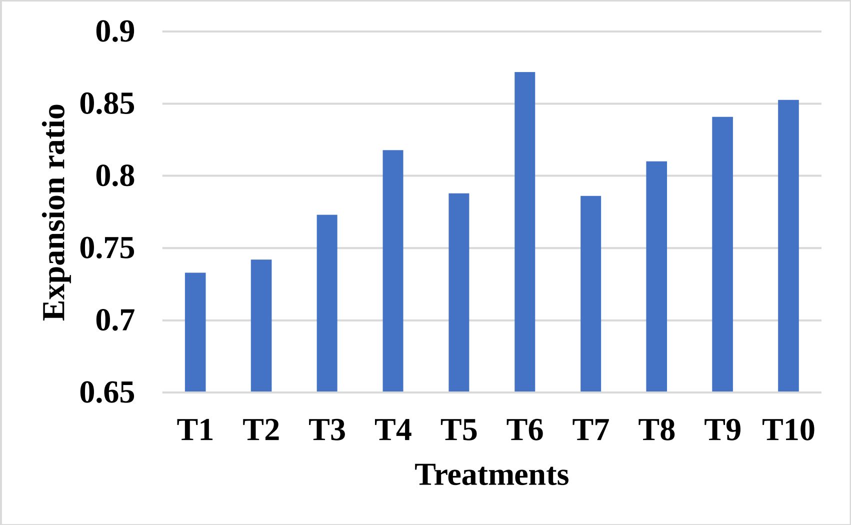

Fig 4.4 Graph showing expansion ratio of different treatments

4.2.5 Cooking time

Cooking time of the samples are calculated as 3.5.5. The cooking time values for each treatment are presented in Appendix A (Table A.5) A higher cooking time for pasta typically means that it requires more time to reach the desired level of doneness. Pasta with a higher cooking time may need to be boiled for a longer period to achieve the desired texture, ensuring that it is fully cooked and tender. Highest and lowest cooking time is found in treatment 2 and treatment 5 respectively. (Gull *et al*,2018).

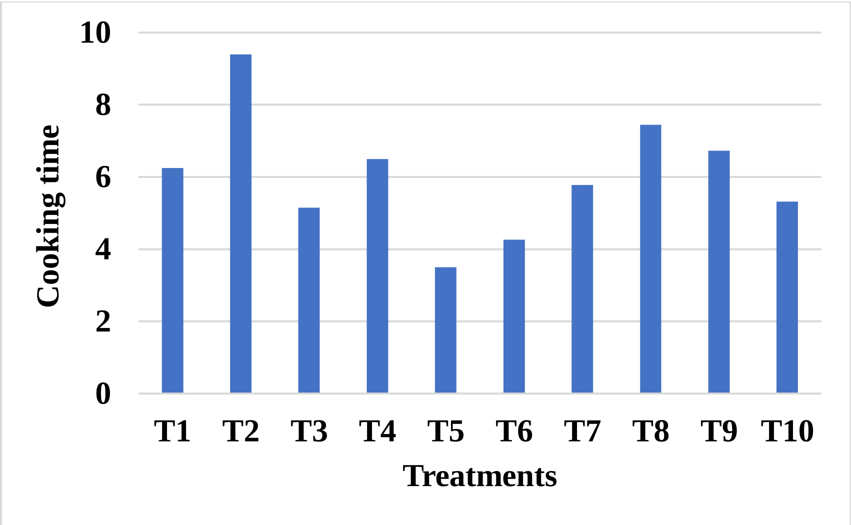

Fig 4.5 Graph showing cooking time of different treatments

4.2.6 Cooking loss

Cooking loss of the treatments are calculated a 3.5.6.A higher cooking loss for pasta means that a greater amount of the pasta's weight is lost during the cooking process. This can be an indication of poor quality or improper cooking techniques. High cooking loss can result in a loss of texture, flavour, and overall quality of the pasta. Highest and lowest cooking loss is found in treatment 5 and treatment 10 respectively (Gull *et al*,2018).

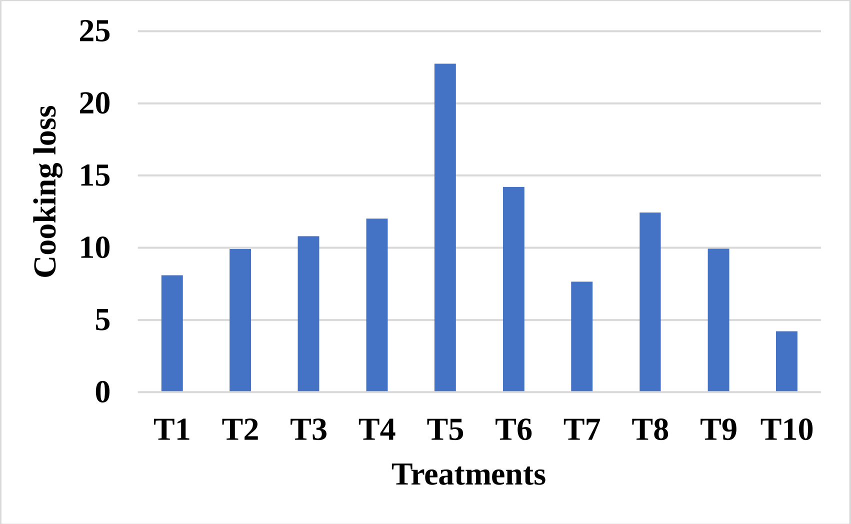

Fig 4.6 Graph showing cooking loss of different treatments

4.2.7 Ascorbic acid

Ascorbic acid values of the treatments using the methodologies as per 3.5.7. It refers to the amount of vitamin C content present in a food treatment that can be measured through a titration process.

The presence of vitamin C in pasta indicates that it has been enriched with this nutrient. A higher amount of vitamin C in pasta can contribute to its nutritional value and provide potential health benefits when consumed as part of a balanced diet. Treatment 5 contain highest amount of vitamin C, which may be due to the composition taken for it (Koh *et al*,2018).

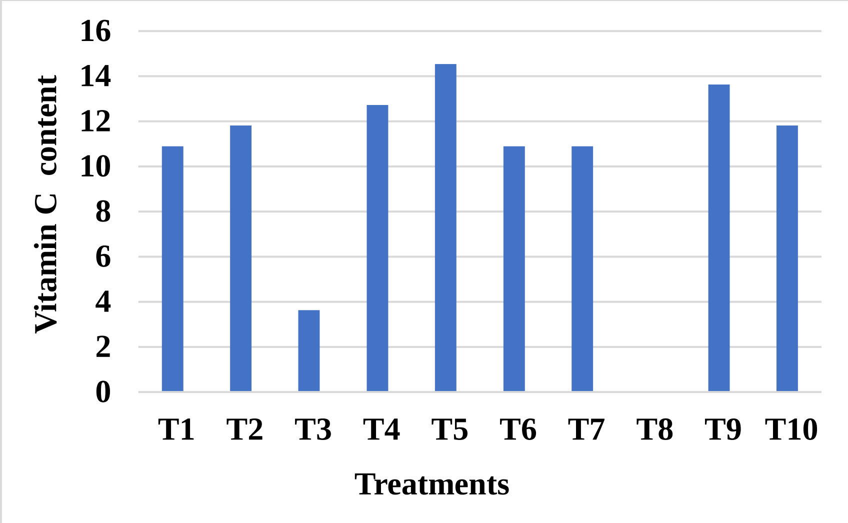

Fig 4.7 Graph showing ascorbic acid of different treatments

4.3 Sensory evaluation

The sensory evaluation of cooked jackfruit pasta involved assessing various attributes using a 9-point hedonic scale. The sensory scores obtained for attributes such as appearance, taste, colour, flavour, odour, texture, elasticity, adhesiveness, mouthfeel, and overall acceptability were subjected to statistical analysis. The results of the analysis and the sensory scores are summarized and presented in the table.

Plate 4.2: Prepared pasta

Table 4.1: The table shows the average value taken from the score card of 10 panel members.

Criteria	Samples						
	A	B	C	D	E	F	G
Appearance	6.6	8.2	7.2	8.4	5.7	6.9	7.2
Taste	6.8	7.7	7.3	7.8	6.5	7.5	7.2
Colour	6.3	8	7.5	7.5	6.3	7.2	7.3
Flavour	6.2	7.1	7.4	7.7	6.6	7.5	6.8
Odour	6.7	7.1	7.2	7.7	6.2	7.4	6.5
Texture	6.2	7.3	7.5	8.1	5.7	6.9	7
Adhesiveness	6.3	6.3	7.5	7.5	6.3	7.2	7.1
Mouth feel	5.6	7.5	7.2	8.1	5.4	6.7	7
Overall acceptability	6.2	8	7.6	8	5.7	7.4	6.9

T_5 T_2

T_7 Control

T10 T8

T9

Plate 4.3: Cooked pasta

Sample A,B,C,D,E, F and G are treatments T_5, T_2, T_7, Control, T_{10}, T_8 and T_9 respectively.

The highest mean score for appearance (8.4) was obtained for the sample which is taken as a control. And the second highest score was obtained for T_2 with a composition of 90% Wheat flour+ 10% Tender jackfruit flour+ (water content 38%).

Similarly, the highest mean score for taste (7.8) was noticed for the Control followed by the T_2 (7.7) with a composition of 90% Wheat flour+ 10% Tender jackfruit flour+ (water content 38%) and T_8 (7.5) 70% Rice flour+ 30% Ragi flour (water content 38%). The lowest mean score (6.5) for taste was recorded for the T_{10} (6.5) with a composition of 35% Wheat flour+ 10% Tender jackfruit flour+ 20% Ragi flour+ 35% Rice flour (water content 38%).

The highest mean score for colour (8.0) was obtained for the T_2 with a composition of 90% Wheat flour+ 10% Tender jackfruit flour+ (water content 38%). And the lowest mean score (6.3) for colour was recorded for the T_5 and T_{10} with a composition of 25% Wheat flour+ 25% Tender jackfruit flour+ 25% Ragi flour + 25% Rice flour (water content 38%) and 35% Wheat flour+ 10% Tender jackfruit flour+ 20% Ragi flour+ 35% Rice flour (water content 38%) respectively.

The treatment with the highest mean texture score (8.1) was the control T_2, while the treatment with the second-highest score (7.5) was T_7, composed of 90% Rice flour and 10%

Tender jackfruit flour with a water content of 38%. On the other hand, the treatment with the lowest mean taste score (6.2) was T_5, which consisted of 25% Wheat flour, 25% Tender jackfruit flour, 25% Ragi flour, and 25% Rice flour with a water content of 38%.

Both the control and T_2, composed of 90% Wheat flour and 10% Tender jackfruit flour with a water content of 38%, achieved the highest mean overall acceptability score (8). In contrast, the treatment with the lowest mean overall acceptability score (5.7) was T_{10}, consisting of 35% Wheat flour, 10% Tender jackfruit flour, 20% Ragi flour, and 35% Rice flour, with a water content of 38%.

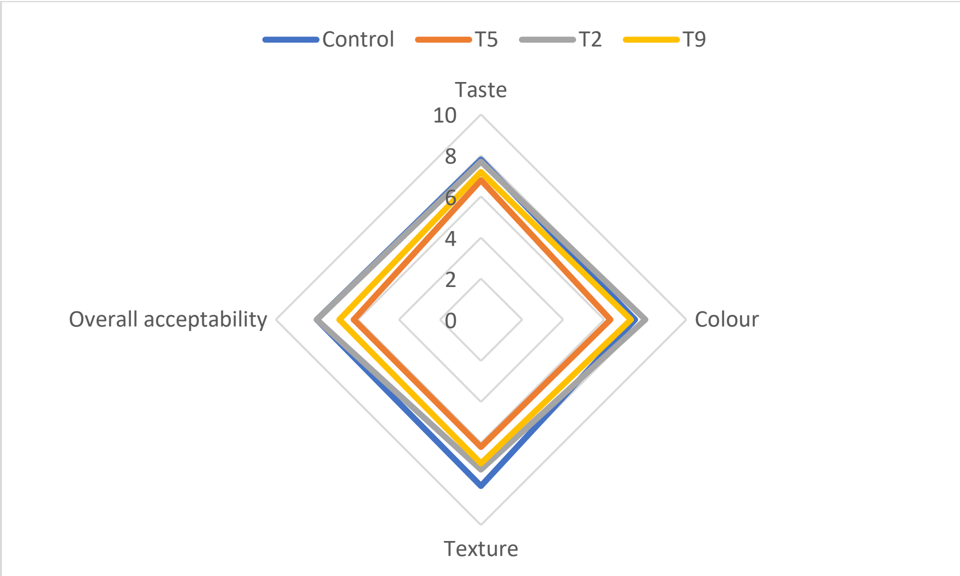

Fig 4.8: Sensory evaluation graph

From this graph it may be concluded that T_2 with the composition 90% Wheat flour, 10% Tender jackfruit flour (water content 38%) had the maximum score for all the characters via taste texture colour and overall acceptance. Therefore, the T_2 may be considered superior when compared to other treatments.

 

Plate 4.4: Uncooked and cooked pasta

4.3 Cost analysis of optimally produced extruded product

The cost estimation for the production of optimised extruded products were conducted and the cost of production of 1kg of extruded product was Rs172.52/-. The benefit: cost ratio for optimised product packed under LDPE was 3.478. The detailed calculation is presented in Appendix C.

SUMMARY AND CONCLUSIONS

CHAPTER V

SUMMARY AND CONCLUSIONS

The pasta made up of tender jackfruit flour, wheat flour, rice flour and ragi flour is a unique and innovative dish that combines the flavours and textures of these four ingredients. Tender jackfruit is the immature stage of the jackfruit (*Artocarpus heterophyllus*) before it ripens. The high fibre content in tender jackfruit supports healthy digestion. Additionally, tender jackfruit provides significant amounts of vitamin C, an antioxidant that supports immune function. Wheat flour is primarily composed of carbohydrates and these carbohydrates include starch, which is the main source of energy in wheat flour. Rice flour is free from gluten, nutrient rich and easily digestible. Ragi flour is rich in calcium, iron, dietary fibre, antioxidants, low glycaemic index and essential amino acids. Pasta was developed using the mentioned ingredients to replicate the properties found in commercially available pasta. The main objectives were to standardize the water content of the mixture and evaluate the physical and functional characteristics of the product.

A total of 14 different sets of proportions consisting of tender jackfruit flour, rice flour, ragi flour, and wheat were used to standardize the mix blend. As a reference, a commercially available pasta product was selected as the control. The blend was meticulously prepared and extruded using a laboratory model extruder. The resulting pasta products were carefully packaged and subjected to analysis for further evaluation.

The standardization of the mix was conducted by taking into account various properties, including cooking loss, cooking time, swelling index, water absorption, water activity, expansion ratio, vitamin C content, moisture content, and sensory evaluations. These properties were carefully evaluated to ensure the mix met the desired standards. Based on the assessment of the aforementioned properties, it was determined that the treatment consisting of 90% wheat flour and 10% tender jackfruit flour, with a water content of 38%, was identified as the optimal blend. This particular option is considered superior in comparison to the others. This treatment showed water activity of 0.54 a_w, swelling index 1.153 g/g, water absorption of 1.472 ml/gm, expansion ratio of 0.742, cooking time of 9.4 min, and cooking loss 9.91%, ascorbic acid 11.81mg/100g. Based on results of sensory evaluation treatment B of 90% wheat flour and 10% tender jackfruit flour, with a water content of 38% have a highest mean score values on appearance, taste, colour, texture, overall acceptability.

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APPENDICES

APPENDIX A

Table A.1: Water activity of extruded product

Treatments	**Water activity(a_w)**
T_1	0.639
T_2	0.544
T_3	0.627
T_4	0.641
T_5	0.563
T_6	0.510
T_7	0.526
T_8	0.652
T_9	0.601
T_{10}	0.649

Table A.2: Swelling index values of extruded product

Treatments	Swelling index
T_1	1.092
T_2	1.153
T_3	1.152
T_4	1.167
T_5	1.071
T_6	1.085
T_7	1.21
T_8	1.187
T_9	1.183
T_{10}	1.168

Table A.3: Water absorption values of extruded product

Treatments	Water absorption (ml/gm)
T_1	1.197
T_2	1.472
T_3	1.089
T_4	1.296
T_5	1.178
T_6	1.295
T_7	1.345
T_8	1.246
T_9	1.581
T_{10}	1.233

Table A.4: Expansion ratio values of extruded product

Treatments	Expansion ratio
T_1	0.7330
T_2	0.742
T_3	0.7731
T_4	0.8179
T_5	0.7878
T_6	0.8719
T_7	0.7862
T_8	0.8101
T_9	0.8410
T_{10}	0.8526

Table A.5: Cooking time values of different treatments

Treatments	Cooking time(min)
T_1	6.25
T_2	9.4
T_3	5.15
T_4	6.5
T_5	3.5
T_6	4.26
T_7	5.78
T_8	7.45
T_9	6.73
T_{10}	5.32

Table A.6: Cooking loss values of different treatments.

Treatments	Cooking loss (%)
T_1	8.1
T_2	9.91
T_3	10.8
T_4	12.02
T_5	22.74
T_6	14.22
T_7	7.65
T_8	12.45
T_9	9.93
T_{10}	4.21

Table A.7: Ascorbic acid values of different treatments

Treatments	Vitamin C content(mg/100g)
T_1	10.9
T_2	11.81
T_3	3.63
T_4	12.72
T_5	14.54
T_6	10.9
T_7	10.9
T_8	___
T_9	13.63
T_{10}	11.81

APPENDIX B

Score Card

Table B: Score card of sensory evaluation

Criteria	Samples						
	A	B	C	D	E	F	G
Appearance							
Taste							
Colour							
Flavour							
Odour							
Texture							
Adhesiveness							
Mouth feel							
Overall acceptability							

Like extremely -9

Like very much- 8

Like moderately- 7

Like slightly-6

Neither like nor dislike-5

Dislike slightly-4

Dislike moderately-3

Dislike very much-2

Dislike extremely-1

Date:

Name:

Signature:

APPENDIX C

COST ANALYSIS

Cost of machineries	
Cost of pasta maker	Rs 3,00,000 /-
Cost of dryer	Rs 2,50,000 /-
Cost of hammer mill	Rs 15,000 /-
Cost of sealing machine	Rs 2,000/-
Cost of miscellaneous items	Rs 1,800/-
Total cost	Rs 5,68,800

25% subsidy therefore, total cost (C) = Rs.4,26,600/-

<u>Assumption</u>

Life span (L)	= 8 years
Annual working hours (H) = 250 days (per day 8 hours)	= 2000 hours
Salvage value (S)	= 10% of initial cost
Interest on initial cost (i)	= 15% annually
Repair and maintenance	= 5% of initial cost
Insurance and taxes	= 2% of initial cost
Electricity charge	= Rs 7/unit
Labour wages	= Rs 600/day

1. <u>Total fixed cost of extrusion</u>

i. Depreciation	= Rs.23.99/h
ii. Interest	= Rs.17.5/h
iii. Insurance and taxes	= 2% of initial cost
	= Rs.4.226/h

Total fixed cost = Rs.45.756/h

2. <u>Total variable cost of extrusion</u>

i. Repair and maintenance = 5% of initial cost

= Rs.10.665 /h

ii. Electricity cost

a) Energy consumed by the pasta maker = 1 kW/h

Cost of energy consumption/h = 1×8×7

= Rs 56/ day

b) Energy consumed by dryer = 2 kW/h

Cost of energy consumption/h = 2×10×7

= Rs 140/day

c) Cost of energy consumption for sealer/h = 0.2 kW/h

= 0.2×2×7

= Rs 2.8/day

d) Energy requirement for hammer mill = 2 kW/h

Cost of energy consumption/h = 2×7×5

=70 Rs/day

iv. Labour cost = Rs 600/day

Packaging cost = Rs 50/ day

v. Cost of raw material for preparation of 10kg of extruded product

SL NO	Raw material	Quantity (Kg)	Unit rate (Per Kg)	Total amount (Rs)
1	Wheat	9	50	450
2	Jackfruit	10	30	300
	Total			750

Therefore variable/operating cost	=Rs.1679.46
Total cost of production of 10kg of extruded product	= Fixed cost + Variable cost
	=Rs.1725.21 Kg of product
	= Rs.172.52/kg of product
The market selling price of 1kg of fortified pasta	= 600 Rs /kg
Benefit-cost ratio	= 600/172.52
	= 3.47

Therefore, the total production cost of 1kg of extruded product was found to be Rs.172.52/Kg.

DEVELOPMENT OF TENDER JACKFRUIT FLOUR BASED PASTA

by
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ABSTRACT
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in
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Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

Department of Processing and Food Engineering
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ABSTRACT

Jackfruit, a tropical fruit, has garnered significant attention in recent times owing to its distinct flavor, texture, and adaptability. This delectable fruit boasts an impressive nutrient profile, including noteworthy amounts of vitamin C, potassium, and dietary fibre. Commonly utilized in Southeast Asian cuisine, tender jackfruit is harvested during its youthful, green stage, prior to the complete maturation of its seeds. With its low glycaemic index, tender jackfruit proves advantageous for individuals managing diabetes. Incorporating tender jackfruit flour into pasta dough unveils a healthier, more nourishing, and truly delightful substitute for conventional pasta, offering numerous health benefits. Hence the study titled " Development of Tender Jackfruit based Pasta " is conducted in KCAET, Tavanur which encompasses the following specific objectives; Development of nutritional tender jackfruit flour-based pasta, Evaluation of various quality parameters of pasta, Optimization of product parameter. In the study we use various composition of pasta with tender jackfruit flour, wheat flour, rice flour and ragi flour. We have initially conducted one preliminary study for finding the optimum water content required for the pasta dough preparation. In that we obtained pasta dough with 38% is optimum. After conducting various quality evaluations along with the sensory evaluation we found that pasta with composition of Wheat flour (90%) and tender jackfruit flour(10%) is standardised composition for pasta prepared with tender jackfruit. The standardization of the mix was conducted by taking into account various properties, including cooking loss, cooking time, swelling index, water absorption, water activity, expansion ratio, vitamin C content, moisture content, and sensory evaluations. In the cost analysis study we found that cost of production for pasta made with wheat flour (90%) and tender jackfruit flour (10%) is Rs.172.52 per kg. Such a pasta made with tender jackfruit flour will be a better alternative for the current regular pasta with health benefits too.