PROCESS OPTIMIZATION OF MUSHROOM INCORPORATED PASTAS

By

SOMITHA N. S.

(2019-16-005)

THESIS

Submitted in partial fulfilment of the

requirement of the degree of

Masters in Community Science

(FOOD SCIENCE AND NUTRITION)

Faculty of Agriculture

KERALA AGRICULTURAL
UNIVERSITY DEPARTMENT OF
COMMUNITY SCIENCE COLLEGE OF
AGRICULTURE VELLANIKKARA,
THRISSUR – 680656 KERALA, INDIA

2022

DECLARATION

I hereby declare that the thesis entitled "**Process optimization of mushroom incorporated pastas**" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed during the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Somitha

SOMITHA N. S.

Vellanikkara

DECLARATION

Certified that the thesis entitled "**Process optimization of mushroom incorporated pastas**" is a bonafide record of research work done independently by Ms. SOMITHA N. S. under my guidance and that it has not previously formed during the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara

DR. SEEJA THOMACHAN PANJIKKARAN
Major Advisor
Associate Professor and Head
Dept. of Community Science
College of Agriculture,
Vellanikkara

CERTIFICATE

We, the undersigned members of the advisory committee of **Ms. Somitha N. S. (2019-16-005)**, a candidate for the degree of **Master of Science** in **Community Science** with a major field in **Food Science and Nutrition**, agree that the thesis entitled **"Process optimization of mushroom incorporated pastas"** may be submitted by **Ms. Somitha N. S.** in partial fulfillment of the requirement for the degree.

Dr. Seeja Thomachan Panjikkaran
Major Advisor
Associate Professor and Head
Dept. of Community Science
College of Agriculture
Vellanikkara

Dr. Sharon C.L.
Assistant Professor
Dept. of Community Science
College of Agriculture
Vellanikkara

Dr. Lakshmy P. S.
Assistant Professor
Dept. of Community Science
College of Agriculture
Vellanikkara

Dr. Sudheer K.P.
Professor and Head
Department of Agricultural Engineering
College of Agriculture, Vellanikkara

ACKNOWLEDGEMENT

I thank God Almighty from the bottom of my heart for all the blessings I have received while I have been studying. The fortitude and bravery offered towards me allowed me to finish this difficult task.

I consider myself extremely fortunate and blessed to have, **Dr. Seeja Thomachan Panjikkaran**, *Associate professor and Head, Dept of Community Science, as chairperson of my advisory committee. Words are incapable of expressing the depth of my gratitude to her. I'm delighted to express my sincerest gratitude for her professional advice, insightful feedback, consistent encouragement, inexhaustible tolerance, warm demeanour, and mental support over the duration of the research. Her extensive knowledge, helpful suggestions, unmerited assistance, expertise, and most importantly, her understanding and excitement during the research time, have all significantly aided in the successful completion of the thesis. I will always be grateful to her with my whole heart.*

I consider myself fortunate to thank **Dr. Sharon C. L.,** *and* **Dr. Lakshmy P. S.,** *Assistant Professors, College of Agriculture, Kerala Agricultural University, Vellanikkara, and the members of my advisory committee for their invaluable assistance, boundless support, suggestions, and constant encouragement throughout the work period.*

Words cannot adequately express my sincere gratitude to **Dr. Sudheer K. P.**, *Professor and Head, Department of Agricultural Engineering, College of Agriculture, Kerala Agricultural University, Vellanikkara, and member of my advisory committee, for the constructive criticism, inspiration, and encouragement. I want to express my gratitude to him for all of his assistance and cooperation. I would like to take this opportunity to express my gratitude to the entire KAU incubation centre staff, led by Dr. Sudheer, for their unwavering guidance and support in helping me finish my job.*

I take this opportunity to express my sincere gratitude to **Dr. Suman K. T.** *and* **Dr. Aneena E. R.** *for their kind support and valuable suggestions. For his support* *and advice, I am also grateful to* **Dr. Pratheesh P. Gopinath***, Assistant professor, Kerala Agricultural University, Vellayani.*

My best friends **Riya** *and* **Amrutha** *deserve my deepest gratitude for their unfailing support and encouragement. For their help, I really thank my seniors* **Athira, Ajisha, Simla, Remmya molu, Rajeesha, Riya, Sreelakshmi, Athira, Delgi, Meera***, and my juniors* **Reshma, Gayathri, Neha, Nova,** *and* **Fathima.** *For accompanying and encouraging me throughout the research process, I want to especially thank my seniors* **Nivya, Sruthy,** *and* **Vidya***. For their genuine assistance and unwavering cooperation, I would like to thank* **Kumari chechi** *and* **Rose Chechi** *of the Department of Community Science.*

Special thanks to **Mr. Aravind** *and* **Mrs. Rajitha** *Student's Computer Club, College of Agriculture, Kerala Agricultural University, Vellanikkara for rendering necessary help. The award of* **KAU Junior research fellowship** *is thankfully acknowledged.*

Last but not least, I humbly acknowledge the love and unwavering support of **my parents** *and* **sister Sonitha***.*

Somitha N. S.

CONTENTS

List of Tables

List of figures

List of plates

INTRODUCTION

INTRODUCTION

Convenience foods have become an integral part of our food habits. Nowadays these foods with high nutritional quality are gaining acceptance in day to day life. They help consumers to reduce time as well as physical and mental efforts required for food preparation, consumption and clean-up. Thus development of healthy foods is needed in order to satisfy the market demand for functional food products.

In India, the convenience food industry, with a 90 per cent contribution of Ready-to-Eat segment in 2013, has been growing at a compounded annual growth rate (CGAR) of 15 per cent from 2007 to 2013. Use of composite flours in pasta can improve its sensory quality, rheology characteristics, and nutritional values as well as its overall acceptance. Composite flour is a good new approach which is done by blending various sources of tubers, legumes, cereals and fruit flour in different percentages to produce variety of food products.

Nutritionally, mushrooms are low in energy and fat but high in protein, and dietary fibre. They also contain a variety of minerals and trace elements. Mushrooms are common vegetable product that has also been linked to pharmaceutical and medicinal uses. Oyster mushrooms possess good nutritional properties, but are highly perishable with shelf life of one day in room temperature and three days in refrigerate condition.

Tuber crops are the most important food crops for humans after cereals and grain legumes. They offer around six per cent of global calorie consumption and are important sources of animal feed and industrial raw materials. In terms of total volume production, cassava, sweet potato and potato are among the top ten food crops grown in developing countries.

Cassava is grown in developing countries of Africa, Asia and Latin America where the lower portions of the population use this low cost, high nutrient main food. It is a rich source of starch with a content of 78 to 90 per cent on dry matter, making it suitable for blending in different preparations. Elephant foot yam is yet another underutilised tuber crop which is rich in calorie, proteins, resistant starch, minerals like potassium, iron and manganese and have considerable amount of vitamin C. High resistant starch content promotes it as a functional food due to the prominent health benefits.

Fruits and vegetables in the human diet give essential nutrients, vitamins, and fibre that are necessary for the maintenance of good health. India is the second world's biggest fruit and vegetable grower. Each year, India produces 88.9 million metric tonnes of fruit and 162.89 million metric tonnes of vegetables (NHB, 2014). However, this excess production is rarely fully utilised, and roughly 30 per cent of it is lost during various stages of handling and distribution.

Jackfruit is well - known as "poor man's food" fruit. Jackfruit has anti-diabetic, anti-bacterial, anti-inflammatory and anti-helminthic properties. The fruit is rich in carbohydrate, minerals, dietary fiber, carboxylic acid, vitamins and minerals. The rich bioactive profile of jackfruit makes it a highly nutritious and desirable fruit crop.

Breadfruit is a cultural icon in the pacific and it is an important staple crop in the region and it makes substantial contributions to local food security. It is also known as traditional starch rich crop. Breadfruit is an excellent dietary staple and compares favorably with taro, plantain, cassava and sweet potato. Breadfruit flour has a high starch content of 80.9 per cent, 4.2 per cent, crude fibre, 1.6 per cent, ash content and 4.5 per cent protein. Blending with other flours have reported best pasting properties in terms of starch stability, gelatinization index and set back values.

The addition of fruit flours and tuber flours to mushroom flour can be effectively utilized for developing products which can improve the overall diet quality. Considering the large yields, highly perishable nature of these fruits/tubers and their immense potential for product development, the present study entitled 'Process optimization of mushroom incorporated pastas" was proposed with the objectives to standardise mushroom incorporated nutri-rich pastas and to evaluate its nutritional, organoleptic and shelf life qualities.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The literature pertaining to the study entitled "Process optimization of mushroom incorporated pastas" is presented under the following sub headings.

2.1. Importance of convenient foods

2.2. Pasta – types, significance and consumer preference

2.3. Nutritional significance of tuber flour

2.4. Nutritional significance of fruit flour

2.5. Qualities of composite flours

2.1. Importance of convenient foods

Convenience foods play a major role in day to day life. These foods are saviours for busy and working people. Convenient foods are commercially prepared foods known for the ease of preparation and consumption and help the consumers for thinking about new food choices and consumption pattern according to their life style (Arya, 1992).

De Boer *et al*. (2004) defined convenient foods as fully prepared or partially prepared food items where some or all of the preparation time, culinary skills or energy inputs are provided by food processor than a home maker. Therefore, convenience is defined in terms of time, physical energy and mental effort saving related to food preparation and food consumption.

Convenient foods help the consumer to save the time and effort for food preparation and solve the meal scheduling problems (Buckley *et al*., 2007). Harris and Shiptsova (2007) stated that convenient foods are fully or partially prepared foods by a significant time, skills and energy. The intended role of convenience foods is to transfer from the kitchen to the food service provider with minimum attributes of preparation skills and energy inputs.

The purchasing behaviour and buying decisions are the multiple factors affecting the consumers to choose the convenience foods (Emery, 2013). The consumption of convenient foods is related with the availability of processed foods with the intention to consume (Contini *et al*., 2018).

Convenience foods help people to save time spend for kitchen activities and decreases the spoilage. The demand for convenience food is increasing due to increased population, changing household works, female participation in labour force and longer working hours (Ryan *et al*., 2004).

Srinivasan and Shende (2015) observed that various factors that influence the working women to choose convenience foods are the non-availability of certain ingredients for the preparation of variety of foods. Convenience foods are available in market with a variety of forms, which include products like canned products, ready to cook or ready to serve food items. These products are well designed by considering the demand and requirement of the consumer. They are also made safe for consumption and also has good shelf life.

Srinivasan and Shende (2016) revealed that the elements that influence non-working women to purchase convenience food are to avoid going to market and time saving in cooking and pre-preparation processes. About 76 per cent of working women in nuclear family also demands convenient foods.

Factors which influences the behaviour of people and the food consumption pattern is not accurately static and are influenced by social, cultural and biological factors (Worsely, 2000). Consumers for convenient foods are divided to four convenience food categories as ready meals, take away meals, restaurant meals and pub meals (De Boer *et al*., 2004). Many of the ready to cook products available to the consumers in the supermarkets are in the form of extruded snacks and they have high shelf life. Extruded products are appealing to the consumers in terms of enhanced crunchiness and crispiness (Robin *et al*., 2011). The processing of extruded foods such as pastas, baby foods and chips has become increasingly involved in recent years.

2.2. Pasta – types, significance and consumer preference

Pasta is a typical Italian dish that has gained popularity in other nations as well. The term is derived from the Italian word pasta, which means "dough" or "pasta" as in a small cake. They can be easily prepared, handled, cooked, and stored. The most important consumer attribute is the cooking quality of the pasta, which includes the cooking time, water absorption, texture, taste, and aroma of the cooked product (Gelencser *et al.*, 2008). Its popularity has grown due to its ease of preparation and palatability (Petitot *et al.*, 2009). Pasta can also refer to dishes in which pasta is the main ingredient and is served with sauce or seasonings.

Pasta is a popular cereal food that includes spaghetti, noodles, vermicelli, and macaroni, among other things. Despite the fact that pasta is thought to have originated in the Mediterranean and Asia, its growing popularity has made it a tasty and nutritious cuisine all over the world. Pasta is a very popular food in both Europe and America. Pasta has been integrated into world culture and food through European displacement, mainly from Italy, with its overall creation expanding step by step (Wang *et al.*, 2016).

Semolina, the white starchy endosperm of durum wheat, is the single ingredient used to make traditional Italian pasta. Soft wheat can now be added, and pasta can also be made using buckwheat, rice, mung bean starch, and whole wheat flour. Noodles are a broad name for ribbons or solid cylinders of pasta made from a variety of flours, occasionally with the addition of egg. Although durum wheat semolina is most commonly used, spring wheat and other cereals or legumes can also be utilised (Wu *et al.*, 2001). Wheat flour or semolina and water are the main ingredients in Pasta (Kill, 2002).

Pasta comes in a variety of shapes and is divided into two types: fresh pasta and dried pasta. Fresh pasta is normally created with fresh ingredients, unless it is going to be delivered, in which case the decomposition rates of the needed ingredients, such as eggs, are taken into account. Fresh pasta is softer than dried pasta and takes about half the time to cook. Fresh pasta does not expand after cooking (Krishnan and Prabhasankar, 2012).

Pasta with excellent physical and sensory qualities has strength and elasticity in the dough form, high tensile strength in the dried form, minimal cooking loss, and stickiness with good flavour after cooking (De Noni and Pagani, 2010).

Initially, Pasta was considered to be in a category of ‘fattening food’, but recently, it has been perceived to be a “healthy option”. The versatility of pasta as a base to any meal, it can be easily served to both health conscious consumers as well as food lovers quenching for new tastes (Krishnan and Prabhasankar, 2012).

Pasta is regarded as a product with low glycemic index (Bjorck *et al.*, 2000). Research has shown that sugars are progressively liberated from pasta during digestion, leading to a controlled increase in postprandial blood glucose and insulin response (Tudorica *et al.*, 2002).

The increasing demand for good quality gluten free products among the celiac patients have paved the way for incorporating other flours in pasta than durum wheat (Marti *et al.*, 2010). The raw materials used as substitutes of wheat in the celiac product formulations are maize, rice, pseudo-cereals, sorghum as well as their starches (Osella *et al.*, 2014). Padalino *et al.* (2014) pointed the effectiveness in the use of maize flour for pasta making. He also has observed that pasta of maize flour enriched with 15% chickpea flour can reduce the nutritional deficiencies which may affect the celiac patients.

Rice flour has also become a substitute of wheat in pasta making. White or polished rice was used in it (Yang and Tao, 2008). Marti *et al.* (2010) prepared gluten-free pasta with brown rice flour which has high fibre content than polished rice. A combination of brown rice flour and corn flour (60:40) has increased the consumer acceptability of gluten free pasta (da Silva *et al.*, 2016). Similarly pasta has been manufactured using sorghum, potato flour (Ferreira *et al.*, 2016) amaranth flour, quinoa, buckwheat (Alvarez-Jubete, 2010). To enhance the health value of pasta, researches have carried out in incorporating vegetables (Barcelon *et al*., 2014), fibre and even functional ingredients (Jaworska *et al*., 2020).

Owing to this rapid transition of pasta from junk food to healthy food, pasta has gained its importance all around the world. In India too, pasta is a rapidly growing segment of the food industry, owing to the consumer demand forready to eat foods. There are currently around 30 pasta brands available in the Indian market (Jalgaonkar and Jha, 2016).

According to the International Pasta Organisation's (IPO) most recent World Pasta Industry Report (2021), the global pasta market is worth $21.8 million. In 2020, the Indian pasta market is estimated to be valued USD 392 million. The market is predicted to develop at a CAGR of more than 16.2% between 2021 and 2026, reaching a value of around USD 965 million by 2026.

The need for new meals, new tastes, increased purchasing power, transportation, mechanisation, and infrastructural development, global consumption of pasta products is steadily increasing (Rekha *et al*., 2013). Pasta has become a truly worldwide cuisine, and the growing body of scientific evidence supporting its restorative impact is encouraging news for anyone who wants to eat for health, taste, and comfort.

2.3. Nutritional significance of tuber flour

Starchy roots and tuber crops play a pivotal role in the human diet. There are number of roots and tubers which make an extensive biodiversity even within the same geographical location. Thus, they add variety to the diet in addition to contributing numerous desirable nutritional and health benefits such as antioxidative, hypoglycemic, hypocholesterolemic, antimicrobial, and immunomodulatory activities (Nuani *et al*., 2022).

Tuber as a source of local food is an organ of plants that serves as a storage of carbohydrates. A number of bioactive constituents such as phenolic compounds, saponins, bioactive proteins, glycoalkaloids, and phytic acids are responsible for the observed effects. Many starchy tuber crops, except the common potatoes, sweet potatoes, and cassava, are not yet fully explored for their nutritional and health benefits. Roots and tubers have a great potential to provide economical sources of dietary energy, in the form of carbohydrates (Chandrasekhara, 2019).

Cassava is the most commonly cultivated root crop in the tropic regions. Cassava is a perennial shrub belonging to the family Euphorbiaceae. Cassava plays an important role as staple food for more than 500 million people in the world due to its high carbohydrate content. A number of bioactive compounds are present in cassava namely, cyanogenic glucosides such as linamarin and lotaustralin, non cyanogenic glucosides, hydroxycoumarins such as scopoletin, terpenoids, and flavonoids are reported in cassava roots (Chandrasekhara and Josheph, 2016).

Cassava is rich in carbohydrates and deficient in proteins and fats (Emmanuel *et al*., 2015). Processing of cassava roots leads to decreased cyanide content and improved shelf life stability. Efforts to increase its commercial utilization accept blending cassava flour with other high protein content flours or starches derived from other sources (Chisenga *et al*., 2019).

The nutritional composition of cassava was 4.13% moisture, 0.63% ash, 1.37% fat, 0.60% protein, 1.83% crude fibre and 91.41% of total carbohydrates and the cassava fibre has a good nutritional quality compared to that of wheat bran as a standard fibre (Fiorda *et al*., 2013).

Cassava has high glycaemic index value due to its high starch content. Cassava has nearly twice the calories per 100 grams when compared with other tuber vegetables. A 100 gram of cassava provides 20.6 milligrams of vitamin C. Vitamin C present in cassava helps to fight against free radicals (Daemo *et al*., 2022). Cassava flour offers antioxidants and helps to decrease inflammation.

Cassava roots have sulphur containing amino acids, methionine and cysteine. Cassava also contains anti-nutrients that can be either positive or has adverse effect on health depending up on the amount ingested. Some compounds in this act as antioxidants and anticarcinogens (Montagnac *et al*., 2009).

Elephant foot yam is one of the most nutritious tuber crop. Because it has high yield potential, medicinal property and therapeutic values and it is referred to as 'king of tuber crops' (Sengupta *et al*., 2008).

Amorphophallus is one among the major vegetable (tuber) crops grown in Asian countries. In China and Japan, it has been used as food and a food additive for more than 1000 years. Elephant foot yam is a low-caloric, soluble polysaccharide dietary fibre used in foods and as medicine component. The polysaccharides have been also largely consumed as nutritional supplements. The important health benefits described for elephant foot yam include in reducing cholesterol, normalizing triglyceride content and improving blood sugar levels, and promoting intestinal activity and immune function in human beings. Yam is considered as an indigestible dietary fibre, being resistant to hydrolysis by the action of digestive enzymes in humans (Behera and Ray, 2017).

The digestibility of amorphophallus starch by alpha-amylase was studied that 98% digestibility for gelatinized starch as compared to 21% for raw starch (Wankhede and Sajjan, 1981). Elephant foot yam is one of the naturally occurring low glycaemic carbohydrate sources compared with traditional, soluble fibres and it has many favourable features for the food industry (Behera and Ray, 2017).

Elephant foot yam is not a good source of protein. Crude protein content of the tuber ranges from 0.84 – 2.60% and that is much less than that in cereals and pulses. Roots and tubers are very poor in fat content. The fat content in elephant foot yam is just 0.07 – 0.40% and is a good source of minerals (Moorthy, 2002). Elephant foot yam is a functional food due to the presence of resistant starch which has numerous health benefits on humans (Suriya *et al*., 2016). Elephant foot yam is a low caloric, soluble polysaccharide used in foods and is used as medicinal ingredient. The importance of elephant foot yam include reducing cholesterol, normalising triglyceride content and improving blood sugar levels and promoting intestinal activity and immune function in human beings. It is considered as an indigestible dietary fibre and resistant to hydrolysis by action of digestive enzymes (Behera and Ray, 2016).

2.4. Nutritional significance of fruit flour

Kumar and Kumar (2004) stated that fruits have been major food for mankind and it constitutes an important item in our diet. Fruits are no longer luxury, and they belong to an important class of protective foods, which provide adequate vitamins and minerals that are needed for the maintenance of the health (George, 2005).

Kaur and Maini (2001) observed that fruits contain phytochemicals and antioxidants that have health promoting benefits and can reduce the cardiovascular diseases, cancer and various other degenerative disease. Consumption of fruits may lead to prevention of chronic disease like type II diabetes and cancers (Lila, 2007). These prevention effects of fruits are due to the presence of health promoting phytochemicals such as flavonoids, carotenoids, phenolic compounds and vitamins. Now a days consumption of fruits are increasing because of the beneficial effects on human health associated with the dietary intake of fruits (Singh *et al.*, 2012).

Nanjundaswamy (1990) reported that the nutritional composition of 100 gram edible portion of jackfruit contain moisture 72 per cent, protein 1.3 g, fat 0.3 g, carbohydrate 25.4 g, fibre 1.0 g, minerals like calcium 22 mg, phosphorus 38 mg, sodium 2 mg, and potassium 470 mg and vitamins like thiamine 0.003 mg, niacin 4 mg and ascorbic acid 8 mg. Jackfruit has high amount of protein, starch, calcium and thiamine (Burkill, 1997). The edible part of jackfruit contains moisture 76.2 per cent, protein 0.70g, fat 0.30g, carbohydrate 19.80g (Singh and Srivastava, 2000).

A study was conducted by Baruah (2014) in jackfruit pulp incorporated toffee by incorporating jackfruit pulp in levels of 10, 20, 30 and 40 per cent. Crude protein, crude fat, ash, crude fiber, iron and total sugar contents of jackfruit toffee was recorded to be 1.74 (g/100g), 0.28 (g/100g), 1.26 (g/100g), 1.30 (g/100g), 0.70 (mg/100g) and 18.52 (g/100g) respectively.

Munishamanna *et al.* (2012) conducted a study in developing various value added products incorporating jackfruit flour. The products have improved the sensory qualities as well as the nutritional qualities of the products by the incorporation of jackfruit flour.

Kumari *et al*. (2015) developed raw jackfruit based noodles by mixing refined flour and jackfruit bulb flour and seed flour in the ratio of 50:10:40. The prepared product was found to be highly acceptable and had good nutritional and shelf life qualities.

Breadfruit has protein 1.31%, fat 0.31%, carbohydrate 27.82%, fibre 1.5% and total ash 1.232 %. It also rich in calcium, phosphorous, iron, potassium, carotene and vitamin B (Wang *et al*., 2011). Ojokoh *et al*. (2014) observed that breadfruit – cow pea fermentation improves the nutritional composition and it used as complementary food for infants in PEM management.

Breadfruit contains amylopectin 77.48% and amylose 22.52%. A study conducted by Hafid *et al*. (2019) on nutritional composition of chicken nuggets using additional variation of breadfruit. The substitution of tapioca flour with breadfruit flour was better nutritionally. Nuggets with 50% substitution of breadfruit flour and 50% of tapioca flour had moisture content of 61.5%, ash 1.65%, protein 17.55% and fat 17.72%

Ishera *et al*. (2021) studied that nutritional composition of wheat – breadfruit flour composite cookies. Breadfruit flour was incorporated in the ratio of 20, 40, 60, 80 and 100. Incorporating breadfruit flour improved mineral, carbohydrate and fiber content of the cookies. In nutritional and sensory qualities, 40% breadfruit and 60% wheat incorporated cookies were highly acceptable.

Akeem *et al*. (2017) conducted a study that developing instant noodles produced from composite breadfruit flour with increased protein, ash, carbohydrate and fiber content.

2.5. Qualities of composite flours

The process of mixing different flours to produce high quality foods is referred as composite flour technology. The formulation of composite flour is an essential factor for the good functioning of value added products development (Rehman *et al*., 2007). The value added products developed from composite flour not only improves quality, but also it provides essential attributes to consumer preference. Composite flours are a mixture of several flours obtained from roots, tubers, cereals and legumes with or without the addition of wheat flour. Composite flours are only a mixture of different vegetables flours rich in starch or protein. Development of the products by incorporation of blends of different levels of flour in a product help to meet the daily nutritional requirement. Composite flour is defined as a mixture of flours obtained from tubers which rich in starch such as cassava, yam, potato and protein-rich flour and cereal, with or without wheat flour that created to satisfy specific functional characteristics and nutrient composition (Noorfarahzilah *et al*., 2014). The functional properties of composite flours are swelling capacity, water absorption, oil absorption, emulsion activity, emulsion stability, foam capacity and foam stability. Composite flours can be formulated by combining cassava, maize, rice, sorghum, millets, potato, barley, sweet potato and yam in different proportions (Chandra *et al*., 2015).

Tharise *et al*. (2014) stated that composite flour technology is the process of mixing various types of flours from tubers with cereals or legumes with or without adding wheat flour. This is one of the study that promote the use of composite flours that are locally grown crops and have high protein content was used to produce protein rich composite flours.

Composite flour is considered as advantageous in developing areas as it reduces the importing of wheat and uplift the use of locally grown crops as flour (Noorfarahzilah *et al*., 2014)

Ekunseitan *et al*. (2017) reported high protein and fat content of oyster mushroom. Due to high protein and fat content of oyster mushroom, it could be incorporated into various recipies for improving nutritional qualities of the food items. The proteins present in mushrooms are in the form of easily digestable and better in quality compared with many legume source foods and vegetable foods.

Germination plays a major role in promoting the qualities of composite flours. Sibian and Riar (2020) reported that supplementing germinated legume flours will produce a product with high nutrition and digestibility. Germination is one of the best and inexpensive methods to improve the nutritional qualities and functional characteristics.

To improve the nutritional qualities of the composite flours a readily available protein rich mushroom flour are added. To improve the nutritional and textural qualities, various sources of starch, fibre, protein from other agricultural products rich in nutrients can be incorporated with mushroom flour (Thomas *et al.*, 2022).

Cassava and wheat flours have the highest swelling capacity due to flours (Singh *et al*., 2003). Shanti *et al*. (2005) observed that the composite flour mixture could provide a balanced nutrient. The fiber content of composite flour varied from 0.86% to 1.02%. The fibre content of wheat flour was higher than the fortified flour (Kumar and Saini, 2016).

Noorfarahzilah *et al*. (2014) studied that composite flour in development of food products by blending with wheat flour with various sources of tubers, legumes, cereals and fruit flours in different levels to produce food products. The use of composite flour and its positive effects can be seen in the functional and physico chemical properties of the products.

Amandikwa *et al*. (2015) observed the impact of yam flour substitution on characteristic of wheat bread. Yam flour was substituted at 25, 50 and 75% in wheat flour for bread production. It was observed that the mean score of sensory quality was poor when the substitution of yam flour increased and the organoleptic evaluation of bread samples shown that the substitution level of 50% or above the yam produced bread that was not acceptable whereas 25% was acceptable for consumers.

Moisture content, low peroxide value and zero microbial count of the product showed that cassava strips can be stored for period of four weeks without any spoilage. The addition of cowpea flour increases the protein content of cassava strips. This indicates that cassava strips could be a helpful for improving nutritional content (Dada *et al*., 2018).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The methods followed and materials used for the thesis entitled "Process optimisation of mushroom incorporated pastas" are discussed under the following headings.

3.1 Collection of raw materials
3.2 Standardisation of nutri-rich ready to cook extruded food from tuber flour and mushroom flour
3.3 Standardisation of nutri-rich ready to cook food from fruit flour and mushroom flour
3.4 Preparation of spice mix
3.5 Organoleptic evaluation
3.6 Quality evaluation of selected nutri-rich pastas
  3.6.1. Nutritional qualities
  3.6.2. Health studies
  3.6.3. Shelf life studies
3.7 Cost of production
3.8 Statistical analysis

3.1. Collection of raw materials

Oyster mushroom (*Pleurotus florida*) was collected from KVK Thrissur, Kerala Agricultural University. Cassava, elephant foot yam, breadfruit and jackfruit were collected from households and local market. All the other ingredients required for the study were purchased from the local market.

3.2. Standardisation of nutri-rich ready to cook extruded food from tuber flour and mushroom flour

Tubers selected for the study were cassava and elephant foot yam. Pastas were prepared using combinations of cassava flour with oyster mushroom flour and elephant foot yam flour with oyster mushroom flour.

Table 1: Proportion of ingredients in tuber flour and oyster mushroom flour incorporated pastas

Combinations	Treatments				
	T_0 (control)	T_1	T_2	T_3	T_4
CF + OMF	100% CF	90% + 10%	80% + 20%	70% + 30%	60% + 40%
EFYF + OMF	100% EFYF	90% + 10%	80% + 20%	70% + 30%	60% + 40%

(CF - cassava flour, EFYF – elephant foot yam flour, OMF – oyster mushroom flour)

3.3. Standardisation of nutri-rich ready to cook extruded food from fruit flour and mushroom flour

Flours were prepared from mature jackfruit (*koozha* type) and breadfruit. Pastas were prepared using combinations of jackfruit flour with oyster mushroom flour and breadfruit flour with oyster mushroom flour.

Table 2: Proportion of ingredients in fruit flour and oyster mushroom flour incorporated pastas

Combinations	Treatments				
	T_0 (control)	T_1	T_2	T_3	T_4
JF + OMF	100 % JF	90% + 10%	80% + 20%	70% + 30%	60% + 40%
BF + OMF	100 % BF	90% + 10%	80% + 20%	70% + 30%	60% + 40%

(JF – jackfruit flour, BF – breadfruit flour, OMF – oyster mushroom flour)

Mixing of composite flour (100g)

↓

Made into dough

↓

Transfer and knead in pasta machine for 1 minute

↓

Extrude pasta using single screw

↓

Cutting to desired shapes

↓

Drying (60ºC - 75ºC for 2 hours)

Figure 1: Flow chart for the preparation of ready to cook extruded food pasta

3.4. Preparation of spice mix

Spice mix (100g) were standardised using preliminary studies. The ingredients used in study were purchased from local market and mixed well using a sieve. The ingredients and the amount used for the spice mix are detailed below:

Coriander powder - 40g

Garam masala - 7g

Turmeric powder - 2g

Chilli powder - 8g

Garlic powder - 3.5g

Onion powder	-	3.5g
Aamchur powder	-	7g
Pepper powder	-	2g
Powdered sugar	-	7g
Corn flour	-	10g
Salt	-	10g

All the ingredients were mixed together and were packed in 5g sachets for seasoning 100g pastas.

3.5. Organoleptic evaluation

The organoleptic qualities of the pastas were conducted by score card method using nine-point Hedonic scale by a panel of fifteen selected judges.

3.5.1. Selection of judges

Triangle test suggested by Jellinek (1985) was carried out in the laboratory. Based on the results of triangle test, a panel of fifteen judges (between 18 - 35 years) were selected. The acceptability trials of pastas were done by this panel

3.3.3. Selection of the most acceptable treatment

The best treatment was selected through sensory parameters by applying Kendall's coefficient of concordance.

3.6. Quality evaluation of selected ready to cook extruded foods

3.6.1. Nutritional qualities

The nutritional qualities of pastas was carried out in three replications and the methods used are discussed below.

3.6.1.1. Moisture

Moisture content of pastas was estimated by the method of A.O.A.C (1980). To determine the moisture content of the products, five gram pasta was taken in a petridish and dried at 60°C to 70°C in a hot air oven, cooled in a desiccator and weighed. The process of heating and cooling was repeated till constant weight was achieved. The moisture content of the ready to cook extruded foods was calculated from the loss in weight during drying.

$$\text{Moisture content (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

3.6.1.2. Energy

Energy content of selected ready to cook pastas were calculated according to Gopalan *et al*. (1989) and expressed as kilocalories (k Cal). The energy present in extruded foods was calculated as per the formula given below.

Energy (k Cal) = (CHO x 4) + (Protein x 4) + (Fat x 9)

3.6.1.3. Total Carbohydrate

The total carbohydrate content was analysed calorimetrically using anthrone reagent (Sadasivam and Manickam, 1997). Food sample of 100 mg was hydrolysed with 5 ml of 2.5 N HCl and then cooled to room temperature. Later the residue was neutralized with solid carbonate until the effervescence ceases and the volume was made up to 100 ml and centrifuged. Pipetted 0.1 ml of supernatant and made up to 1 ml, added 4 ml anthrone reagent, heated for eight minutes, cooled rapidly and the intensity of green to dark green colour was read at 630 nm.

A graph was prepared using serial dilutions of standard glucose. From the standard graph the amount of total carbohydrate present in the sample was estimated and expressed in grams.

3.6.1.4. Protein

Protein was estimated by the method of A.O.A.C. (1980). Sample (0.2 g) was digested with six ml Conc. H_2SO_4 after adding 0.4 g of $CUSO_4$ and 3.5 g K_2SO_4 in a digestion flask until the colour of sample was converted to green. After digestion, it was diluted with water and 25 ml of 40 per cent NaOH was pumped. The distillate was collected in two per cent boric acid containing mixed indicators and then titrated with 0.2N HCl to determine the nitrogen content. The nitrogen content thus estimated was multiplied with a factor of 6.25 to get the protein content.

3.6.1.5. Fat

The fat content of the extruded foods was estimated using the method given by Sadasivam and Manickam (1997). Five gram of sample was taken in a thimble and stoppered with cotton. The material was extricated with petroleum ether for six hours without interruption by gentle heating in a Soxhlet apparatus. Extraction flask was then cooled and ether was separated by heating and the weight was noted. The fat content was expressed in gram per 100g of the sample.

3.6.1.6. Fibre

The crude fibre of products was estimated using method given by Sadasivam and Manickam (1997). Two grams of dried and powdered sample was boiled with 200ml of 1.25 per cent sulphuric acid for 30 minutes. It was filtered using muslin cloth and washed with boiling water. The residue was again boiled with 200ml of 1.25 per cent of sodium hydroxide for 30 minutes. Repeated the filtration through muslin cloth and residue was washed with 25ml of boiling 1.25% of sulphuric acid, three 50 ml portion of water and 25ml of alcohol. Then obtained residue was taken in ashing dish (W_1) dried at 130ºC for 2 hours, cooled the dish in a desiccator and weigh (W_2). The residue was again ignited in muffle furnace at 600ºC for 30 minutes, cooled in a desiccator and reweighed (W_3).

$$\text{\% crude fibre in ground sample} : \frac{\text{Loss in weight on ignition } (W2 - W1) - (W3 - W1)}{\text{Weight of the sample}} 100$$

3.6.1.7. Starch

The starch content was estimated calorimetrically using the anthrone reagent as suggested by Sadasivam and Manickam (1997). The sample (0.5g) was extracted repeatedly with 80 per cent ethanol to remove sugars completely. The residue was dried over a water bath and 5 ml water and 6.5 ml 52 per cent perchloric acid were added and extracted at 100ºC for 20 minutes. The sample was centrifuged and re-extracted with fresh perchloric acid. The supernatant was pooled and made up to 100 ml. Pipetted out 0.2 ml of the supernatant and made up to 100 ml. Pipetted out 0.2 ml of the supernatant and made up to 1 ml with water and 4 ml of anthrone reagent, heated for 8 minutes, cooled and read the OD at 630 nm.

A standard graph was prepared using serial dilution of standard glucose solution. From the graph, glucose content of the sample was computed and multiplied by a factor 0.9 to arrive at the starch content and expressed in percentage.

3.6.1.8. Calcium

Calcium content was estimated by atomic absorption spectrophotometric method using the diacid extract prepared from the sample (Perkin and Elmer, 1982). The diacid was prepared by mixing 70 per cent perchloric acid in the ratio 9:4. Two gram of extruded foods samples was digested in this diacid and the extract was made up to 100 ml. This solution was read directly in atomic absorption spectrophotometer. Calcium content was expressed in mg 100 g of the sample.

3.4.1.9. Iron

Iron content of the sample was estimated by atomic absorption spectrophotometric method using the diacid extract prepared from the sample (Perkin and Elmer, 1982). The diacid solution was directly read in atomic absorption spectrophotometer to find the iron content and expressed in mg per 100 g sample.

3.6.1.10. Sodium

Sodium content of the sample was estimated by using flame photometer as suggested by Jackson (1973). Sample of one gram was digested using diacid solution and made up to 100ml with distilled water. From this made up solution, one ml was directly fed in to the flame photometer and reading was noted. The sodium content was expressed in mg per 100g of the sample.

3.6.1.11. Magnesium

Magnesium content was estimated by atomic absorption spectrophotometric method using the diacid extract prepared from the sample (Perkin and Elmer, 1982). Two gram of pasta samples was digested in this diacid and the extract was made up to 100 ml. This solution was read directly in atomic absorption spectrophotometer. Magnesium content was expressed in mg 100 g of the sample.

3.6.1.12. Potassium

Potassium present in extruded foods was estimated using method suggested by Jackson (1973) with the help of Flame Photometer. One gram of the extruded food sample was digested using diacid solution. The pre-digested sample was used to measure potassium content in flame photometer and it was expressed as mg per 100g of the sample.

3.6.2 Health studies

3.6.2.1. *In vitro* digestibility of starch

One gram of sample in 100 ml water was gelatinized and boiled for one hour and filtered. One ml of the gelatinized solution was taken and one ml of the enzyme solution (saliva diluted with equal quantity water). The mixture was incubated at 37ºC for 1-2 hours; the reaction was stopped by adding 1 ml of sodium hydroxide. Later the glucose was estimated.

3.6.2.2. *In vitro* digestibility of protein (IVPD)

In vitro protein digestibility was assessed by following the procedure as Sadasivam and Manickam (1997). To the powdered vermicelli sample add 10ml of the distilled water where the sample will be adjusted to obtain 6.25mg of protein/litre. The sample was maintained at a temperature of 37˚C with a pH of 8. To the prepared protein suspension added about 1ml of the three enzyme solution (combination of 1.65mg porcine pancreatic trypsin type IX, 3.1mg bovine pancreatic chymotrypsin type II, 1.3mg porcine intestinal peptidase grade III). An aliquot of multienzyme solution were added to one ml of the bacterial protease solution. The sample was recorded for the pH drop within ten minutes using pH meter. *In vitro* protein digestibility was calculated using the formula as suggested as follows.

$$IVPD = 210.46 - 18.10X,$$

i.e. X denoted as pH after 10 minutes of incubation

3.6.2.3. *In vitro* availability of minerals

In vitro availability of calcium, iron and phosphorous were examined using the formula of Duhan *et al.* (2001). For the *in vitro* availability, HCl extractability of minerals was estimated. The selected rhizome flour samples were extracted with 0.03N HCl in a shaker for a period of three hours at 37ºC. The sample was filtered with a help of whatman no. 40 filter paper to obtain a clear extract. The extricated clear extract was dried at 100ºC in an oven followed by wet acid digestion. Then in the digested sample the amount of HCl extractable calcium, iron and phosphorus were estimated as per prescribed procedures above for the estimation of minerals. The formula suggested to compute the HCl extractability were as follows.

$$\text{Mineral extractability (\%)} = \frac{\text{Mineral extractability in 0.03N HCl}}{\text{Total mineral}} \times 100$$

3.6.3. Shelf life studies

The selected treatments were packed in HDPE covers. The standardized spice mix was packed in laminated aluminium pouches (250 gauge) and was kept for the period of three months. The following aspects was studied in the selected samples during storage at monthly intervals.

3.6.3.1. Sensory qualities of the snack

The organoleptic qualities of pastas were conducted by score card method using nine-point Hedonic scale by a panel of fifteen selected judges.

3.6.3.2. Enumeration of total microflora

The microbial population present in the pastas sample were estimated using serial dilution plate count method as suggested by Agarwal and Hasija (1986). The microbial analysis was carried out in extruded foods sample initially and at monthly intervals for three months of storage.

3.6.3.2.1. Preparation of samples and media for microbial enumeration

The sample was prepared by mixing 90ml of distilled water with 10g of pasta sample and shaken well using a shaker to obtain suspension. The serial dilutions were carried out in the prepared water blank. To nine ml of water blank transfer one ml of the prepared suspension with a dilution of 10^{-2}. This is then diluted to 10^{-3} followed by 10^{-4}, 10^{-5} and 10^{-6} using serial dilution techniques. Bacteria, fungi and yeast count were assessed using Nutrient Agar (NA), Potato Dextrose Agar (PDA) and Sabouraud's Dextrose Agar (SDA) media respectively and results were given as cfu/g.

3.6.3.2.2. Enumeration of bacterial colony

Total number of bacterial colony was computed in 10^{-5} dilution in nutrient agar medium. In a sterile petriplate, one ml of 10^{-5} dilution was erupted using a micropipette. To petriplate, pour about 20ml of the nutrient agar medium which is uniformly spread in petriplate by rotating in clockwise and anticlockwise directions. For bacterial colony the enumerated petriplates were kept for 48hrs at room temperature. The total number of bacterial colonies were counted and expressed as cfu/g.

3.6.3.2.3. Enumeration of fungal colony

Total number of fungal colony was enumerated in 10^{-3} dilution in Martin Rose agar medium. In a sterile petriplate, pour one ml of 10^{-3} dilution using a micropipette. To petriplate pour about 20ml of the Potato Dextrose Agar medium is uniformly spread. For fungal colony enumeration, the petriplates were incubated for 4 to 5 days at room temperature. The total number of fungal colonies were counted and expressed as cfu/g.

3.6.3.2.4. Enumeration of yeast colony

Total number of yeast colony was enumerated in 10^{-3} dilution in Sabouraud's Dextrose Agar medium. In a sterile petriplate, pour one ml of 10^{-3} dilution using a micropipette. To petriplate about 20ml of the Sabouraud's Dextrose Agar medium was erupted which is uniformly spread in the petriplate by rotating. For enumeration of yeast population, the petriplates were incubated for 4 to 5 days in room temperature. The total number of yeast colonies were counted and expressed as cfu/g.

3.6.3.3. Insect infestation

Insect infestation of extruded foods were observed and recorded initially and at monthly intervals for three months of storage. Insect infestations were assessed by visual examination.

3.7. Cost of production of selected products

Cost analysis of the products was done to assess the extent of expenses for the preparation of products. The cost of production was worked out based on the market rates of different ingredients used for the preparation of the products. The cost was calculated for 100g of the product and compared with the price of similar product available in the market.

3.7. Statistical analysis of the data

The observations were tabulated and analysed statistically as completely randomised design (CRD). The scores of organoleptic evaluation were assessed by Kendall's coefficient of concordance.

RESULTS

4. RESULTS

The results of the present study entitled "Process optimization of mushroom incorporated pastas" are presented under the following headings.

4.1. Standardisation of nutri-rich ready to cook extruded food from tuber and mushroom flour

4.1.1. Cassava and mushroom flour incorporated pastas

4.1.2. Elephant foot yam and mushroom flour incorporated pastas

4.2. Standardisation of nutri-rich ready to cook extruded food from fruit and mushroom flour

4.2.1. Jackfruit and mushroom flour incorporated pastas

4.2.2. Breadfruit and mushroom flour incorporated pastas

4.3. Quality evaluation of selected ready to cook extruded foods

4.3.1. Nutritional qualities

4.3.2. Health studies

4.3.3. Shelf life studies

4.4. Cost of production

4.1. Standardisation of nutri-rich ready to cook extruded food from tuber and mushroom flour

Tubers selected for the study were cassava and elephant foot yam. Pastas were prepared using combinations of oyster mushroom flour with cassava flour; and oyster mushroom flour with elephant foot yam flour.

4.1.1. Cassava and mushroom flour incorporated pastas

Pastas were prepared by varying the proportions of cassava flour and oyster mushroom flour. The control (T_0) was 100% cassava flour and the treatments was repeated by varying the proportions of cassava and mushroom flour. Organoleptic evaluation of the treatments were carried out and the scores are tabulated in Table 3. The different quality attributes were ranked based on their mean scores using Kendall's coefficient of concordance (W).

Table 3: Mean scores for organoleptic evaluation of pastas from cassava flour and mushroom flour

Parameters	T_0	T_1	T_2	T_3	T_4	W
Appearance	7.80 (4.90)	6.80 (1.80)	7.13 (2.90)	7.24 (3.40)	7.05 (2.00)	0.628**
Colour	7.66 (3.50)	7.06 (2.80)	7.13 (2.10)	7.28 (3.40)	7.16 (3.20)	0.137*
Flavour	7.46 (3.60)	7.13 (1.40)	7.46 (3.20)	7.55 (3.60)	7.31 (3.20)	0.350**
Texture	7.20 (2.70)	7.20 (2.90)	7.16 (2.80)	7.28 (3.00)	7.13 (3.60)	0.052*
Taste	6.93 (3.00)	7.00 (2.60)	7.18 (3.40)	7.21 (3.00)	7.02 (3.00)	0.035*
Overall Acceptability	7.40 (3.20)	7.06 (3.20)	7.03 (3.20)	7.22 (3.00)	7.16 (2.40)	0.049**
Mean total score	7.40	7.04	7.18	7.29	7.13	

Values in parentheses are mean rank score based on Kendall's coefficient of concordance (W)
(** significant at 1% level, * significant at 5% level)
(T_0 – 100% CF ; T_1 – 90% CF + 10% OMF ; T_2 – 80% CF + 20% OMF ; T_3 – 70% CF + 30% OMF ; T_4 – 60% CF + 40% OMF)
CF – Cassava flour , OMF – Oyster mushroom flour

The mean organoleptic scores for the appearance of cassava and mushroom flour incorporated pasta ranged from 6.8 (T_1) to 7.24 (T_3) with mean rank score from 1.80 to 3.40. The score for the appearance was recorded highest for T_0 (7.80) followed by T_3 (7.24). The lowest score was recorded for T_1.

The highest mean score (7.66) for colour was recorded for T_0 and the lowest mean score of 7.06 was noticed in T_1. The mean scores for colour in mushroom flour incorporated pastas ranged from 7.06 to 7.28 with the mean rank scores ranging from 2.80 to 3.40.

The mean scores for flavour of cassava and mushroom incorporated pasta ranged from 7.13 to 7.55 with mean rank score varying from 1.40 to 3.60. The highest score of 7.55 was noticed in T_3 and the lowest mean score of 7.13 was noticed in T_1.

Among different treatments tried for the preparation of pasta using cassava and mushroom flour the highest mean score of 7.28 for texture was recorded for T_3 with mean rank score of 3.00 and the lowest mean score of 7.13 was noticed in T_4.

The mean score and mean rank scores for taste of cassava and mushroom flour pasta ranged from 7.00 to 7.21 and 2.60 to 3.40 respectively. The highest mean score of 7.21 was noticed in T_3 and the lowest mean score was found to be in T_1.

Overall acceptability was recorded highest for the pasta prepared using cassava flour alone (T_0), wheras in blended flours T_3 (7.22) followed by T_4 (7.16) attained higher scores. The mean rank score ranged from 3.20 to 2.40.

Treatment T_3 (70% CF + 30% OMF) attained highest total score of 43.74 for organoleptic attributes compared to other treatments. The lowest total score was observed in T_1 (90% CF +10% OMF).

Based on the total scores; the control (T_0) and from the blended pastas the treatment (T_3) were selected for further studies.

Based on Kendall's coefficient of concordance (W) value, significant agreement among judges was noticed in the evaluation of different quality attributes of cassava flour and mushroom flour incorporated pastas.

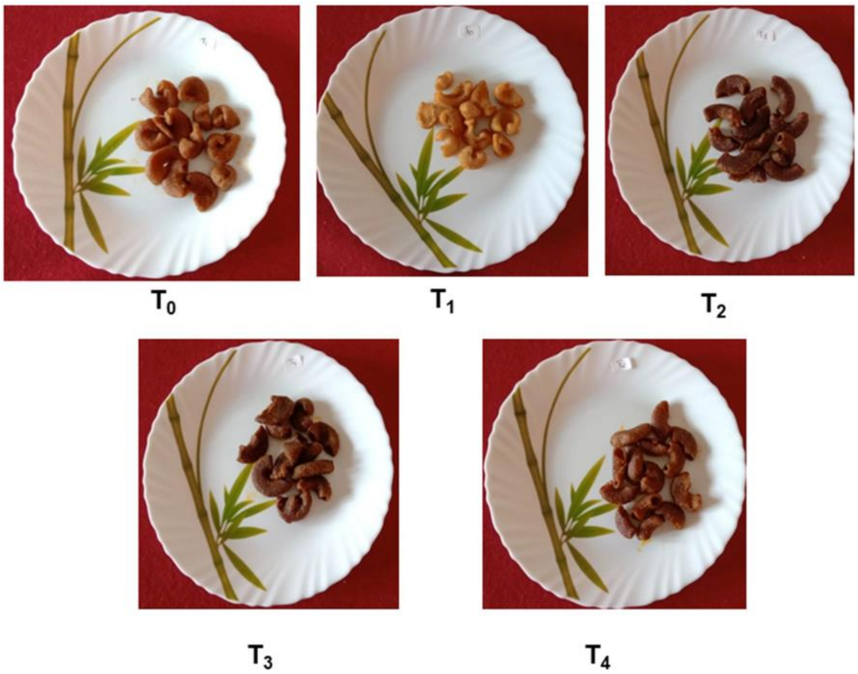

Plate 1 : Different treatments prepared with cassava and mushroom flour

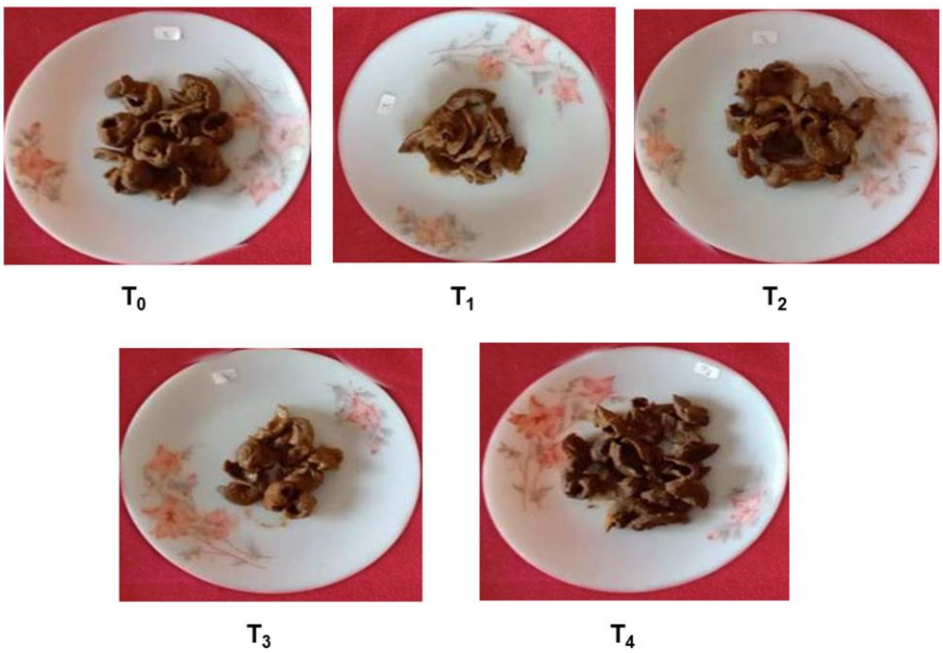

Plate 2: Different treatments prepared with elephant foot yam and mushroom flour

4.1.2. Elephant foot yam and mushroom flour incorporated pastas

Pasta was prepared in different combinations using elephant foot yam flour and mushroom flour and the organoleptic evaluation was carried out. The mean scores of the organoleptic evaluation of the pastas prepared using elephant foot yam flour and mushroom flour is given in Table 4. In case of elephant foot yam incorporated mushroom pastas, the mean scores for the organoleptic qualities obtained was much lower than the acceptable levels, it was concluded that the pasta had very little acceptability and so the entire treatment was omitted from further studies.

Table 4: Mean scores for organoleptic evaluation of pastas from elephant foot yam flour and mushroom flour

Parameters	T_0	T_1	T_2	T_3	T_4
Appearance	2.88	3.62	3.33	3.66	3.66
Colour	3.11	3.22	3.22	3.55	3.33
Flavour	3.04	3.88	3.88	3.90	3.76
Texture	2.88	3.41	3.45	3.44	2.88
Taste	2.55	3.12	3.21	3.22	3.11
Overall Acceptability	2.88	3.33	3.32	3.34	2.88
Total scores	2.89	3.45	3.40	3.51	3.27

(T_0 – 100% EFYF ; T_1 – 90% EFYF + 10% OMF ; T_2 – 80% EFYF + 20% OMF ; T_3 - 70% EFYF + 30 % OMF ; T_4 – 60% EFYF + 40% OMF)
EFYF – Elephant foot yam flour, OMF – Oyster mushroom flour

4.2. Standardisation of nutri-rich ready to cook extruded food from fruit and mushroom flour

Fruits selected for the study were jackfruit and breadfruit. Pastas were prepared using combinations of jackfruit with oyster mushroom flour and breadfruit with oyster mushroom flour. Organoleptic evaluation of the treatments were carried out and the different quality attributes were ranked based on their mean scores using Kendall's coefficient of concordance (W).

4.2.1. Jackfruit and mushroom flour incorporated pastas

Pastas were prepared by incorporating jackfruit and mushroom in varying proportions. The treatments T_1 to T_4 varied from 90 to 60 per cent jackfruit flour and 10 to 40 per cent mushroom flour. Table 5, shows the mean scores obtained for organoleptic attributes of pasta made from jackfruit flour and mushroom flour.

The mean scores for the appearance of jackfruit and mushroom flour incorporated pasta ranged from 8.15 (T_1) to 5.91 (T_4) with mean rank score from 4.37 to 2.03. The appearance score was recorded highest for T_1 (8.15) followed by T_2 (6.57).

The mean scores for colour ranged from 7.71 to 5.75 with the mean rank scores ranging from 3.90 to 2.13 respectively. The highest mean score of 7.71 was recorded for T_1 and the lowest mean score of 5.75 was noticed for T_3.

The mean scores for flavour of jackfruit flour and mushroom flour incorporated pastas ranged from 7.28 to 4.62 with mean rank score varying from 3.67 to 1.53. The highest score of 7.42 was noticed T_0 and the lowest mean score of 4.62 was noticed in T_4.

Among different treatments tried for the preparation of pasta using jackfruit and mushroom flour the highest mean score of 7.14 for texture was recorded for T_1 with mean rank score of 3.43 and the lowest mean score of 5.00 for texture was noticed in T_4.

The mean score for taste of jackfruit and mushroom flour pasta ranged from 5.93 to 7.02 respectively. The highest mean score of 7.02 was noticed in T_1 and the lowest mean score was found to be in T_3.

Table 5: Mean scores for organoleptic evaluation of pasta from jackfruit flour and mushroom flour

Parameters	T_0	T_1	T_2	T_3	T_4	W
Appearance	7.42 (3.63)	8.15 (4.37)	6.57 (2.67)	6.36 (2.30)	5.91 (2.03)	0.507**
Colour	7.28 (3.40)	7.71 (3.90)	6.93 (3.33)	5.75 (2.13)	5.88 (2.23)	0.308**
Flavour	7.42 (3.93)	7.28 (3.67)	6.75 (3.43)	5.57 (2.43)	4.62 (1.53)	0.438**
Texture	6.85 (3.23)	7.14 (3.43)	6.21 (2.97)	5.78 (2.53)	5.00 (2.83)	0.061*
Taste	6.55 (3.57)	7.02 (4.10)	6.31 (3.13)	5.93 (2.63)	6.11 (1.57)	0.400**
Overall acceptability	6.82 (3.47)	7.35 (3.97)	6.60 (3.30)	5.91 (2.57)	5.35 (1.70)	0.345**
Mean total score	7.05	7.44	6.56	5.88	5.47	

Values in parentheses are mean rank score based on Kendall's coefficient of concordance (W)
(** significant at 1% level, * significant at 5% level)
(T_0 – 100% JF ; T_1 – 90% JF + 10% OMF ; T_2 – 80% JF + 20% OMF ; T_3 – 70% JF + 30% OMF ; T_4 – 60% JF + 40% OMF)
JF – Jackfruit flour , OMF – Oyster mushroom flour

Among the different treatments tried for the jackfruit and mushroom flour pastas the highest mean score of overall acceptability was noticed in T_1 with the mean rank score of 7.35. The lowest mean score of 5.35 noticed in T_4.

The treatment, T_1 (90% JF + 10% OMF) attained higher mean total score of 7.44 for organoleptic attributes compared to other treatments. The lowest total score was observed in T_4. Based on Kendall's coefficient of concordance (W) value, significant agreement among judges was noticed in the evaluation of different quality attributes of jackfruit flour and mushroom flour incorporated pasta.

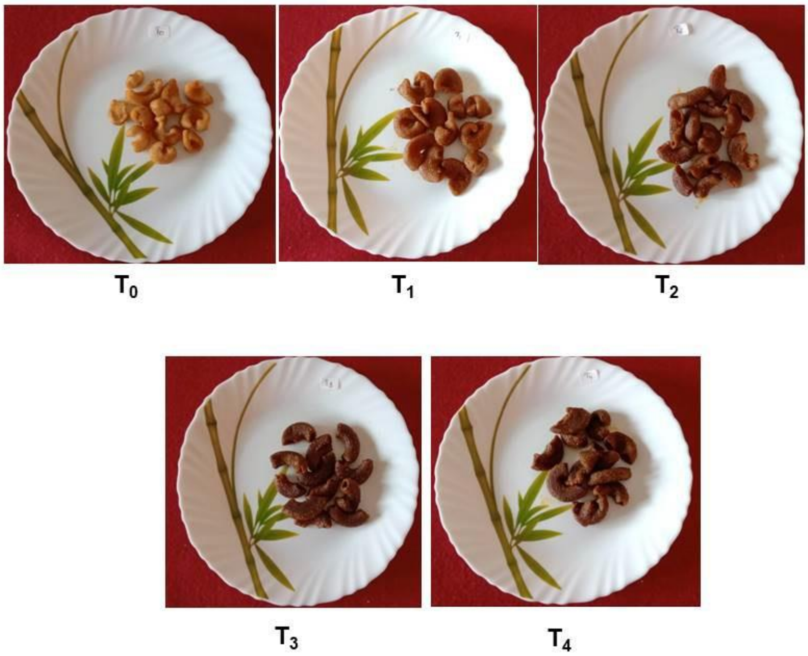

Plate 3 : Different treatments prepared with jackfruit and mushroom flour

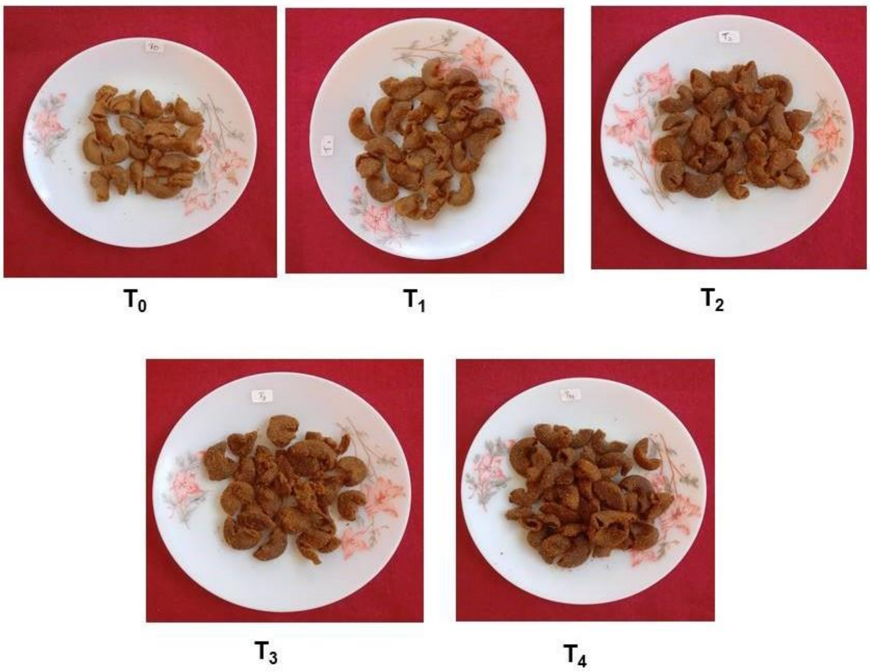

Plate 4: Different treatments prepared with breadfruit and mushroom flour

4.2.2. Breadfruit and mushroom flour incorporated pastas

Pastas were prepared by incorporating breadfruit flour and mushroom flour in varying proportions from 60% to 100% breadfruit flour and 10% to 40% mushroom flour. Table 6 shows the mean scores obtained for organoleptic parameters of pastas made from breadfruit flour (T_0) and blending of breadfruit flour and mushroom flour(T_1 to T_4).

The mean scores for the appearance of breadfruit and mushroom flour incorporated pasta ranged from 7.13 (T_1) to 6.80 (T_2) with mean rank score from 2.90 to 1.80. The appearance score was recorded highest for treatment T_0 (100 % Breadfruit flour) with a score of 7.80.

The mean scores for colour ranged from 7.60 to 7.06 with the mean rank scores ranging from 3.50 to 2.10 respectively. The highest mean score of 7.60 was recorded for T_0 and the mean score of 7.06 was noticed in T_4.

The mean scores for flavour of breadfruit and mushroom incorporated pasta ranged from 7.46 to 7.13 with mean rank score varying from 3.60 to 1.40. The lowest mean score of 7.13 was noticed in T4 and the highest score of 7.46 noticed T_0 and T_1.

Among different treatments tried for the preparation of pasta using breadfruit and mushroom flour the highest mean score of 7.13 for texture was recorded for T_1 with mean rank score of 2.80 and the lowest mean score of 7.00 for texture was noticed in T_4.

The mean score and mean rank scores for taste of breadfruit and mushroom flour pasta ranged from 7.46 to 7.20 respectively. The highest mean score of 7.46 was noticed in T_1 and the lowest mean score was found to be in T_4.

Among the different treatments tried for the breadfruit and mushroom flour pastas the highest mean score of overall acceptability was noticed in T_1 with the mean rank score of 7.46. The lowest mean score of 7.06 was noticed in T_4 (60 % BF + 40 % OMF).

Table 6: Mean scores for organoleptic evaluation of pastas from breadfruit flour and mushroom flour

Parameters	T_0	T_1	T_2	T_3	T_4	W
Appearance	7.80 (4.90)	7.13 (2.90)	7.20 (3.40)	7.08 (2.00)	6.80 (1.80)	0.628**
Colour	7.60 (3.50)	7.13 (2.10)	7.28 (3.40)	7.16 (3.40)	7.06 (2.80)	0.137**
Flavour	7.46 (3.60)	7.46 (3.20)	7.35 (3.60)	7.31 (3.20)	7.13 (1.40)	0.350**
Texture	6.93 (2.70)	7.13 (2.80)	7.02 (3.00)	7.05 (3.60)	7.00 (2.90)	0.052*
Taste	7.20 (3.00)	7.46 (3.40)	7.28 (3.00)	7.31 (3.00)	7.20 (2.60)	0.035*
Overall Acceptability	7.40 (3.20)	7.20 (3.20)	7.20 (3.20)	7.16 (2.40)	7.06 (3.00)	0.049*
Mean total score	7.39	7.25	7.22	7.17	7.04	

Values in parentheses are mean rank score based on Kendall's coefficient of concordance (W)
(** significant at 1% level, * significant at 5% level)
(T_0 – 100% BF ; T_1 – 90% BF + 10% OMF ; T_2 – 80% BF + 20% OMF ; T_3 – 70% BF + 30% OMF ; T_4 – 60% BF + 40% OMF)
BF – Breadfruit flour , OMF – Oyster mushroom flour

Treatment T_0 attained higher mean total score 7.39 for organoleptic attributes, whereas in blended pasta the treatment T_1 attained the highest score of 7.25 compared to other treatments. The lowest total score was observed in T_4. Based on Kendall's coefficient of concordance (W) value, significant agreement among judges was noticed in the evaluation of different quality attributes of breadfruit flour and mushroom flour incorporated pastas.

Selection of pasta

Based on the organoleptic qualities, the most acceptable treatment from each set was selected. The selected pasta and their combinations are summarised in Table 7.

Table 7 : Combinations of selected pastas

	Pasta	Combination
1	Cassava flour + mushroom flour	T_3 (70% CF + 30% OMF)
2	Jackfruit flour + mushroom flour	T_1 (90% JF + 10% OMF)
3	Breadfruit flour + mushroom flour	T_1 (90% BF + 10% OMF)

4.3. Quality evaluation of selected ready to cook extruded food

The selected pastas along with control (T_0) from each set were utilised for the further studies. The pastas were subjected to various analysis which includes the nutritional qualities, health studies and shelf life studies.

4.3.1. Nutritional qualities

4.3.1.1. Nutritional qualities of pastas prepared with cassava flour and mushroom flour incorporated pastas

The nutrients such as energy, carbohydrate, protein, fat, fibre, starch and reducing sugar and mineral content of pastas prepared with cassava flour and mushroom flour incorporated pastas were estimated and is given in table 8 and 9.

Table 8: Comparison of the nutritional qualities of pastas prepared with cassava flour and mushroom flour

Nutrients (per 100g)	SET 1		
	Control (T_0)	T_3	CD value
Moisture (%)	7.92	6.85	0.121*
Energy (k Cal)	386.78	391.52	0.139*
Total Carbohydrate (g)	88.1	80.6	0.239*
Protein (g)	7.92	9.36	0.133*
Total fat (g)	0.30	0.20	NS
Fibre (g)	1.89	2.86	0.041*
Starch (g)	79.03	67.00	0.093*
Reducing sugar (%)	0.84	0.94	NS

4.3.1.1.1. Moisture

The moisture content of pasta made with 100% cassava flour was 7.92 per cent and that with 70% cassava flour and 30% mushroom flour was 6.85 per cent. On statistically analysing the data, it was found that there were significant difference between the moisture content of both these pastas.

4.3.1.1.2. Energy

The energy content of pasta made with 100% cassava (T_0) was 386.78 k Cal and that with 70% cassava with 30% mushroom flour (T_3) was 391.52 k Cal. On statistically analysing data, it was found that there were significant difference between the energy content of pastas

4.3.1.1.3. Total carbohydrate

Carbohydrate content in control was 88.1 g/100g of sample whereas in T_3 it was 80.6 g/100g. The carbohydrate content of the control and the best treatment was found to have a statistically significant difference.

4.3.1.1.4 Protein

Protein content in control was 7.92 g/100g and in T_3 it increased to 9.36 g/100g and was found to have a statistically significant difference.

4.3.1.1.5. Total fat

Fat content of pasta made with 100% cassava (T_0) was 0.30 g/100g and that with 70% cassava and 30% mushroom flour (T_3) was 0.20 g/100g. On statistically analysing the data, it found that there were no significant difference was seen between the fat content of these pasta.

4.3.1.1.6. Fibre

Fibre content in control was 1.89 g/100g of sample whereas in T_3 it increased to 2.86 g/100g. A statistically significant difference was observed in the fibre content of the control and the best treatment T_3.

4.3.1.1.7. Starch

Starch content in control pasta was 79.03 g/100g of sample and in T_3 it was 67 g/100g. On statistically analysing the data, it was found that there were significant differene between starch content of these pasta.

4.3.1.1.8. Reducing sugar

Reducing sugar content of pasta made with 100% cassava (T_0) was 0.84% and that with 70% cassava and 30% mushroom (T_3) was 0.94%. On statistically analysing the data, it was found that there were no significant difference between the reducing sugar content of these pastas.

Table 9 : Comparison of the mineral content of pastas prepared with cassava flour and mushroom flour

Minerals (mg 100 g^{-1})	SET 1		
	T_0	T_3	CD value
Calcium	50.80	54.90	2.180*
Iron	2.91	3.60	0.588*
Sodium	9.88	12.48	0.106*
Magnesium	38.20	40.80	0.170*
Potassium	255.00	292.01	1.529*

Critical difference (CD) values are significant at 5% level
CF –Cassava flour , OMF – Oyster mushroom flour
(T_0 – 100% CF ; T_3 – 70% CF + 30% OMF)

The mineral contents in cassava based pasta (T_0) and the selected treatment (T_3) was estimated (Table 9)(Figure 1). The calcium content in control was 50.80 mg/100g and in T_3 was 54.90 mg/100g. Iron content increased from 2.91 to 3.60 mg/100g and observed a significant difference on statistical interpretation. The sodium content in T_0 was 9.88 mg/100g and sodium content in selected pasta (T_3) has 12.48 mg/100g. Magnesium content in T_0 was 38.20 mg/100g and in T_3 it increased to 40.80 mg/100g in cassava and mushroom incorporated pasta. Potassium content in T_3 was 292.01 mg/100g and in T_0 it was 255.00 mg/100g and on statistically analysing the data, there were significant difference between these pastas.

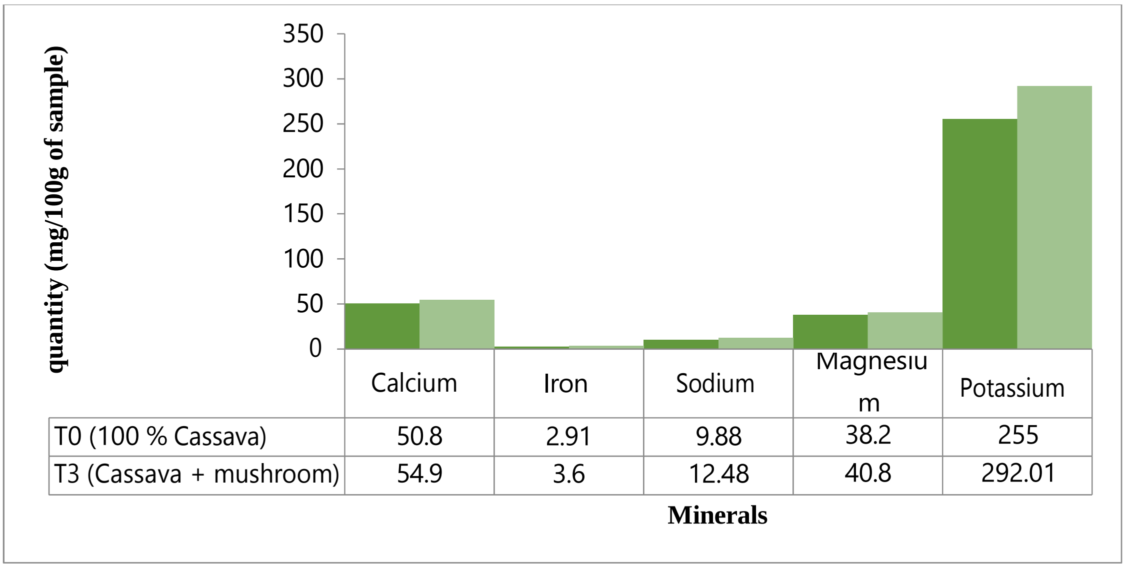

Figure 2: Comparison of the mineral content of pastas prepared with cassava flour and mushroom flour

4.3.1.2. Nutritional qualities of pastas prepared with jackfruit flour and mushroom flour

The nutrients such as energy, carbohydrate, protein, fat, fibre, starch and reducing sugar and mineral content of pastas prepared with jackfruit flour and mushroom flour incorporated pastas was estimated and is given in table 10 and 11.

4.3.1.2.1. Moisture

The moisture content of pasta made with 100% jackfruit (control T_0) was 6.29 per cent and that with 90% jackfruit and 10% mushroom (best treatment T_1) was 6.67 %. On statistically analysing the data, it was found that there were was significant difference between the moisture content of pastas.

4.3.1.2.2. Energy

The energy content of pasta made with 100% jackfruit (control T_0) was 324.79 k Cal and that with 90 % jackfruit flour and 10 % mushroom flour (T_1) was 334.99 k Cal. On statistically analysing the data, the energy value were significantly different.

Table 10: Comparison of the nutritional qualities of pastas prepared with jackfruit flour and mushroom flour

Nutrients (per 100g)	SET 3		
	Control (T_0)	T_1	CD value
Moisture (%)	6.29	6.67	0.32*
Energy (kCal)	368.59	355.95	0.16*
Total Carbohydrate (g)	85.07	78.63	0.59*
Protein (g)	6.29	9.48	0.40*
Total fat (g)	0.35	0.39	NS
Fibre (g)	3.52	3.60	0.33*
Starch (g)	74.12	73.39	0.15*
Reducing sugar (%)	1.10	0.37	0.08*

Critical difference (CD) values are significant at 5% level
(T_0 – 100% JF ; T_1 – 90% JF + 10%)
JF – Jackfruit flour , OMF – Oyster mushroom flour

4.3.1.2.3. Total Carbohydrate

Pasta made with 100% jackfruit flour had a total carbohydrate content of 85.07 g/100g while the treatment T_1 had a total carbohydrate content of 78.63 g/100g of sample, which was found to have a significant difference on statistical interpretation.

4.3.1.2.4. Protein

The protein content of pasta made with 100% jackfruit (control T_0) was 6.29g/100g of sample and that with 90% jackfruit flour and 10% mushroom flour (best treatment T_1) was 9.48g/100g of sample. On statistically analysing the data, it was found that there were significant difference between the protein content of these pastas.

4.3.1.2.5. Total fat

Total fat content of the pasta were also estimated and was found that T_1 had a slightly higher fat content (0.39 g/100g of sample) than the control pasta (0.35 g/100g of sample), but was not having any significant difference on statistical interpretation .

4.3.1.2.6. Fibre

The fibre content of pasta made with 100% jackfruit (T_0) was 3.52 g/100g of sample and that with 90% jackfruit flour and 10% mushroom flour (T_1) was 3.60 g/100g of sample. On statistically analysing the data, it was found that there were significant difference between the fibre content among the two treatments.

4.3.1.2.7. Starch

The starch content of pasta made with 100% jackfruit flour (T_0) was 74.12 g/100g of sample and that with 90% jackfruit flour and 10% mushroom flour (T_1) was 73.39 g/100g of sample. On statistically analysing the data, it was found that there were significant difference between the starch content of the pastas.

4.3.1.2.8.. Reducing sugar

The reducing sugar content of T_0 was 1.10 per cent and T_1 was 0.37 per cent. On statistically analysing the data, it was found that there were significant difference between the reducing sugar content of the treatments.

Table 11: Comparison of the mineral content of pastas prepared with jackfruit flour and mushroom flour

Minerals (mg 100 g^{-1})	**SET 3**		
	T_0	T_1	CD value
Calcium	32.24	26.10	0.106*
Iron	1.03	1.64	0.059*
Sodium	7.25	6.85	0.069*
Magnesium	48.08	56.02	0.119*
Potassium	283.00	324.70	1.463*

Critical difference (CD) values are significant at 5% level
(T_0 – 100% JF; T_1 – 90% JF + 10% OMF)
JF – Jackfruit flour, OMF – Oyster mushroom flour

Calcium content in T_0 and T_1 was 32.24 and 26.10 mg/100g, respectively. Iron content in T_0 was 1.03 mg/100g and in T_1 it increased to 1.64 mg/100g. The sodium content in T_0 and T_1 was 7.25 and 6.85 mg/100g, respectively. Magnesium content in T_1 was 56.02 mg/100g and for T_0 it was found to be 48.08 mg/100g. The potassium content in T_0 was 283.00 mg/100g and it increased in treatment T_1 to 324.70 mg/100g. On statistically analysing the data, it was found that there were significant difference between calcium, iron, sodium, magnesium and potassium contents between the treatments.

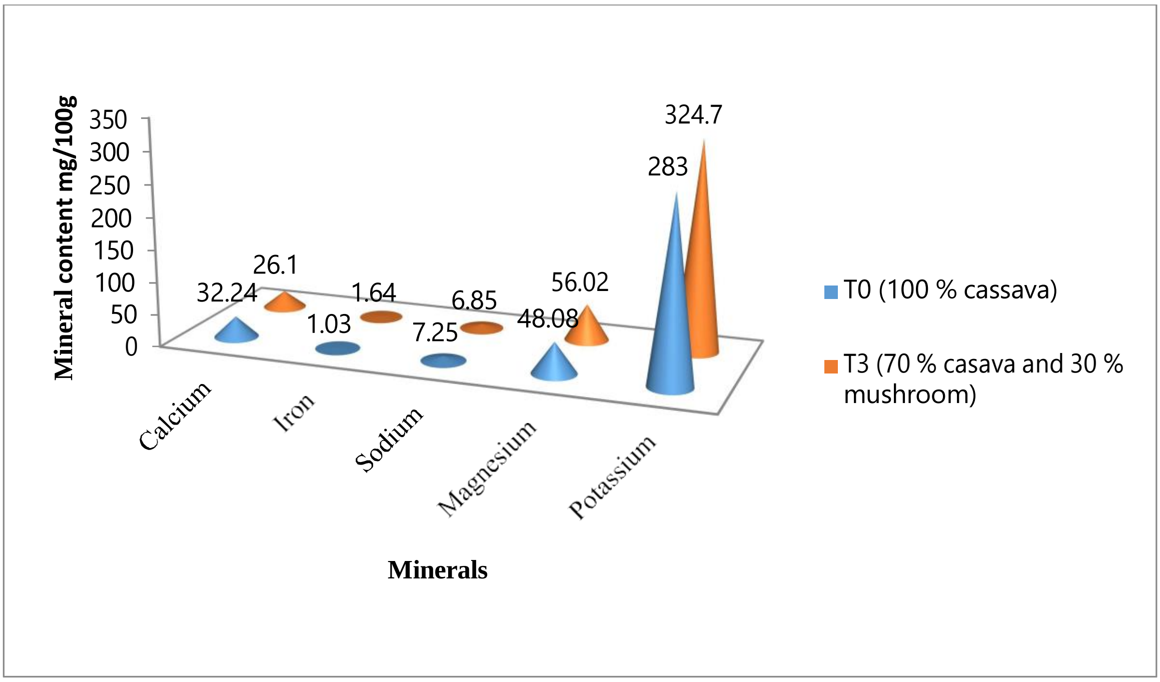

Figure 3: Comparison of the mineral content of pastas prepared with jackfruit flour and mushroom flour

Table 12. depicts the physico-chemical composition of pastas prepared with breadfruit flour and mushroom flour incorporated pastas.

4.3.1.3. Nutritional qualities of pastas prepared with jackfruit flour and mushroom flour

The nutrients such as energy, carbohydrate, protein, fat, fibre, starch and reducing sugar and mineral content of pastas prepared with jackfruit flour and mushroom flour incorporated pastas was estimated and is given in table 12 and 13.

4.3.1.3.1. Moisture

The moisture content of pasta made with 100% breadfruit (T_0) was 7.16% and that with 90% breadfruit flour and 10% mushroom flour (T_1) was 6.03%. On statistically analysing the data, it was found that there were significant difference between the moisture content of both these pastas.

4.3.1.3.2. Energy

The energy content of pasta made with 100% breadfruit (T_0) was 343.52 k Cal and that with 90% breadfruit flour and 10% mushroom flour (T_1) was 320.69 k Cal. On statistically analysing the data, the energy value was significantly different.

Table 12: Comparison of the nutritional qualities of pastas prepared with breadfruit flour and mushroom flour

Nutrients (per 100g)	**SET 4**		
	Control (T_0)	T_1	CD value
Moisture (%)	7.16	6.03	0.06*
Energy (k Cal)	343.52	320.69	0.72*
Total Carbohydrate (g)	80.32	73.49	0.09*
Protein (g)	4.30	5.40	0.07*
Total fat (g)	0.56	0.57	NS
Fibre (g)	7.69	7.52	0.07*
Starch (g)	75.02	69.64	0.07*
Reducing sugar (%)	1.01	2.12	0.17*

Critical difference (CD) values are significant at 5% level
(T_0 – 100% BF ; T_1 – 90% BF + 10% OM)
BF – Breadfruit flour , OMF – Oyster mushroom flour

4.3.1.3.3. Total Carbohydrate

Pasta made with 100% breadfruit flour was 80.37 g/100g while that with 90% breadfruit and 10% mushroom flour decreased to 73.49 g/100g of sample, which was found to have a significant difference on statistical interpretation.

4.3.1.3.4. Protein

The protein content of pasta T_0 was 4.30 g/100g and for T_1 it was 5.40 g/100g of sample. On statistically analysing the data, it was found that there were significant difference between the protein content of the treatments.

4.3.1.3.5 Total fat

Total fat content of the pasta were also estimated and was found that T_1 had a slightly higher fat content (0.57 g/100g of sample) than the control pasta (0.56 g/100g of sample), but was non significant on statistical interpretation.

4.3.1.3.6. Fibre

The fibre content of pasta made with 100% breadfruit flour (T_0) was 7.69 g/100g and that with 90% breadfruit flour and 10% mushroom flour (T_1) was 7.52 g/100g. On statistically analysing the data, it was found that there were significant difference between the fibre content of both these pastas.

4.3.1.3.7. Starch

The starch content of T_0 and T_1 was 75.02 g/100g and 69.64 g/100g, respectively. On statistically analysing the data, it was found that there were significant difference between the starch content of both these pastas.

4.3.1.3.8. Reducing sugar

The reducing sugar content of pasta made with 100% breadfruit flour (control - T_0) was 1.10 per cent and that with 90% breadfruit flour and 10% mushroom flour (best treatment - T_1) was 2.12 per cent. On statistically analysing the data, it was found that there were significant difference between the reducing sugar content of both these pasta.

Table 13: Comparison of the mineral content of pastas prepared with breadfruit flour and mushroom flour

Minerals (mg 100 g^{-1})	**SET 4**		
	T_0	T_1	CD value
Calcium	48.00	37.80	0.982*
Iron	0.06	0.10	NS
Sodium	9.80	12.03	0.158*
Magnesium	18.68	19.72	0.217*
Phosphorous	426.03	511.00	2.816*

Critical difference (CD) values are significant at 5% level
(T_0 – 100% BF ; T_1 – 90% BF + 10% OMF)
BF – Breadfruit flour , OMF – Oyster mushroom flour

Table 13 shows the comparison of the mineral content of pastas prepared with breadfruit flour and mushroom flour incorporated pastas. In breadfruit flour based pasta, the calcium content of control (T_0) was 48.00 mg/100g and T_1 was 37.80 mg/100g. Iron content in the treatment, T_0 and T_1 was 0.06 mg/100g and 0.10 mg/100g, respectively and was found to have no significant diffetrence between the pastas. Sodium content in breadfruit flour based pasta (T_0) was 9.80 mg/100g and in T_1 it was 12.03 mg/100g. Magnesium content in T_0 was 18.68 mg/100g and T_1 had a content of 19.72 mg/100g. The phosphorous content in T_0 was 426.03 mg/100g and in T_1 it was 511.00 mg/100g. On statistically analysing the data, it was found that there were significant difference between calcium, sodium, magnesium and phosphorous content among the treatments.

4.3.2. Health studies

The *in vitro* digestibility of the starch and protein and *in vitro* availability of minerals of pastas are detailed in health studies.

Table 14: Comparison of the *in vitro* digestibility of the starch and protein of pastas prepared with cassava flour and mushroom flour

***In vitro* digestibility (%)**	**SET 1**		
	T_0	T_3	CD value
Protein	67.52	83.10	0.807*
Starch	64.03	61.13	0.092*

Critical difference (CD) values are significant at 5% level
CF –Cassava flour, OMF – Oyster mushroom flour
(T_0 – 100% CF ; T_3 – 70% CF + 30% OMF)

In vitro digestibility of protein content in cassava based pasta (T_0) is 67.52% and in treatment T_3 it increased to 83.10%. The *in vitro* digestibility of starch content in pasta prepared with 100% cassava flour was 64.03% and on incorporating of mushroom flour it decreased to 61.13%. On statistical interpretation, there were significant difference between the *in vitro* digestibility of the starch and protein content of the pastas.

Table 15: Comparison of the *in vitro* availability of the minerals of pastas prepared with cassava flour and mushroom flour

Minerals (%)	**SET 1**		
	T_0	T_3	CD value
Iron	37.09	37.80	NS
Calcium	40.80	41.10	0.203*
Phosphorous	64.05	63.17	0.172*
Magnesium	67.02	68.12	2.269*

Critical difference (CD) values are significant at 5% level
CF –Cassava flour , OMF – Oyster mushroom flour
(T_0 – 100% CF ; T_3 – 70% CF + 30% OMF)

Table 15. depicts the *in vitro* availability of the minerals of pastas prepared with cassava flour and mushroom flour. No significant difference was observed in the *in vitro* availability of iron content, but the percentage *in vitro* availability was found

to be 37.09 % and 37.80 % for T_0 and T_3, respectively. A significant difference was observed in the calcium, phosphorous amd magnesium contents. The *in vitro* availability of calcium for T_0 and T_3 was found to be 40.80 % and 41.10%, respectively. The treatment with cassava flour alone had an *in vitro* availability for phosphorus as 64.05% and for blended pasta it was 63.17%. The *in vitro* availability of magnesium for T_0 and T_3 was found to be 67.02% and 68.12%, respectively.

Table 16: Comparison of the *in vitro* digestibility of the starch and protein of pastas prepared with jackfruit flour and mushroom flour

Nutrients (%)	**SET 3**		
	T_0	T_1	CD value
Protein	50.39	57.76	0.117*
Starch	71.00	61.10	1.553*

Critical difference (CD) values are significant at 5% level
JF –Jackfruit flour , OMF – Oyster mushroom flour
(T_0 – 100% JF ; T_1 – 90% JF + 10% OMF)

In vitro digestibility of protein content in jackfruit flour based pasta (T_0) is 50.39% and for T_1 it was 57.76%. The *in vitro* digestibility of starch content in T_0 and T_1 are 71.00 and 61.10% respectively. On statistically analysing the data, there were significant difference between both these pastas.

Table 17: Comparison of the *in vitro* availability of minerals for pastas prepared with jackfruit flour and mushroom flour

Minerals (%)	**SET 3**		
	T_0	T_1	CD value
Iron	28.80	29.40	0.288*
Calcium	40.60	41.50	0.685*
Phosphorous	84.90	83.48	0.417*
Magnesium	39.80	40.00	NS

Critical difference (CD) values are significant at 5% level
JF –Jackfruit flour, OMF – Oyster mushroom flour
(T_0 – 100% JF ; T_1 – 90% JF + 10% OMF)

Table 17. shows the *in vitro* availability of pastas prepared with jackfruit flour and mushroom flour. *In vitro* availability of iron content in T_0 and T_1 was 28.80 % and 29.40%, respectively. The *in vitro* calcium availability of jackfruit based pasta (T_0) was 40.60 per cent and T_1 was 41.50 per cent. The highest *in vitro* mineral availability was seen in phosphorous with 84.90% and 83.48% in T_0 and T_1, respectively. On statistically analysing the data, there were significant difference between iron, calcium and phosphorous contents among the treatments. No significant difference was observed the *in vitro* mineral availability of magnesium as 39.80 % for T_0 and 40 % for T_1.

Table 18: Comparison of the *in vitro* digestibility of the starch and protein of pastas prepared with breadfruit flour and mushroom flour

Nutrients (%)	**SET 4**		
	T_0	T_1	CD value
Protein	62.98	69.23	0.491*
Starch	58.32	52.56	0.188*

Critical difference (CD) values are significant at 5% level
BF –Breadfruit flour, OMF – Oyster mushroom flour
(T_0 – 100% BF ; T_1 – 90% BF + 10% OMF)

In vitro digestibility of protein content in breadfruit based pasta (T_0) is 62.98 % and it increased in T_1 to 69.23 % with a statistical significant difference. The *in vitro* digestibility of starch content in (T_0) was found as 58.32% and for T_1 as 52.56 %. On statistically analysing the data, there were significant difference in the *in vitro* digestibility of starch content of these pastas.

Table 19: Comparison of the *in vitro* availability of minerals for pastas prepared with breadfruit flour and mushroom flour

Minerals (%)	SET 4		
	T_0	T_1	CD value
Iron	38.50	39.00	NS
Calcium	40.00	40.50	0.265*
Phosphorous	68.60	69.00	0.049*
Magnesium	77.25	78.24	0.087*

Critical difference (CD) values are significant at 5% level
BF –Breadfruit flour , OMF – Oyster mushroom flour
(T0 – 100% BF ; T1 – 90% BF + 10% OMF)

Table 19. shows the *in vitro* availability of pastas prepared with breadfruit flour and mushroom flour. *In vitro* availability of iron content in T_0 and T_1 was 38.50 and 39.00 per cent, respectively. The *in vitro* calcium availability of breadfruit based pasta (T_0) was 40.00 per cent and T_1 was 40.50 per cent. The *in vitro* availability for phosphorous was 68.60 per cent and 69.00 per cent in T_0 and T_1, respectively. On statistically analysing the data, there were significant difference between calcium, phosphorous and magnesium contents among the treatments.

4.3.3. Shelf life studies

Pasta made with tuber flour/ fruit flours were packed in HDPE covers and were kept for three months storage in room temperature.

4.3.3.1. Organoleptic evaluation of the selected extruded food during storage

The organoleptic qualities of the selected pasta during storage were tabulated and given in Table 20.

Table 20: Mean scores for organoleptic evaluation of cassava and mushroom based pasta at monthly intervals

Parameters	SET 1 (T_3 – 70% CF + 30% OMF)			
	Initial	1st month	2nd month	3rd month
Appearance	7.24	7.16	7.00	6.98
Colour	7.28	7.24	7.10	7.04
Flavour	7.55	7.19	6.98	6.01
Texture	7.28	7.18	7.12	7.04
Taste	7.21	7.04	6.80	6.50
Overall acceptability	7.22	7.02	6.48	6.03
Total	7.29	7.13	6.91	6.61

CF – Cassava flour, OMF – Oyster mushroom flour

Based on organoleptic scores the selected pasta, T_3 (70% CF + 30% OMF) were acceptable upto three months of storage with gradual decline in all sensory attributes.

Initially the highest score for appearance obtained was 7.24 and that decreased to 7. 16 (1st month), 7.00 (2nd month) and to 6.98 (3rd month) during storage. The organoleptic scores of colour was 7.28 initially and gradually reduced to 7.24 in first month, 7.10 in second month and 7.04 at the end of the storage.

A gradual decrease was also observed for organoleptic scores of flavour, texture, taste and overall acceptability. The scores for flavour and texture was 7.55 and 7.28 initially and it gradually decreased to 7.18 and 7.04 in first month, 7.12 and 6.80 in second month, and scored 7.04 and 6.50 mean scores at the end of storage. The highest score for taste was obtained initially with 7.21 and it decreased to 7.04 at the 1st month of storage, 6.80 at 2nd month and 6.50 at the end of the storage. The overall acceptability also decreased from 7.22 to 6.03 at the end of the storage.

Table 21: Mean scores for organoleptic evaluation of fruit flour and mushroom based pastas at monthly intervals

Parameters	SET 3 (T_1 – 90% JF + 10% OMF)				SET 4 (T_1 – 90% BF + 10% OMF)			
	Initial	1st month	2nd month	3rd month	Initial	1st month	2nd month	3rd month
Appearance	8.15	8.14	8.02	8.00	6.80	6.74	6.40	6.16
Colour	7.71	7.54	7.20	7.08	7.06	6.89	6.70	6.18
Flavour	7.28	7.01	6.70	6.01	7.13	6.70	6.25	6.00
Texture	7.14	7.10	7.02	6.77	7.00	6.75	6.67	6.51
Taste	7.02	6.60	6.15	6.00	7.20	7.04	6.87	6.52
Overall acceptability	7.35	7.05	6.24	6.18	7.06	6.50	6.10	6.00
Total	7.44	7.24	6.88	6.67	7.04	6.77	6.49	6.22

JF – Jackfruit flour, OMF – Oyster mushroom flour, BF – Breadfruit flour

Table 21 depicts the mean organoleptic scores of pastas prepared with fruit flours (90% JF +10% OMF and 90 % BF + 10 % OMF) and mushroom flours. The highest score for appearance obtained for T_1 was 8.15 that decreased to 8.14 (1^{st} month), 8.02 (2^{nd} month) and 8.00 (3^{rd} month) during the storage. The colour of treatment T_1 was 7.71 which gradually reduced to 7.54 in first month, 7.20 in second month and 7.08 at the end of the storage.

The flavour and texture of treatment T_1 (90% JF +10% OMF) was 7.28 and 7.14 in the initial stage and it gradually decreased to 7.01 and 6.60 in the first month, 6.70 and 7.02 in the second month and scored 6.77 and 6.00 mean scores at the end of the storage. The highest score for taste obtained was T_1 (7.02) and that decreased to

6.60 at the first month of storage, 6.15 in the second month and 6.00 in the end of the storage. The overall acceptability also decreased from 7.35 to 6.18.

The best treatment for the pasta prepared with breadfruit flour and oyster mushroom flour attained a score of 6.80 for appearance which gradually decreased to 6.16 at the end of storage. The organoleptic scores for color was 7.06, initially and gradually decreased to 6.18 at the end of the storage.

The organoleptic score for flavour and texture was 7.13 and 7.00, initially which gradually decreased to 6.70 and 6.75 in the first month, 6.25 and 6.67 in the second month and 6.00 and 6.51 at the end of the storage. The highest score for taste was 7.20 and that decreased to 7.04 in first month, 6.87 in second month and 6.52 at end of the storage period. The overall acceptability also decreased from 7.06 to 6.00 at the end of the storage.

Even though, all the selected pastas were acceptable, jackfruit flour and mushroom added pasta were observed to have better score compared to breadfruit flour and mushroom flour pasta.

4.3.3.2. Nutritional qualities of the selected extruded food during storage

4.3.3.2.1. Effect of storage on nutritional qualities of pastas prepared with cassava flour and mushroom flour

The nutrients such as energy, carbohydrate, protein, fat, fibre, starch, reducing sugar and mineral content of pastas prepared with cassava flour and mushroom flour were estimated during storage and is given in table 22 and 23.

Table 22: Comparison of the nutritional qualities of pastas prepared with cassava flour and mushroom flour

Nutrients (per 100g)	SET 1 (T_3 – 70% CF + 30 % OMF)		
	Initial	3rd month	CD value
Moisture (%)	6.85	8.60	0.017*
Energy (k Cal)	391.52	344.62	0.025*
Total carbohydrate(g)	80.60	78.03	0.188*
Protein (g)	9.36	7.72	0.041*
Total fat (g)	0.20	0.18	NS
Fibre (g)	2.86	1.07	0.016*
Starch (g)	67.00	66.18	0.271*
Reducing sugar (%)	0.94	0.98	NS

Critical difference (CD) values are significant at 5% level

CF – Cassava flour , OMF – Oyster mushroom flour

4.3.3.2.1.1. Moisture

The moisture content of pasta made with 70% cassava flour and 30% mushroom flour (T_3) was 6.85% and at the end of the storage the moisture content increased to 8.60%. On statistically analysing the data, it was found that there were significant difference between the moisture content of both these pastas.

4.3.3.2.1.2. Energy

The energy content of selected pasta was 391.52 k Cal initially and at the end of the storage the energy content decreased to 344.62 k Cal. On statistically analysing the data, it was found that there is significant difference between the energy content of pastas during storage.

4.3.3.2.1.3. Total Carbohydrate

The total carbohydrate content of pasta made with 70 % cassava and 30% mushroom flour (T_3) was 80.6 g/100g and at the end of the storage period it decreased 78.03 g/100g. A statistically significant difference was obtained in the carbohydrate content of pastas after three months of storage.

4.3.3.2.1.4. Protein

Pasta prepared with 70% cassava flour and 30% mushroom flour had an initial protein content of 9.36 g/100g which decreased during storage to 7.72 g/100g. A significant difference was observed in the protein content during storage.

4.3.3.2.1.5. Total fat

Fat content of pasta prepared with 70% cassava flour and 30% mushroom flour was 0.20 g/100 g and at the end of the storage period it was 0.18 g/100g. On statistically analysing the data it was found that there were no significant difference between the fat content of these pastas.

4.3.3.2.1.6. Fibre

The fibre content of pasta decreased from 2.86 g/100g to 1.07 g/100g. A statistically significant difference was observed in the fibre content after the storage period.

4.3.3.2.1.7. Starch

The starch content of pasta made with 70 % cassava flour and 30 % mushroom flour was 67.00 g/100g and at the end of the storage the starch content was 66.18 g/100g. On statistically analysing the data, it was found that there is significant difference between starch content of these pastas.

4.3.3.2.1.8. Reducing sugar

Reducing sugar content of fresh pasta was 0.94 % and at the end of the storage the reducing sugar content was 0.98 %. On statistically analysing the data, it was found that there is no significant difference between the reducing sugar content of these pastas.

Table 23: Comparison of the mineral contents of pastas prepared with cassava flour and mushroom flour

Minerals (mg 100 g^{-1})	SET 1 (T_3 – 70% CF + 30% OMF)		
	Initial	3rd month	CD value
Calcium	54.90	54.00	0.013*
Iron	3.60	2.18	0.028*
Sodium	12.48	11.68	0.155*
Magnesium	40.80	39.50	0.177*
Potassium	292.01	291.00	0.099*

Critical difference (CD) values are significant at 5% level
CF – Cassava flour, OMF – Oyster mushroom flour

The calcium content of the pasta made with 70% cassava flour and 30% mushroom flour was 54.90 mg/100g and at the end of the storage it was 54.00 mg/100g. The iron content of the pasta was 3.60 mg/100g which decreased to 2.18 mg/100g at the end of storage. A slight decrease with statistically significant difference was seen in sodium, magnesium and potassium content after the storage period of three months.

4.3.3.3.2. Effect of storage on nutritional qualities of pastas prepared with jackfruit flour and mushroom flour

The nutrients such as energy, carbohydrate, protein, fat, fibre, starch, reducing sugar and mineral content of pastas prepared with jackfruit flour and mushroom flour incorporated pastas was estimated during storage and is detailed in table 24 and 25.

Table 24: Comparison of the nutritional qualities of pasta prepared with jackfruit flour and mushroom flour

Nutrients (per 100g)	SET 3 (T_1 – 90% JF + 10% OMF)		
	Initial	3rd month	CD value
Moisture (%)	6.67	8.10	0.085*
Energy (kCal)	355.95	345.60	0.096*
Total carbohydrate(g)	78.63	77.42	0.155*
Protein (g)	9.48	8.35	0.117*
Total fat (g)	0.39	0.28	NS
Fibre (g)	3.60	2.55	0.108*
Starch (g)	73.39	72.09	0.719*
Reducing sugar (%)	0.37	0.49	NS

Critical difference (CD) values are significant at 5% level
JF – Jackfruit flour, OMF – Oyster mushroom flour

4.3.3.3.2.1. Moisture

The moisture content of pasta made with 90 % jackfruit flour and 10% mushroom flour was 6.67% and at the end of the storage it was 8.10%. On statistically analysing the data, it was found that there is significant difference between the moisture content of both these pastas.

4.3.3.3.2.2. Energy

The energy content of pasta made with 90% jackfruit flour and 10% mushroom flour was 355.95 kCal, initially and at the end of the storage it decreased with a statistically significant difference to 345.60 kCal.

4.3.3.3.2.3. Total Carbohydrate

The total carbohydrate content of pasta made with 90% jackfruit flour and 10% mushroom flour was 78.63 g/100g and at the end of the storage it was 77.42 g/100g. On statistically analysing data, it was found that there is significant difference between the carbohydrate content of these pastas.

4.3.3.3.2.4. Protein

The protein content decreased from 9.48 to 8.35% at the end of third month of storage. On statistically analysing data, it was found that there is significant difference between the protein content in the selected pasta.

4.3.3.3.2.5. Total fat

The total fat content of pasta made with 90 % jackfruit flour and 10 % mushroom flour was 0.39 g/100g at initial and at the end of the storage it was 0.28 g/100g. On statistically analysing data it found that there were no significant difference between fat content of these pasta

4.3.3.3.2.6. Fibre

The fibre content of pasta decreased from 3.60 g/100g to 2.55 g/100g during storage. On statistically analysing the data it was found that there is significant difference between the fibre content of pasta.

4.3.3.3.2.7. Starch

The starch content of pasta made with 90% jackfruit flour and 30% mushroom flour was 73.39 g/100g which decreased to 72.09 g/100g at the end of the third month of storage. On statistically analysing the data, it was found that there is significant difference between starch content of these pasta.

4.3.3.3.2.8. Reducing sugar

The reducing sugar content of pasta made with 90% jackfruit flour and 30% mushroom was 0.37 %, which increased to 0.49 % at the end of the storage. On statistically analysing the data, it was found that there was no significant difference between the reducing sugar content of these pastas.

Table 25: Comparison of the mineral content of pasta prepared with jackfruit flour and mushroom flour

Minerals (mg 100 g^{-1})	**SET 3** (T_1 – 90% JF + 10% OMF)		
	Initial	3rd month	CD value
Calcium	26.10	25.20	0.056*
Iron	1.64	1.50	0.033*
Sodium	6.85	6.10	0.012*
Magnesium	56.02	54.91	0.207*
Potassium	324.70	320.15	0.277*

Critical difference (CD) values are significant at 5% level

JF – Jackfruit flour, OMF – Oyster mushroom flour

The calcium content of pasta made with 90 % jackfruit flour and 10% mushroom flour was 26.10 mg/100g and at the end of the storage it was 25.20 mg/100g. The iron content of the pasta was 1.64 mg/100g which decreased to 1.50 mg/100g at the end of the storage. A slight decrease with statistically significant difference was seen in the sodium , magnesium and potassium content after the storage period of three months.

4.3.3.3.3. Nutritional qualities of pastas prepared with breadfruit flour and mushroom flour pasta during storage

The nutrients such as energy, carbohydrate, protein, fat, fibre, starch, reducing sugar and mineral content of pastas prepared with breadfruit flour and mushroom flour incorporated pastas was estimated during storage and is given in table 26 and 27.

Table 26: Comparison of the nutritional qualities of pasta prepared with breadfruit flour and mushroom flour

Nutrients (per 100g)	SET 4 (T_1 – 90% BF + 10% OMF)		
	Initial	3rd month	CD value
Moisture (%)	6.03	7.80	0.017*
Energy (kCal)	320.69	309.21	1.066*
Total carbohydrate(g)	73.49	71.90	0.078*
Protein (g)	5.40	4.30	0.027*
Total fat (g)	0.57	0.49	NS
Fibre (g)	7.52	6.18	0.551*
Starch (g)	69.64	67.55	0.016*
Reducing sugar (%)	2.12	3.01	0.021*

Critical difference (CD) values are significant at 5% level
BF – Breadfruit flour, OMF – Oyster mushroom flour

4.3.3.3.3.1. Moisture

The moisture content of pasta made with 90% breadfruit flour and 10% mushroom flour increased from 6.03 % to 7.80 % at the end of the storage. On statistically analysing the data, it was found that there is significant difference between the moisture content of both these pastas.

4.3.3.3.3.2. Energy

The energy content of pasta made with 90% breadfruit flour and 10% mushroom flour was 320.69 kCal initially and at the end of the storage it decreased with a statistically significant difference to 309.21 kCal.

4.3.3.3.3.3. Total Carbohydrate

The total carbohydrate content of pasta made with 90% jackfruit flour and 10% mushroom flour was 73.49 g/100g initially and at the end of the storage it was 71.90 g/100g. On statistically analysing the data, it was found that there is significant difference between the carbohydrate content of pastas.

4.3.3.3.3.4. Protein

The protein content of pasta decreased from 5.40 g/100g initially and at the end of the storage it was decreased to 4.30 g/100g. On statistically analysing data, it was found that there is significant difference between the protein content of selected pastas.

4.3.3.3.3.5. Total fat

The total fat content of pasta made with 90% breadfruit flour and 30% mushroom flour was 0.57 g/100g initially and at the end of the storage it decreased without any statistically significant difference to 0.49 g/100 g.

4.3.3.3.3.6. Fibre

The fibre content of selected pasta was 7.52 g/100g at initially and at the end of the storage it was decreased to 6.18 g/100g. On statistically analysing data, it was found that there is significant difference between the fibre content of pastas.

4.3.3.3.3.7. Starch

The starch content of pasta made with 90 % breadfruit flour and 10 % mushroom flour was 69.64 g/100g which decreased to 67.55 g/100g at the end of the third month of storage. On statistically analysing the data, it was found that there is significant difference between the starch content of these pasta during storage.

4.3.3.3.3.8. Reducing sugar

The reducing sugar content of selected pasta was 2.12 % which increased to 3.01% at the end of the storage. On statistically analysing the data, it was found that there was no significant difference between the reducing sugar content of these pastas.

Table 27: Effect of storage on the mineral content of pasta prepared with breadfruit flour and mushroom flour

Minerals (mg 100 g^{-1})	SET 4 (T_1 – 90% BF + 10% OMF)		
	Initial	3rd month	CD value
Calcium	37.80	36.55	0.075*
Iron	0.10	0.09	NS
Sodium	12.03	11.42	0.252*
Magnesium	19.72	17.88	0.027*
Potassium	511.00	500.25	0.191*

Critical difference (CD) values are significant at 5% level
BF – Breadfruit flour, OMF – Oyster mushroom flour

The calcium content of pasta made with 90% breadfruit flour and 10% mushroom flour was 37.80 mg/100g and at the end of the storage it was 36.55 mg/100g. The iron content of the pasta was 0.10 mg/100g which decreased to 0.09 mg/100g at the end of the storage. A slight decrease with statistically significant difference was seen in the sodium, magnesium and potassium content after the storage period of three months.

4.3.3.5. Health studies of the selected extruded food during storage

Table 28: Effect of storage on the *in vitro* digestibility of protein and starch prepared with cassava flour and mushroom flour

Nutrients (%)	**SET 1** (T_3 – 70% CF + 30% OMF)		
	Initial	3rd month	CD value
Protein	83.10	82.58	1.065*
Starch	61.13	60.00	0.211*

Critical difference (CD) values are significant at 5% level
CF – Cassava flour, OMF – Oyster mushroom flour

Initial *in vitro* digestibility of protein content in cassava based pasta was 83.10 % and at the end of storage it was 82.58 %. On statistically analysing the data, it was found that there is significant difference between the *in vitro* digestibility of protein content of both these pasta.

Initial *in vitro* digestibility of starch content in cassava based pasta was 61.13 % and it decreased to 60.00 % on storage. On statistically analysing the data, it was found that there is significant difference between the starch content of both these pasta.

Table 29: Effect of storage on the *in vitro* availability of the minerals of pasta prepared with cassava flour and mushroom flour

Minerals (%)	**SET 1** (T_3 – 70% CF + 30% OMF)		
	Initial	3rd month	CD value
Calcium	41.10	39.05	0.511*
Iron	37.80	37.01	0.012*
Phosphorous	63.17	61.12	0.066*
Magnesium	68.12	68.05	0.177*

Critical difference (CD) values are significant at 5% level
CF – Cassava flour, OMF – Oyster mushroom flour

In vitro availability of calcium content was 41.10 per cent at first month and 39.05 per cent at end of the storage period. The iron content availability through *in vitro* at the end of the storage is 37.01 % and at the first month it was 37.80 %. The *in vitro* availability of phosphorous content in the selected treatment was 63.17 per cent, initially and it reduced to 61.12 per cent at end of the storage period. A slight decrease in the *in vitro* availability of magnesium content in selected pasta was observed at the end of the storage period. On statistically analysing the data, it was found that there is significant difference between the *in vitro* mineral content of pastas.

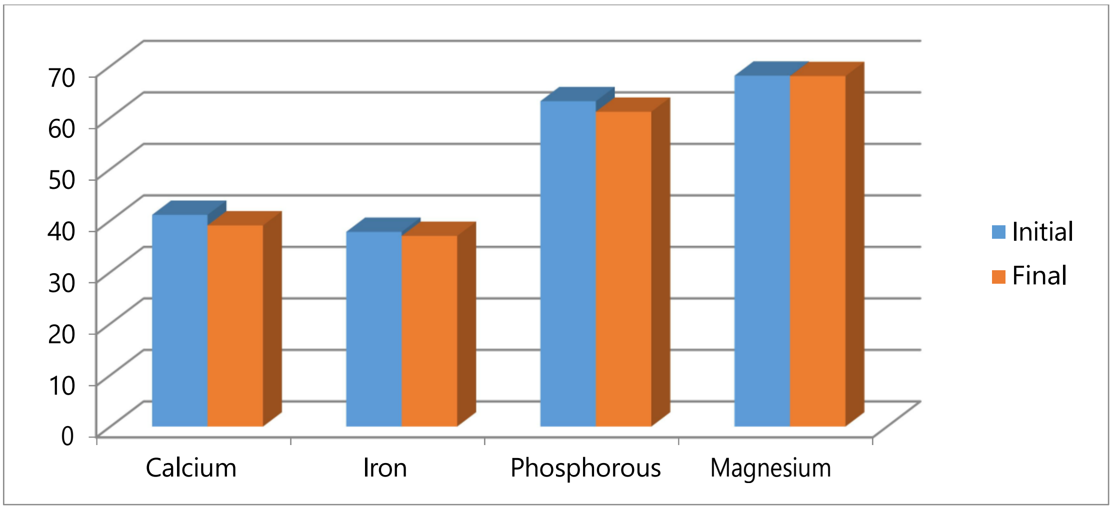

Figure 4: Effect of storage on the *in vitro* availability of the minerals of pasta prepared with cassava flour and mushroom flour

Table 30 : Effect of storage on the i*n vitro* digestibility of protein and in the pastas prepared with jackfruit flour and mushroom flour

Nutrients (%)	**SET 3** (T$_1$ – 90% JF + 10% OMF)		
	Initial	3rd month	CD value
Protein	57.76	56.00	0.021*
Starch	61.10	59.00	0.124*

Critical difference (CD) values are significant at 5% level
JF – Jackfruit flour, OMF – Oyster mushroom flour

In shelf life study the *in vitro* digestibility of protein content in jackfruit based pasta was 57.76 % and it decreased to 56.00 % at end of the storage. The *in vitro* digestibility of starch in jackfruit based pasta was 61.10% and after storage it decreased to 59.00%. On statistically analysing the data, it was found that there is significant difference in *in vitro* digestibility of starch and protein during storage.

Table 31: Effect of storage on the *in vitro* availability of the minerals of the pastas prepared with jackfruit flour and mushroom flour

Minerals (%)	SET 3 (T1 – 90% JF + 10% OMF)		
	Initial	3rd month	CD value
Calcium	41.50	40.85	0.117*
Iron	29.40	28.95	0.151*
Phosphorous	83.48	82.05	0.214*
Magnesium	40.00	39.05	0.122*

Critical difference (CD) values are significant at 5% level
JF – Jackfruit flour, OMF – Oyster mushroom flour

In vitro availability of the calcium content was 41.50 per cent with a slight decrease to 40.85% at end of the storage period. The *in vitro* availability of iron content at the end of the storage was only 28.95 per cent and at the first month it was 29.40 per cent. A high *in vitro* availability in phosphorus content was noted with 83.48 per cent at initial level and 82.05% at end of the storage period. *In vitro* availability of magnesium content in selected pasta was 40.00 % and in 39.05 % at the end of the storage period. On statistically analysing the data, it was found that there is significant difference between the treatments.

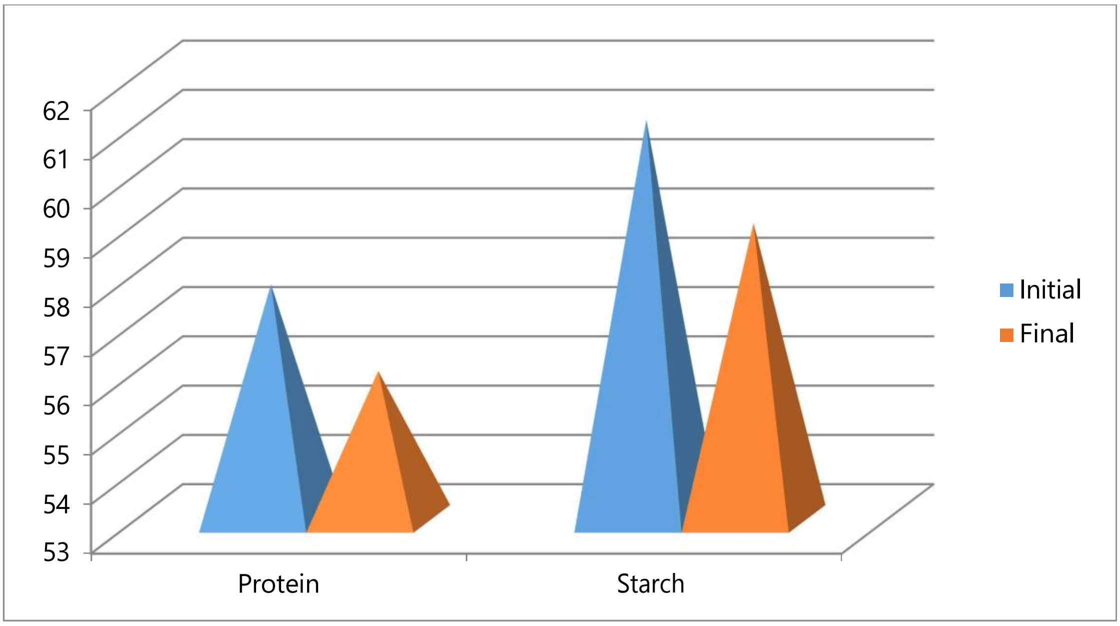

Figure 5: Effect of storage on the i*n vitro* digestibility of protein and starch in the pastas prepared with jackfruit flour and mushroom flour

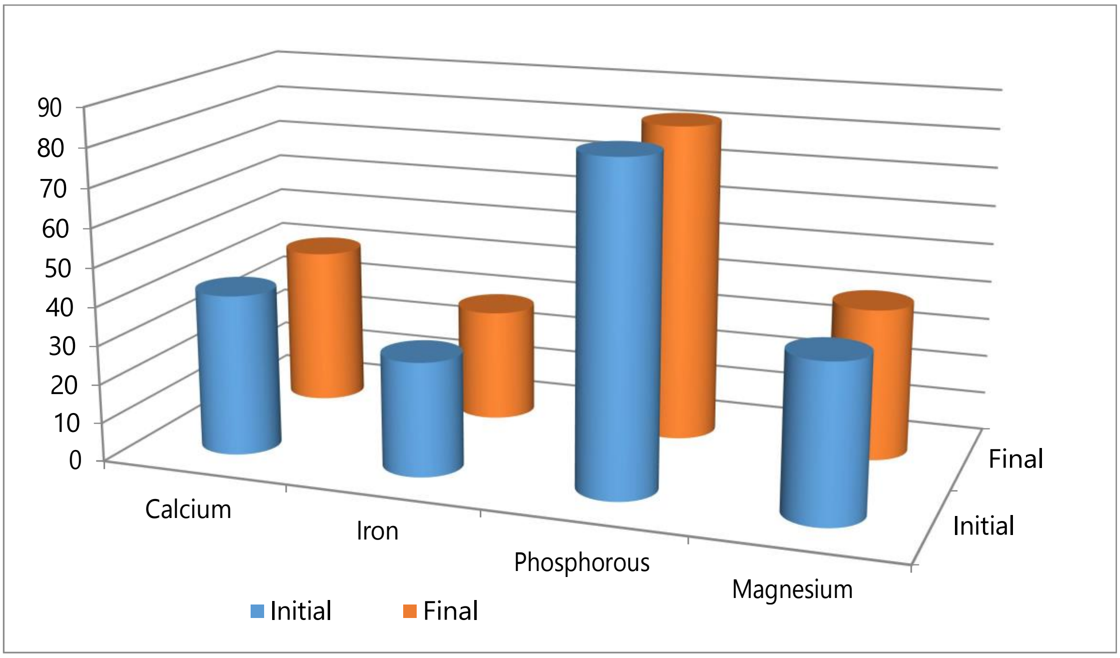

Figure 6: Effect of storage on the *in vitro* availability of the minerals of the pastas prepared with jackfruit flour and mushroom flour

Table 32: Effect of storage on the *in vitro* digestibility of protein and starch in pasta prepared with breadfruit flour and mushroom flour

Nutrients (%)	SET 4 (T_1 – 90% BF + 10% OMF)		
	Initial	3rd month	CD value
Protein	69.23	67.80	0.081*
Starch	52.56	51.95	0.095*

Critical difference (CD) values are significant at 5% level
BF – Breadfruit flour, OMF – Oyster mushroom flour

In shelf life study the *in vitro* digestibility of protein content in breadfruit based pasta was 69.23 per cent and in at the end of the storage period the protein digestibility decreased to 67.80 per cent. The *in vitro* digestibility of starch content in breadfruit based pasta was 52.56 per cent and in the end of the storage it was 51.95 per cent. On statistically analysing the data, it was found that there is significant difference in the *in vitro* digestibility during storage.

Table 33: Effect of storage on the *in vitro* availability of the minerals of the pastas prepared with breadfruit flour and mushroom flour

Minerals (%)	SET 4 (T_1 – 90% BF + 10% OMF)		
	Initial	3rd month	CD value
Calcium	40.50	39.18	0.077*
Iron	39.00	38.54	0.121*
Phosphorous	69.17	68.25	0.411*
Magnesium	78.24	77.98	0.089*

Critical difference (CD) values are significant at 5% level
BF – Breadfruit flour, OMF – Oyster mushroom flour

In vitro availability of calcium in breadfruit based pasta was 40.50 per cent which decreased to 39.18 per cent at end of the storage period. The *in vitro* availability of iron content was only 39.00 per cent and 38.54 per cent, wheras the availability of Phosphorus content in the selected treatment was 69.17 per cent and 68.25 per cent, initially and at end of the storage period. *In vitro* availability of magnesium content in selected pasta was 78.24 per cent initially and 77.98 per cent at the end of the storage period. On statistically analysing the data, it was found that there is significant difference between the *in vitro* availability of mineral content of pastas.

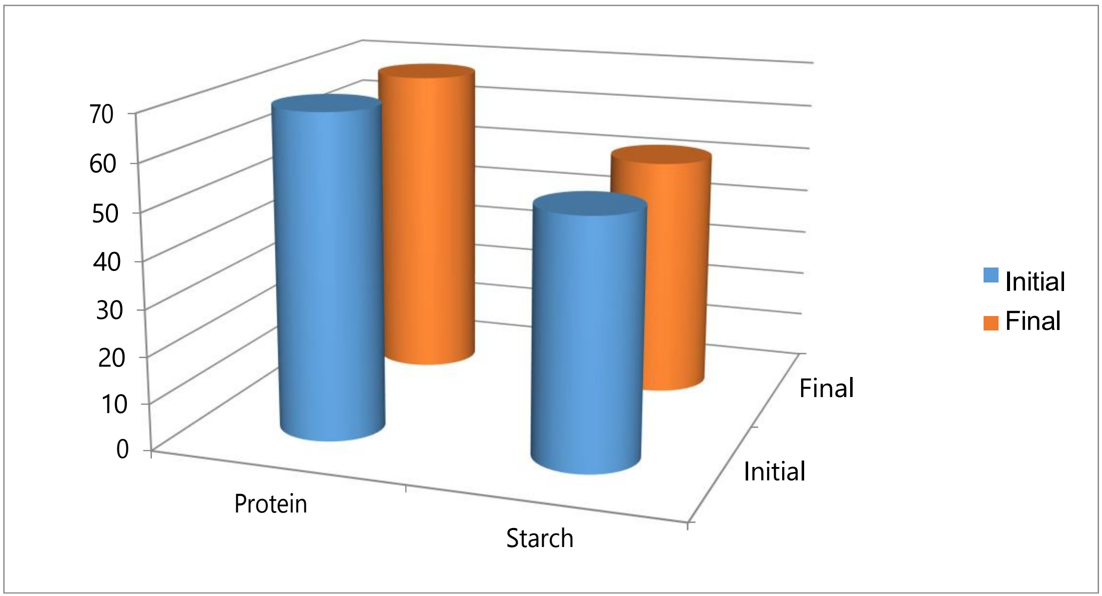

Figure 7: Effect of storage on the *in vitro* digestibility of protein and starch in pasta prepared with breadfruit flour and mushroom flour

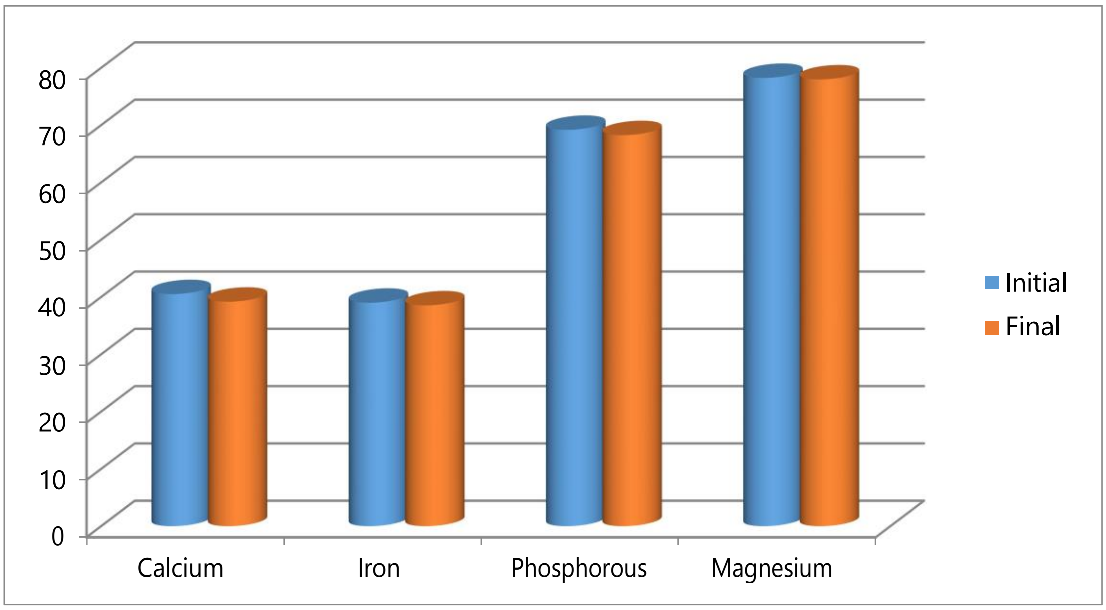

Figure 8: Effect of storage on the *in vitro* availability of the minerals of the pastas prepared with breadfruit flour and mushroom flour

4.3.3.3. Insect infestation of the selected extruded food during storage

The insect infestation of the selected pasta were assessed at monthly intervals for a period of three months. No insect infestation observed throughout the storage period.

4.3.3.3.3. Microbial enumeration of the selected extruded food during storage

The microbial population of the pasta was assessed at monthly intervals for a period of three months and the results are presented in table 34.

Table 34: Total microbial count of cassava flour and mushroom flour pastas at monthly intervals

Microbial population (cfu g^{-1})	SET 1 (T_3 – 70% CF + 30% OMF)			
	Initial	1st month	2nd month	3rd month
Bacteria ($x10^5$)	1.00	1.40	2.00	2.33
Fungi ($x10^3$)	ND	ND	ND	1.00
Yeast ($x10^5$)	ND	ND	ND	ND

CF – Cassava flour, OMF – Oyster mushroom flour

The initial bacterial count was found to be 1.00 $x10^5$cfu g^{-1}, which increased gradually to 2.33 $x10^5$ cfu g^{-1} during the end of third month. The first and second month had 1.4 $x10^5$cfu g^{-1} and 2.00 $x10^5$cfu g^{-1} respectively.

The fungal growth was not detected in initial, first month and second month of storage. During the end of third month a fungal growth of 1 $x10^3$cfu g^{-1} was detected.

Yeast growth was not detected throughout the storage period.

The microbial population of the fruit flour and mushroom pasta was assessed at monthly intervals for a period of three months and the results are presented in table 35.

Table 35: Total microbial count of fruit flour and mushroom flour pastas at monthly intervals

Microbial population (cfu g^{-1})	SET 3 (T_1 – 90% JF + 10% OMF)				SET 4 (T_1 – 90% BF + 10% OMF)			
	Initial	1st month	2nd month	3rd month	Initial	1st month	2nd month	3rd month
Bacteria ($x10^5$)	1.00	1.23	2.18	2.53	1.00	1.20	1.40	2.15
Fungi ($x10^3$)	ND	ND	1.00	1.13	ND	ND	ND	1.20
Yeast ($x10^5$)	ND	ND	ND	ND	ND	ND	ND	ND

JF – Jackfruit flour, BF – Breadfruit flour, OMF – Oyster mushroom flour

The bacterial count in the jackfruit and mushroom based pasta was enumerated. The initial bacterial count was found to be 1.00 $x10^5$cfu g^{-1}, which increased gradually to 2.53 $x10^5$cfu g^{-1} during the end of third month. The first and second month had 1.23 $x10^5$cfu g^{-1} and 2.18 $x10^5$cfu g^{-1} respectively.

In case of breadfruit and mushroom based pasta, the initial bacterial count was found to be 1.00 $x10^3$cfu g $^{-1}$, which increased gradually to 2.15 $x10^3$cfu g^{-1} during the end of third month. The first and second month had 1.20 $x10^3$cfu g^{-1} and 1.40 $x10^3$ cfu g^{-1} respectively.

The fungal growth was not detected in initial, first month and second month of storage in the jackfruit and mushroom based pasta. During third month a fungal growth of 1 $x10^3$cfu g $^{-1}$ was detected in the pasta.

A fungal growth of 1.20 $x10^3$cfu g^{-1} was detected at the end of the storage period of three months, in pasta prepared with breadfruit flour.

Yeast growth was not detected throughout the storage period in the pasta prepared using fruit flours.

4.3. Cost of production

Table 36: Cost of production of the selected extruded foods

Products	Cost (Rs/100g)
Cassava and mushroom pasta	98.50
Jackfruit and mushroom pasta	50.50
Breadfruit and mushroom pasta	52.00

The cost of production of the selected pasta was calculated based on cost of raw ingredients, fuel charges and electricity charges. The cost of 100g pasta prepared with cassava flour and mushroom flour was Rs 98.50, whereas it was Rs 50.50, Rs 52.00 for jackfruit flour and mushroom flour, breadfruit flour and mushroom flour pastas, respectively.

DISCUSSION

5. DISCUSSION

Results of the study entitled "**Process optimization of mushroom incorporated pastas**" are discussed under the following headings

5.1. Standardisation of nutri- rich ready to cook extruded food from tuber and mushroom flour

5.1.1. Cassava and mushroom flour incorporated pastas

5.1.2. Elephant foot yam and mushroom flour incorporated pastas

5.2. Standardisation of nutri-rich ready to cook extruded food from fruit and mushroom flour

5.2.1. Jackfruit and mushroom flour incorporated pastas

5.2.2. Breadfruit and mushroom flour incorporated pastas

5.3. Quality evaluation of selected ready to cook extruded foods

5.3.1. Nutritional qualities

5.3.2. Health studies

5.3.3. Shelf life studies

5.4. Cost of production

5.1. Standardisation of nutri-rich ready to cook extruded food from tuber and mushroom flour

Tuber selected for the study were cassava and elephant foot yam. Pastas were prepared using combinations of oyster mushroom flour with cassava flour and oyster mushroom flour with elephant foot yam flour. Organoleptic evaluation of the treatments were carried out and the different quality attributes were ranked based on their mean scores using Kendall's coefficient of concordance (W).

5.1.1. Cassava and mushroom flour incorporated pastas

Flour was prepared from cassava and oyster mushroom. Pastas were prepared using combinations of cassava flour with oyster mushroom flour in varying proportions. The treatments T_1 to T_4 varied from 90 per cent cassava flour to 60 per cent cassava flour and 10 to 40 per cent mushroom flour. Based on organoleptic evaluation T_3 was selected as best treatment. Based on organoleptic evaluation, T_3 (70% CF + 30% OMF) were highly acceptable for appearance, colour, flavour, texture and overall acceptability. Similar study was conducted by Ojo *et al.* (2017) for finding the suitability of composite flour incorporating cassava flour and mushroom flour for extruded products and found that the incorporation of 70 per cent of cassava and 30 per cent of mushroom flour was highly acceptable. As in the present study, noodles prepared with 100 per cent cassava flour also had similar sensory properties of the commercially available wheat noodles (Akhmad *et al.*, 2013). Similarly, noodles incorporating pearl millet and tubers like cassava and sweet potato, blend up to 50 per cent level was acceptable and this was suitable for celiac patients (Schober *et al.*, 2005).

5.1.2. Elephant foot yam and mushroom flour incorporated pastas

Elephant foot yam flour was also utilised to develop pasta along with the addition of mushroom flour. In a study, elephant foot yam was incorporated with wheat flour in the range of 10 - 40 per cent for cake making and was found that only 20 per cent incorporation was acceptable (Saklani and Kaushik, 2020). Similarly in the production of pasta, incorporation of only 10 per cent along with ragi, corn flour and wheat flour was found to be acceptable (Seema *et al.*, 2016). Thus, we can assume that incorporation of higher quantities of yam flour without the addition of any other cereal flours may be the reason for the unacceptability of the pasta prepared in the present study.

5.2. Standardisation of nutri-rich ready to cook extruded food from fruit and mushroom flour

Fruits selected for the study were jackfruit and breadfruit. Pastas were prepared using combinations of jackfruit with oyster mushroom flour and breadfruit with oyster mushroom flour. Organoleptic evaluation of the treatments were carried out and the different quality attributes were ranked based on their mean scores using Kendall's coefficient of concordance (W).

5.3 Standardisation of jackfruit flour and mushroom flour

Flour were prepared from mature jackfruit (*koozha* type) and oyster mushroom. Pastas were prepared by incorporating jackfruit and mushroom in varying proportions. The treatments T_1 to T_4 varied from 60 to 90 per cent jackfruit flour and 10 to 40 per cent mushroom flour. Based on organoleptic evaluation T_1 was selected as best treatment.

In the present study, the pasta was standardised from 4 treatments of jackfruit and mushroom flour based pastas with varying proportions of jackfruit (100, 90, 80, 70, 60) and mushroom flour (10, 20, 30, 40). Based on organoleptic evaluation, T_1 (90 % JF + 10% OMF) were highly acceptable for appearance, colour, flavour, texture and overall acceptability.

Lakmali (2021) developed pasta from jackfruit bulb flour, jackfruit seed flour, semolina, cassava flour, corn flour with varying proportions. The best treatment selected was pasta produced by using the formulation of T_3 (40:40:10:5:5, JFS: JFB: semolina: CF: corn flour), which scored the highest mean score among all the sensory attributes.

Swati *et al.* (2019) also developed similar pasta as of the present study, and was found that had higher acceptability. The study also revealed that incorporation of red amaranthus can even turn the pasta into a functional food.

Similarly, noodles were standardised by Kumari (2015) using jackfruit bulb flour, jackfruit seed flour and wheat flour in different combinations. The study revealed that higher acceptability was gained for the pasta having 50 per cent of jackfruit bulb flour, 10 per cent jackfruit seed flour and 40 per cent of wheat flour. Das (2011) also developed a similar pasta using jackfruit flour, wheat flour and green gram flour and reported to have high acceptability. In contrary to these studies, in the present study wheat flour is omitted which have made it gluten free and also have incorporated with mushroom flour to improves its nutritional qualities.

5.5. Standardisation of breadfruit flour and mushroom flour

Flours were prepared from breadfruit and oyster mushroom. Pastas were prepared using combinations of breadfruit flour with oyster mushroom flour. Pastas were prepared by incorporating breadfruit flour and mushroom flour in varying proportions. The treatments T_1 to T_4 varied from 60 to 90 per cent cassava flour and 10 to 40 per cent mushroom flour. Based on organoleptic evaluation T_1 was selected as best treatment.

Various studies had incorporated breadfruit flour to wheat flour in developing extruded products. The incorporation of 50 per cent each of breadfruit flour and wheat flour was found to highly acceptable in the production of noodles (Akeem *et al.*, 2017). Similarly Adebowale *et al.* (2017) developed noodles produced from blends of 30% breadfruit starch and 80% wheat flour showed superior culinary and sensory attributes while Akanbi *et al.* (2011) had reported incorporation of only 20 per cent was acceptable.

5.3. Quality evaluation of selected ready to cook extruded foods

The selected pastas along with control (T_0) from each set were utilised for the further studies. The pastas were subjected to various analysis which includes the nutritional qualities, health studies and shelf life studies.

5.3.1. Nutritional qualities

5.3.1.1.Nutritional qualities of selected cassava flour and mushroom flour pastas

In the present study moisture value of pasta made with 100% cassava flour (control T_0) was 7.92 per cent and that with 70% cassava flour and 30% mushroom flour (T_3) was 6.85 per cent. Robert *et al.* (2019) conducted a study on cassava flour by various drying methods and the moisture content found in cassava flour was 5.95 per cent to 11.18 per cent, which is similar to the present study. Noodles made with oven dried cassava flour (100 per cent) was found to be 9.07 per cent and when incorporating 30 per cent mushroom, the moisture content increased to 9.20 per cent which is higher than the present study (Ojo *et al.*, 2017). In contrary to this, Sanni *et al.* (2007) conducted a study in production of instant noodles from cassava, soybean and wheat flour, which had a moisture content ranging from 2.1 to 3.7 per cent.

In the present study energy value of pasta made with 100% cassava flour (control T_0) was 386.78 Kcal and that with 70% cassava flour and 30% mushroom flour (T_3) was 391.52 Kcal. The energy value of the noodles made with cassava and mushroom flour developed by Ojo *et al.* (2017) was 340.41 kcal. Zacharia (2020) developed finger millet nutri flakes with cassava flour which had 219.54 kcal energy.

Pasta made with 100 % cassava flour had a total carbohydrate content of 88.10 g/100g while the treatment T_3 had a total carbohydrate content of 80.6 g/100g of sample. Sanni *et al.* (2007) observed that the carbohydrate content of cassava noodles ranged from 64.70 to 79.70 g/100g. Robert *et al.* (2019) reported that carbohydrate content in the cassava flours ranged from 83.49 to 86.11g/100g, which is similar to the findings of the present study. Zacharia (2020) developed finger millet nutri flakes with cassava flour had carbohydrate content of 44.32 g/100g.

The protein content of pasta made with 100 % cassava flour (control T_0) was 7.92 g/100g of sample and that with 70 % cassava flour and 30 % mushroom flour (best treatment T_3) was 9.38 g/100g of sample. Sanni *et al.* (2007) observed that the protein content of the instant noodles was ranged from 5.8 to 12.1 g/100g. Ojo *et al.* (2017) reported that the cassava and mushroom flour based noodle had a protein content of 5.73 g/100 g of sample. Robert *et al.* (2019) reported that the protein content in the cassava flour ranged between 0.73 to 1.16 g/100 g of sample and so the increase in the protein content of the pasta made in the present study can be thus attributed to the protein content of mushroom flour incorporated.

Total fat content of the pasta were also estimated and was found that T_3 had a slightly low fat content (0.20 g/100g of sample) than the control pasta (0.30 g/100g of sample). Robert *et al.* (2019) observed that the fat content in cassava flour ranged from 0.49 to 0.64 g/100g of sample. Akhmad *et al.* (2013) studied that the fat content in noodles was 0.27 g/100g. low fat content will enhance the storage life of the product due to the lowered chance of rancid flavour development.

The fibre content of pasta made with 100% cassava (T_0) was 1.89 g/100g of sample and that with 70 % cassava flour and 30 % mushroom flour (T_3) was 2.86 g/100g of sample. Zacharia (2020) developed finger millet nutri flakes with cassava flour had 2.86 per cent total fibre. Robert *et al.* (2019) observed that the fibre content in cassava flour ranges from 1.84 to 2.07 g/100g. Akhmad *et al.* (2013) studied that the fiber content in wet cassava noodles was 3.4 per cent while the fibre content in instant cassava noodles was 0.2 to 0.8 per cent (Sanni *et al.*, 2007). Aishah and Wan Rosli (2013) reported that the fibre content of the mushrooms ranges from 33.0 % to 37.5 %, depending on the drying methods. The higher values of fibre content in the treatment (T_1) may be attributed to the added mushroom.

The starch content of pasta made with 100 % cassava flour (T_0) was 79.03 g/100g of sample and that with 70 % cassava flour and 30 % mushroom flour (T_3) was 67 g/100g of sample. Robert *et al.* (2019) observed that the starch content of cassava flour ranges from 82.39 to 84.04 g/100g. The higher values of starch shows that cassava is predominantly starch food as compared to protein and fat. Due to its high content of starch, it can be used for the production of noodles, as it improves the binding property of the composite flour. Akhmad *et al.* (2013) conducted a study on development of wet noodles based on cassava flour and the starch content observed was 87.3 g/100g, which is similar to the findings of the present study.

The reducing sugar content of pasta made with 100% cassava flour (T_0) was 0.84 per cent and that with 70 % cassava flour and 30 % mushroom flour (T_3) as 0.94 per cent. Mogra and Midha (2013) reported that vermicelli standardised with malted wheat flour had total sugars of 8.91 per cent and reducing sugars of 2.41 per cent. Cassava flour and mushroom flour had lesser reducing content than wheat flour hence the result of the present study.

Calcium content of pasta T_0 and T_3 was 50.80 and 54.90 mg/100g, respectively. Iron content in T_0 was 2.91 mg/100g and in T_3 it increased to 3.60 mg/100g. The sodium content in T_0 and T_3 was 9.88 and 12.48 mg/100g, respectively. Magnesium content in T_3 was 40.80 mg/100g and for T_0 it was found to be 38.20 mg/100g. The potassium content in T_0 was 255.00 mg/100g and it increased in treatment T_3 to 292.01 mg/100g. Geetha *et al*. (2013) had pointed out that cassava flour incorporated to the wheat noodles increased the mineral contents such as calcium, phosphorous and iron compared to the instant noodles. The sodium content in cassava based wet noodles was 29.5 mg/100g (Akhmad *et al*., 2013). Shobha and Asha (2015) standardised maize based vermicelli with a proportion of 50 per cent maize flour and 50 per cent wheat flour. The formulated maize based vermicelli was found to have a calcium content of 108.8 mg/100g, magnesium content of 89 mg/100g. Wahyono and Bakri (2018) had reported that mushroom fortified wheat noodles have improved the micronutrient content of the pasta. This fact is proved by the results of the present study.

5.3.1.2. Nutritional qualities of selected jackfruit flour and mushroom flour pastas

Based on organoleptic evaluation T_1 (90% JF + 10% OMF) was selected for further studies. The selected pastas was evaluated for proximate composition like moisture, energy, total carbohydrate, protein, total fat, fibre, starch and reducing sugar.

Moisture provides a measure of the water content of the product and it is also index of storage stability of the product. The moisture content of pasta made with 100% jackfruit (control T_0) was 6.29 and that with 90% jackfruit and 10% mushroom (best treatment T_1) was 6.67 %. Moisture content in jackfruit based nutri flour was 0.96 %. Jackfruit bulb flour contains 1.28 % and *varikka* jackfruit bulb flour had 1.39 % (Swati, 2019). Lower the moisture content of the flour, the better its shelf life and hence the quality. Mohan (2019) stated that one of the key factors that affects the quality of the Ready to Cook (RTC) mixtures is moisture content and the mean moisture content of jackfruit RTC mixtures was 5.38 per cent.

In the present study energy value of pasta made with 100% jackfruit (control T_0) was 368.59 Kcal and that with 90% jackfruit flour and 10% mushroom flour (T_1) was 355.95 Kcal. Ajisha (2018) reported that the energy value of jackfruit vermicelli initially differing from 267.02 to 282.64 Kcal and which decreased to 262.54 to 277.63 Kcal at fourth month of storage and which was lower than control (317.08 Kcal). Kumari (2015) observed that raw jackfruit and jackfruit seed flour incorporated noodles has energy content of prepared noodles varying from 291.60 to 380 Kcal.

Pasta made with 100% jackfruit flour had a total carbohydrate content of 85.07g/100g while the treatment T_1 had a total carbohydrate content of 78.63 g/100g of sample. Soumya (2022) reported that the carbohydrate content of nutri flour was 31.59g/100g which was higher than *koozha* jack bulb flour 14.74g/100g and *varikka* jack bulb flour 19.79g/100g. Tharani (2018) observed that *koozha* jackfruit rind flour had a carbohydrate content of 29g/100g whereas Amadi *et al.* (2018) reported that carbohydrate content of jackfruit bulb has 7.74g/100g. Tiwari and Vidyarthi (2015) reported that jackfruit bulbs are high in nutritive value, and he also reported that 100g of jackfruit bulb contains 18g of carbohydrate. Baliga *et al.* (2011) identified that 18.9g/100g carbohydrate present in jackfruit bulb.

The protein content of pasta made with 100 % jackfruit (control T_0) was 6.29g/100g of sample and that with 90% jackfruit flour and 10% mushroom flour (best treatment T_1) was 9.48g/100g of sample. Hettiaratchi *et al.* (2011) observed that considerable amount of protein is present in jackfruit bulb flour. Noodle produced by the jackfruit flour has good firmness quality due to high protein content in jackfruit bulb flour.

Total fat content of the pasta were also estimated and was found that T_1 had a slightly higher fat content (0.39 g/100g of sample) than the control pasta (0.35 g/100g of sample). Ajisha (2018) conducted a study in jackfruit based vermicelli. The roasted raw jackfruit and jackfruit seed flour based vermicelli had fat content 0.80 to 1.88g 100^{-1}.

The fibre content of pasta made with 100% jackfruit (T_0) was 3.52 g/100g of sample and that with 90% jackfruit flour and 10% mushroom flour (T_1) was 3.60 g/100g of sample. Swami *et al*. (2012) reported that dietary fibre content of the bulb increased at the maturity state. Divya (2016) reported that *varikka* bulb contains dietary fibre of 1.76 g/100g. Dietary fibre is higher in *koozha* cultivator compared with *varikka* cultivator. Anila and Divakar (2018) reported that the fibre content in different types of jackfruit bulb flours ranges from 1.14 to 2.24 g/100g which is lower than the present study. The starch content of pasta made with 100% jackfruit flour (T_0) was 74.12 g/100g of sample and that with 90 % jackfruit flour and 10 % mushroom flour (T_1) was 73.39 g/100g of sample. Ajisha (2018) observed that the starch content in jackfruit based vermicelli has 84.40 to 96.17 per cent.

Sucrose needs to be hydrolyzed and decomposed to its glucose and fructose molecules to act as a reducing sugar in flour components. The reducing sugar content of pastas T_0 was 1.10 per cent and T_1 was 0.37 per cent. Ajisha (2018) reported that reducing sugar content of jackfruit based vermicelli ranged from 1.56 to 2.34 per cent.

Calcium content of pasta T_0 and T_1 was 32.24 and 26.10 mg/100g, respectively. Iron content in T_0 was 1.03 mg/100g and in T_1 it increased to 1.64 mg/100g. The sodium content in T_0 and T_1 was 7.25 and 6.85 mg/100g, respectively. Magnesium content in T_1 was 56.02 mg/100g and for T_0 it was found to be 48.08 mg/100g. The potassium content in T_0 was 283.00 mg/100g and it increased in treatment T_1 to 324.70 mg/100g. Ajisha (2018) conducted a study in jackfruit based vermicelli and found that it had a calcium content (53.17 mg/100g) and sodium (18.14 mg/100g). Kumari (2015) reported that the total mineral content in jackfruit bulb flour was 0.8g. Tiwari and Vidyarthi (2015) stated that the jackfruit bulbs have high nutritive value and also they reported that in 100g of jackfruit bulb flour contains calcium (35 mg) and potassium (215 mg). Swami *et al*. (2012) reported that the mineral content in the jackfruit bulb flour was calcium content (30 mg/100g), magnesium (34 mg/100g), phosphorous (20.0 to 57.2 mg/100g), potassium (287 to 323 mg/100g), iron (0.4 to 1.9 mg/100g) and sodium (35 mg/100g). Baliga *et al*. (2011) observed that the calcium content in jackfruit bulb flour was 20 mg/100g calcium, 30 mg/100g phosphorous, 500 mg/100g of iron.

5.3.3. Nutritional qualities of selected breadfruit flour and mushroom flour pastas

The moisture content of pasta made with 100 % breadfruit (control T_0) was 7.16 per cent and that with 90 % breadfruit and 10 % mushroom (best treatment T_1) was 6.03 per cent. Adebowale *et al*. (2017) stated that the moisture content is a measure of water content and also an indicator of storage stability and the study also reported that the moisture content in breadfruit noodles ranges from 7.43 to 7.67 per cent, which is similar to the findings of the present study. Akeem *et al.* (2017) conducted a study in noodles by incorporating breadfruit flour and wheat flour and the moisture content observed was much lesser than the present study which ranged from 2.50 to 3.50 per cent. Nochera and Ragone (2016) reported that breadfruit bar had a moisture content of 12.5 per cent.

In the present study energy value of pasta made with 100% breadfruit (control T_0) was 343.52 Kcal and that with 90% breadfruit flour and 10% mushroom flour (T_1) was 320.69 Kcal. Nochera (2016) reported that the breadfruit bar has energy content of 384 Kcal.

Pasta made with 100 % breadfruit flour had a total carbohydrate content of 80.32 g/100g while the treatment T_1 had a total carbohydrate content of 73.49 g/100g of sample. Akeem *et al*. (2017) reported that the carbohydrate content in noodle ranges from 64.4 to 69.8 g/100g. The highest carbohydrate content was observed in wheat and breadfruit blend at 50 per cent. Adebowale *et al*. (2017) reported that the carbohydrate content in breadfruit noodle ranges from 77.6 to 84.09 g/100g. Nochera (2016) reported that breadfruit bar had carbohydrate content 83.92 g/100g.

The protein content of pasta made with 100 % breadfruit (control T_0) was 4.30 g/100g of sample and that with 90 % breadfruit flour and 10% mushroom flour (best treatment T_1) was 5.40 g/100g of sample. Akeem *et al*. (2017) reported that the protein content of breadfruit noodle ranges from 12.4 to 19.0 per cent. Adebowale *et al*. (2017) observed that the protein content in breadfruit noodle ranges from 2.80 to 7.63 per cent. Nochera (2016) reported that the breadfruit bar has protein content 2.05 g/100g. Akanbi *et al*. (2011) reported that the protein content in breadfruit starch and wheat flour incorporated noodles ranges from 0.65 to 10.88 per cent.

Total fat content of the pasta were also estimated and was found that T_1 had a slightly higher fat content (0.57 g/100g of sample) than the control pasta (0.56 g/100g of sample). Akeem *et al*. (2017) observed that the fat content in noodles ranges from 5.0 to 18.0 per cent. Adebowale *et al*. (2017) reported that the fat content in breadfruit noodle ranges from 0.20 to 0.37 per cent. Nochera (2016) observed that the breadfruit bar has fat content 0.43 g/100g. Akanbi *et al*. (2011) reported that the fat content in breadfruit starch and wheat flour incorporated noodles ranges from 0.35 to 3.15 per cent.

The fibre content of pasta made with 100 % breadfruit (T_0) was 7.69 g/100g of sample and that with 90 % breadfruit flour and 10 % mushroom flour (T_1) was 7.52 g/100g of sample. Akeem *et al*. (2017) observed that the fibre content in breadfruit noodle increased as the substitution of breadfruit flour increases and the fibre content ranges from 0.86 to 1.26 per cent. Nochera (2016) conducted a study in breadfruit bar and the fibre content is 3.8 g of fiber and 1.97 g/100g of crude fiber. Ajani *et al*. (2012) states that the increase in the fibre content might be due to high fibre content in breadfruit flour. Akanbi *et al*. (2011) reported that the fibre content in breadfruit starch and wheat flour incorporated noodles ranges from 1.18 to 1.45 g/100g of sample.

Calcium content of pasta T_0 and T_1 was 48.00 and 37.80 mg/100g, respectively. Iron content in T_0 was 0.06 mg/100g and in T_1 it increased to 0.10 mg/100g. The sodium content in T_0 and T_1 was 9.80 and 12.03 mg/100g, respectively. Magnesium content in T_1 was 19.72 mg/100g and for T_0 it was found to be 18.68 mg/100g. The potassium content in T_0 was 426.03 mg/100g and it increased in treatment T_1 to 511.00 mg/100g. Nochera (2016) reported that the breadfruit bar has calcium content 58mg/100g, 1.99mg/100g of iron and 114mg/100g of sodium. Breadfruit flour contains 5.30 mg/100 g of iron and 82.20 mg/100g of calcium (Sharon, 2003).

5.3.2. Health studies

5.3.2.1. *In vitro* digestibility of starch and protein and *in vitro* mineral availability of cassava flour and mushroom flour pasta

In vitro digestibility of starch in the present study was found to be 64.03 in 100 per cent cassava based pasta and in the one which had mushroom, it was 61.13 per cent. Nousheen (2013) carried out a study on the noodles prepared with a combination of modified cassava starch and green gram dhal with a starch content varying from 41.70 to 51.58 per cent.

In vitro digestibility of protein in the present study was found to be 67.52 in 100 per cent cassava based pasta and in the one which had mushroom, it was 83.10 per cent. Rocha-Guzman *et al*. (2012) carried a study on the *in vitro* protein digestibility of the extruded product with a mixture of whole maize flour (60%) and chick pea flour (40%) having 89.1 per cent.

In the present study *in vitro* availability of calcium content in T_0 is 40.80 and in T_3 it is 41.10 mg/100g during the storage period it was decreased to 39.05. The iron content in T_0 is 37.09 and in T_3 it was 37.80 at third month of storage it was decreased to 37.01. The magnesium content in T_0 is 67.02 and in T_3 it was 68.12 and in the end of storage it decreased to 68.05 mg/100g. Thilagavathi *et al*. (2015) prepared extruded products like noodles, spaghetti and macaroni with addition of millet and pulse flour and observed the *in vitro* availability of minerals. The calcium availability varied from 35.16 to 68.07 per cent (noodles), 34.20 to 67.01 per cent (spaghetti) and 37.12 to 69.53 per cent (macaroni). The availability of iron differs from 43.69 to 53.60 per cent in noodles, 42.74 to 52.63 per cent in spaghetti and 44.73 to 54.26 per cent in macaroni. The noodles, spaghetti and macaroni had *in vitro* availability of magnesium ranging from 57.25 to 69.78 per cent, 56.80 to 70.00 per cent and 58.21 to 70.90 per cent. The *in vitro* availability of phosphorus varied from 62.96 to 71.11 per cent in noodles, 63.09 to 71.61 per cent in spaghetti and 63.23 to 71.76 per cent in macaroni.

The availability of potassium present in noodles, spaghetti and macaroni ranged from 67.29 to 70.20 per cent, 66.82 to 69.66 per cent and 67.59 to 70.45 per cent respectively.

5.3.2.2. *In vitro* digestibility of starch and protein and *in vitro* mineral availability of jackfruit flour and mushroom flour pasta

In vitro digestibility of starch and protein of a product is affected by various factors such as milling, cooking, germination and so on (Kaur *et al.*, 2015). The *in vitro* digestibility of starch of jackfruit pasta was 50.39 and jackfruit mushroom pasta was found to be 57.76 per cent. The *in vitro* digestibility of protein was 71.00 for control and for T_1 it was 61.10 per cent.

In vitro availability of minerals in pastas prepared with jackfruit flour and mushroom flour. *In vitro* availability of iron content in T_0 and T_1 was 28.80 and 29.40%, respectively. The *in vitro* calcium availability of jackfruit based pasta (T_0) was 40.60 per cent and T_1 was 41.50 per cent. The highest *in vitro* mineral availability was seen in phosphorous with 84.90% and 83.48% in T_0 and T_1, respectively.

5.3.2.3. *In vitro* digestibility of starch and protein and *in vitro* mineral availability of breadfruit flour and mushroom flour pasta

The *in vitro* digestibility of starch of breadfruit pasta was 58.32 and breadfruit mushroom pasta was found to be 52.56 per cent. The *in vitro* digestibility of protein was 62.98 for control and for T_1 it was 69.23 per cent. *In vitro* digestibility of breadfruit starch was found to be 93 per cent. The amylose content in the starch acts as a main factor which influences the *in vitro* digestibility as the amylose rich starch is difficult to swell or to gelatinize. Apart from this, the digestibility is also affected by many factors such as amylopectin content, cooking temperature, processing method and also phosphorous contents (Rincon and Padilla, 2004).

In vitro availability of pastas prepared with breadfruit flour and mushroom flour. In vitro availability of iron content in T_0 and T_1 was 38.50 and 39.00 per cent, respectively. The *in vitro* calcium availability of breadfruit based pasta (T_0) was 40.00

per cent and T_1 was 40.50 per cent. The *in vitro* availability for phosphorous was 68.60 per cent and 69.00 per cent in T_0 and T_1, respectively.

5.3.3. Shelf life studies

Pasta made with tuber flour and fruit flours were packed in HDPE covers and were kept for three months storage in room temperature.

5.3.3.1. Organoleptic evaluation of the selected cassava flour and mushroom flour pasta during storage

Based on organoleptic scores the selected pasta, T_3 (70% CF + 30% OMF) were acceptable upto three months of storage with gradual decline in all sensory attributes.

Initially the highest score for appearance obtained was 7.24 and that decreased to 7.16 (1^{st} month), 7.00 (2^{nd} month) and to 6.98 (3^{rd} month) during storage. The organoleptic scores of colour was 7.28, initially and gradually reduced to 7.24 in first month, 7.10 in second month and 7.04 at the end of the storage.

A gradual decrease was also observed for organoleptic scores of flavour, texture, taste and overall acceptability. The scores for flavour and texture was 7.55 and 7.28 initially and it gradually decreased to 7.18 and 7.04 in first month, 7.12 and 6.80 in second month, and scored 7.04 and 6.50 mean scores at the end of storage. The highest score for taste was obtained initially with 7.21 and it decreased to 7.04 at the first month of storage, 6.80 at second month and 6.50 at the end of the storage. The overall acceptability also decreased from 7.22 to 6.03 at the end of the storage. Thirty per cent incorporation of cassava starch with blend of sago and jackfruit flour (1:1) produced fried crackers with the most acceptable physicochemical characteristics (Mustapha *et al*, 2015).

Emmanuel *et al.* (2015) conducted a study on noodles by incorporating whole cassava flour and soybean flour and he observed that the soybean- cassava based noodles has greater consumer acceptability compared with whole cassava flour based noodles.

5.3.3.2. Organoleptic evaluation of the selected fruit flour and mushroom flour pasta during storage

In present study the mean organoleptic scores of pastas prepared with fruit flours (90% JF +10% OMF and 90 % BF + 10 % OMF) and mushroom flours. The highest score for appearance obtained for T_1 was 8.15 that decreased to 8.14 (1^{st} month), 8.02 (2^{nd} month) and 8.00 (3^{rd} month) during the storage. The colour of treatment T_1 was 7.71 which gradually reduced to 7.54 in first month, 7.20 in second month and 7.08 at the end of the storage.

The flavour and texture of treatment T_1 (90% JF +10% OMF) was 7.28 and 7.14 in the initial stage and it gradually decreased to 7.01 and 6.60 in the first month, 6.70 and 7.02 in the second month and scored 6.77 and 6.00 mean scores at the end of the storage. The highest score for taste obtained was T_1 (7.02) and that decreased to 6.60 at the first month of storage, 6.15 in the second month and 6.00 in the end of the storage. The overall acceptability also decreased from 7.35 to 6.18. Sahoo (2016), who prepared raw jackfruit based rusk and buns along with wheat flour in different proportions (40:60, 45:55, 50:50,60:40, 70:30, and 80:20) along with control (refined wheat flour). Buns and rusk prepared with 80 per cent of raw jackfruit flour was highly acceptable for taste, texture, flavour and overall acceptability than other treatments.

The best treatment for the pasta prepared with breadfruit flour and oyster mushroom flour attained a score of 6.80 for appearance which gradually decreased to 6.16 at the end of storage. The organoleptic scores for color was 7.06, initially and gradually decreased to 6.18 at the end of the storage.

The organoleptic score for flavour and texture was 7.13 and 7.00, initially which gradually decreased to 6.70 and 6.75 in the first month, 6.25 and 6.67 in the second month and 6.00 and 6.51 at the end of the storage. The highest score for taste was 7.20 and that decreased to 7.04 in first month, 6.87 in second month and 6.52 at end of the storage period. The overall acceptability also decreased from 7.06 to 6.00 at the end of the storage.

Even though, all the selected pastas were acceptable, jackfruit flour and mushroom added pasta were observed to have better score compared to breadfruit flour and mushroom flour pasta.

5.3.3.3. Nutritional qualities of selected cassava flour and mushroom flour pastas during storage

Puwani *et al.* (2006) had reported that the low moisture content can enhance the shelf life stability of the food product by inhibiting the microbial activity and chemical reactions in foods on storage. In the present study moisture value of pasta made with 70% cassava flour and 30% mushroom flour (T_3) was 6.85 per cent during storage it increased to 8.60 per cent. Emmanuel *et al.* (2015) prepared cassava and soybean based noodles and the moisture content in storage was 8.75 per cent.

In the present study energy value of pasta made with 70 % cassava flour and 30 % mushroom flour (T_3) was 391.52 Kcal. Pasta made with 70 % cassava flour and 30 % mushroom flour (T_3) had a total carbohydrate content of 80.6 g/100g of sample during third month of storage it decreased to 78.03 g/100g. Emmanuel *et al.* (2015) prepared cassava and soybean based noodles and the carbohydrate content was 82.75 per cent.

The protein content of pasta made with 70 % cassava flour and 30 % mushroom flour best treatment T_3) was 9.38 g/100g of sample gradually it decreased to 7.72 g/100g during the storage. Emmanuel *et al.* (2015) prepared cassava and soybean based noodles and the protein content was 7.00 per cent. Rachman *et al.* (2022) conducted a study in banana – cassava gluten free pasta and the protein content in cassava based pasta was 6.81 per cent.

Total fat content of the pasta were also estimated and was found that T_3 had a slightly low fat content (0.20 g/100g of sample) and decreased to 0.18 at third month of storage. Emmanuel *et al.* (2015) prepared cassava and soybean based noodles and the fat content in storage was 1.00 per cent.

The fibre content of pasta made with 70% cassava flour and 30% mushroom flour (T_3) was 2.86 g/100g of sample during the third month of storage. The gradual decrease of fibre during storage is due to the degradation of polysaccharide into simple form. Emmanuel *et al*. (2015) prepared cassava and soybean based noodles and the fibre content in storage was 0.10 per cent.

The starch content of pasta made with 70% cassava flour and 30% mushroom flour (T_3) was 67 g/100g of sample the starch content was decreased to 66.18 during the storage period. The reducing sugar content of pasta made with 70% cassava flour and 30% mushroom flour (T_3) as 0.94 per cent and there is a slight increase in reducing sugar content during the storage to 0.98 per cent.

The calcium content of the pasta made with 70% cassava flour and 30% mushroom flour was 54.90 mg/100g and at the end of the storage it was 54.00 mg/100g. The iron content of the pasta was 3.60 mg /100g which decreased to 2.18 at the end of storage. A slight decrease was seen in the sodium, magnesium and potassium content after the storage period of three months. Mineral losses can occur by heat induced chemical reaction between reducing sugars and amino acids and or proteins to form compounds that bind minerals (Dandago, 2009). Considerable amounts of some soluble minerals are dissolved in water and leads to mineral loss during processing and storage

5.3.3.4. Nutritional qualities of selected jackfruit flour and mushroom flour pastas during storage

Moisture provides a measure of the water content of the product and it is also a index of storage stability of the product. The moisture content of pasta made with 90% jackfruit and 10% mushroom (best treatment T_1) was 6.67 % and the moisture content is increased to 8.10 during the storage period. The moisture content increases during storage period especially when the relative humidity is higher around the storage vicinity.

Pasta made with 90 % jackfruit flour and 10 % mushroom flour (T_1) was 355.95 Kcal during storage it decreased to 345.60 Kcal. The energy content decreased on storage due to the decreased amount of protein, carbohydrate and fat. Ajisha

(2018) reported that the energy content of jackfruit vermicelli decreased to 262.24 at fourth month of storage.

Pasta made with 90 % jackfruit flour and 10 % mushroom flour (T_1) had a total carbohydrate content of 78.63 g/100g of sample and it decreased to 77.42 at third month of storage. Nandkule *et al.* (2015) prepared noodles incorporated with jackfruit composite flour and the carbohydrate content was found to be 67 per cent and it was decreased on second month of storage (65%).

The protein content of pasta made with 90 % jackfruit flour and 10 % mushroom flour (best treatment T_1) was 9.48 g/100g of sample. There was a reduction in protein content on storage. Ajisha (2018) observed that the protein content jackfruit based vermicelli decreased 2.02 at the end of the storage period.

Total fat content of the pasta were also estimated and was found that T_1 had a slightly higher fat content (0.39 g/100g of sample) and it decreased during storage to 0.28 g/100 g . A study conducted by Aji *et al.* (2016) in jackfruit based meat analog it has the fat content 0.04 g/100g. The decrease in fat content during storage is due to the lipolytic activities of the enzyme lipoxidase and lipase is the reason for the decrease of fat content (Murugkar and Jha, 2011).

The fibre content of pasta made with 90% jackfruit flour and 10% mushroom flour (T_1) was 3.60g/100g of sample. Nandkule *et al.* (2015) reported that the incorporation of jackfruit composite flour had fibre content of 1.6 and it was decreased to 1.4 per cent on 2 months of storage. McClarey and Blackeney (1999) observed dietary fibre are low digestable. Hurst *et al.* (1993) also reported that decrease in fibre content on storage due to degradation of poly saccharide into simple form.

The starch content of pasta made with 90 % jackfruit flour and 10 % mushroom flour (T_1) was 73.39 g/100g of sample which decreases to 72.09 g/100g after three month of storage. Ajisha (2018) observed that the starch content in jackfruit based vermicelli 79.67 per cent after fourth month of storage.

The reducing sugar content of T_1 was 0.37 per cent and it increased to 0.49 per cent at third month of storage. Ajisha (2018) reported that reducing sugar content of jackfruit based vermicelli initially ranged from 1.56. During fourth month of storage reducing sugar content was decreased. There was increase in reducing and total sugars content on storage period due to the formation of simple sugars like sucrose, glucose and fructose on starch degradation.

The calcium content of pasta made with 90% jackfruit flour and 10% mushroom flour was 26.10 mg/100g and at the end of the storage it was 25.20 mg/100g. The iron content of the pasta was 1.64 mg/100g which decreased to 1.50 mg/100g at the end of the storage. Using nutrients for the growth and reproduction of the microorganisms present in food goods caused a drop in mineral content during storage (Sunday and Dayo, 2012).

5.3.3.5. Nutritional qualities of selected breadfruit flour and mushroom flour pastas during storage

The moisture content of pasta made with 90% breadfruit and 10% mushroom (best treatment T_1) was 6.03 per cent which increased to 7.80 per cent. According to Sharon (2003), after three months of storage, the moisture content of breadfruit flour increased to 8.90%. The amount of solid matter in a food sample is indicated by the moisture content of the sample. The rate of deterioration increases as the moisture content increases.

In the present study energy value of pasta made with 90% breadfruit flour and 10% mushroom flour (T_1) was 320.69 Kcal and it decreased to 309.21 Kcal. The energy content of the breadfruit bar, according to Nochera (2016), was 384 Kcal, which is comparable to the energy content of the pasta developed in the study.

Pasta T_1 had a total carbohydrate content of 73.49 g/100g of sample it decreased to 71.90 g/100g. The protein content of pasta made with 90% breadfruit flour and 10% mushroom flour (best treatment T_1) was 5.40 g/100g of sample which decreased during the storage to 4.30 g / 100g of sample. At the third month of storage, Sharon (2003) noted that the protein level in breadfruit flour had dropped to 4.25 g/100g.

Total fat content of the pasta were also estimated and was found that T_1 had a slightly higher fat content (0.57g/100g of sample) which decreased during storage to 0.49 g/100g. According to Akeem *et al.* (2017), fat has a significant influence on the shelf life of food items; as a result, food products with a relatively high fat content may not be ideal. This is due to the possibility that fat will cause foods to go rancid and produce odorous substances.

The fibre content of pasta made with 90% breadfruit flour and 10% mushroom flour (T_1) was 7.52 g/100g of sample which decreased to 6.18g/100g during the third month of storage. Sharon (2003) noted that during the third month of storage, the fibre level of breadfruit flour dropped to 4.21 g/100g.

5.3.3.6. *In vitro* digestibility of starch and protein and *in vitro* mineral availability of cassava flour and mushroom flour pasta during storage

In vitro digestibility of starch in the present study cassava and mushroom flour pasta had starch content 61.13 per cent which decreased to 60 per cent. *In vitro* digestibility of protein in the present study cassava and mushroom flour pasta had protein content 57.76 per cent which decreased to 56 per cent.

In vitro starch digestibility of pasta products made with millet and pulses varied from 90.0 to 94.5 per cent in noodles and 87.0 to 90.5 per cent in spaghetti, according to Thilagavathi *et al.* (2015). A study on noodles made with a combination of modified cassava starch and green gram dhal, with a starch content ranging from 41.70 to 51.58 per cent, was conducted by Nousheen (2013). By combining sorghum, soy, and channa flours to make gluten-free pasta, Susanna and Prabhasankar (2013) measured an *in vitro* protein digestibility of 95.18± 0.89 per cent. In a study on gluten-free banana-cassava pasta by Rachman *et al.* (2022), the amount of *in vitro* protein digestiblity in the pasta was 73.38 per cent.

In the present study *in vitro* availability of calcium content in T_3 was 41.10 mg/100g during the storage period it was decreased to 39.05 mg/100g. The iron content in T_3 was 37.80 mg/100g at third month of storage it decreased to 37.01 mg/100g. The magnesium content in T_3 was 68.12 mg/100g and in the end of storage it decreased to 68.05 mg/100g. Phosphorous content in T_3 was 63.17 mg/100g , which decreased to 61.12 mg/100g at the end of the storage.

5.3.3.7. *In vitro* digestibility of starch and protein and *in vitro* mineral availability of jackfruit flour and mushroom flour pasta during storage

Through a process known as the Milliard reaction, the amino acids found in the products chemically bond with simple sugars to create brown colours. Protein's nutritional value and bioavailability were reduced by these complex products (Hursh *et al.*, 1993). The *in vitro* digestibility of starch of jackfruit mushroom pasta was found to be 57.76 per cent which decreased to 56.00 per cent during third month of storage. The *in vitro* digestibility of protein in T_1 was 61.10 per cent it decreased to 59.00 per cent during third month of storage.

The percentage of a nutrient that is consumed and then utilised for regular physiological processes is known as the bioavailability of a mineral or trace element (Susan and Hurrell, 1996). The solubility and mobility of a mineral, as well as the presence of water, determine its availability (free water). *In vitro* availability of the calcium content was 41.50 per cent with a slight decrease to 40.85% at end of the storage period. The *in vitro* availability of iron content at the end of the storage was only 28.95 per cent and at the first month it was 29.40 per cent. A high *in vitro* availability in phosphorus content was noted with 83.48 per cent at initial level and 82.05% at end of the storage period. *In vitro* availability of magnesium content in selected pasta was 40.00 % and in 39.05 % at the end of the storage period. Heat-induced chemical reactions involving reducing sugars, amino acids, and/or proteins that result in the formation of molecules that bind minerals can cause mineral losses. These reaction products can retain their mineral binding capabilities because they are more resistant to digestion. Due to the hygroscopic nature of the product, significant amounts of some soluble minerals are dissolved in water, which causes mineral loss during manufacturing and storage (Dandago, 2009).

5.3.3.8. *In vitro* digestibility of starch and protein and *in vitro* mineral availability of breadfruit flour and mushroom flour pasta during storage

The *in vitro* digestibility of starch of breadfruit mushroom pasta was found to be 52.56 per cent. Breadfruit starch's *in vitro* digestibility was determined to be 93% (Akeem *et al.*, 2017). The Maillard reaction, in which a complex intermediate chemical is formed when a free amino group of protein and a carbonyl group of reducing sugar interact, may be the reason why digestibility of the pasta in the study was lower than that of breadfruit starch. Inhibiting the activities of proteolytic and amylolytic enzymes may have reduced the digestibility of starch due to the complex molecules (Marshall and Chrastil, 1992).

In breadfruit and mushroom flour pasta, the *in vitro* protein digestibility was 69.23%. According to James and Nwabueze (2013), the protein digestibility of breadfruit-based snacks ranged from 70.43 to 72.86 per cent.

For human nutrition, minerals are regarded as necessary and minerals from plant sources are less bioavailable than those from animal sources (Lopez *et al.*, 2002). *In vitro* availability of calcium in breadfruit based pasta was 40.50 per cent which decreased to 39.18 per cent at end of the storage period. The *in vitro* availability of iron content was only 39.00 per cent and 38.54 per cent, whereas the availability of phosphorus content in the selected treatment was 69.17 per cent and 68.25 per cent, initially and at end of the storage period. *In vitro* availability of magnesium content in selected pasta was 78.24 per cent initially and 77.98 per cent at the end of the storage period.

5.3.3.9. Insect infestation of the selected extruded food during storage

The insect infestation of the selected pasta were assessed at monthly intervals for a period of three months. No insect infestation was observed throughout the storage period. Packaged food products are susceptible to infestation along the entire marketing and supply chain channels, especially if the packaging is permeable to food odours. Use of proper packaging material can ensure that the product may not be infested during storage (Brodnjak and Trematerra, 2020). Hence, it can be assumed that the absence of insect infestation may be due to the use of adequate packaging material which is HDPE.

5.3.3.10. Microbial enumeration of the selected extruded food during storage

The microorganism present in food products were direct reflection of sanitary quality of the source of materials, processing and storage of sample (Ray and Bhunia, 2001). The moisture content is a significant indication of stability during storage. Lower the moisture content, in grains more is the stability of its products. The moisture content of natural and processed or manufactured foods determine the food's legal standard of identity, texture, palatability, consumer acceptability and shelf life (Rafed, 2017).

Sarah *et al.* (2017) stated that moisture content, relative humidity and temperature are the parameters that directly influence in the microbial growth. Shobha *et al.* (2011) reported that, the food with low moisture content and low water activity along with hygienic handling of the product can reduce the microbial contamination.

The microbial population of the pasta was assessed at monthly intervals for a period of three months. The initial bacterial count was found to be 1.00 $x10^3$cfu g^{-1}, which increased gradually to 2.33 $x10^3$ cfu g^{-1} during the end of third month. The first and second month had 1.4 $x10^3$cfu g^{-1} and 2.00 $x10^3$cfu g^{-1} respectively. The fungal growth was not detected in initial, first month and second month of storage. During the end of third month a fungal growth of 1 $x10^3$cfu g^{-1} was detected. Yeast growth was not detected throughout the storage period.

The microbial population of the fruit flour and mushroom pasta was assessed at monthly intervals for a period of three months. The bacterial count in the jackfruit and mushroom based pasta was enumerated. The initial bacterial count was found to be 1.00 $x10^3$cfu g^{-1}, which increased gradually to 2.53 $x10^3$cfu g^{-1} during the end of third month. The first and second month had 1.23 $x10^3$cfu g^{-1} and 2.18 $x10^3$cfu g^{-1} respectively. The fungal growth was not detected in initial, first month and second month of storage in the jackfruit and mushroom based pasta. During third month a fungal growth of 1 $x10^3$cfu g^{-1} was detected in the pasta

In case of breadfruit and mushroom based pasta, the initial bacterial count was found to be 1.00 x10^3cfu g^{-1}, which increased gradually to 2.15 x10^3cfu g^{-1} during the end of third month. The first and second month had 1.20 x10^3cfu g^{-1} and 1.40 x10^3 cfu g^{-1} respectively. A fungal growth of 1.20 x10^3cfu g^{-1} was detected at the end of the storage period of three months, in pasta prepared with breadfruit flour.

Yeast growth was not detected throughout the storage period in the pasta prepared using fruit flours.

According to Shobha *et al*. (2011) food with low moisture content and low water activity along with hygienic handling of the product reduce the growth of microorganisms. Babajide *et al*. (2010) reported that bacterial and fungal growth decreased on packing in high density polyethylene (HDPE) compared to polyethylene bags. These facts can be attributed to the increased shelf life stability of the pastas prepared in the present study.

Geetha *et al*. (2013) studied the microbial load in the noodles made of cassava during storage. The initial fungal and yeast count for noodles was analysed by using 10^{-4} dilution. The counts ranged between 00 and 03 according to treatment irrespective of the packaging materials. Presence of yeast population was noted in all the stored noodle samples. The maximum and minimum count of fungi was found to be 4 x 10^{-4} and 1 x 10^{-4} cells /g which were within the tolerable limits.

The bacterial count (initial) varied from 0.24 x 10^6 cfu/g to 0.34 x 10^6 cfu/g and was found to be lower than the control vermicelli of 0.66 x 10^6 cfu/g. The bacterial count increased during fourth month of storage (1.74 x 10^6 cfu/g to 1.89 x 10^6 cfu/g). Initially, the fungal count was not detected but during second and fourth month it was observed in the range of 0.30 x 10^3 cfu/g to 0.45 x 10^3 cfu/g and 0.49 x 10^3 cfu/g to 0.67 x 10^3 cfu/g respectively which is less than control vermicelli (0.44 x 10^3 cfu/g to 0.74 x 10^3 cfu/g) (Ajisha, 2018). Shobha and Asha (2015) conducted a study on the microbial load of maize based vermicelli and reported that bacterial load varied from 2.33 to 2.86 x 10^4 cfu/g whereas yeast and mould was found to absent in maize vermicelli. Thomas *et al*. (2014) carried out a study on the microbial load of rice based vermicelli. They reported that bacterial load varied from 3.54 x 10^6 cfu/g to

6.83 x 10^6 cfu/g and yeast count ranged from 0.98 x 10^3 cfu/g to 1.12 x 10^3 cfu/g. Baskaran *et al*. (2011) prepared noodles and stored in polythene pouches for 2 months. The standard plate count of noodles enriched with skimmed milk powder at 5% level increased from 138.83 to 287.5 cfu/g during storage. The yeast and mould count of noodles was 11.83 cfu/g initially and increased to 59.66 cfu/g.

5.4. Cost of production

The cost of production of the selected pasta was calculated based on cost of raw ingredients, fuel charges and electricity charges. The cost of 100g of pasta prepared with cassava flour and mushroom flour was Rs 98.50, whereas it was Rs 50.50, Rs 52.00 for jackfruit flour + mushroom flour, breadfruit flour + mushroom flour pastas, respectively. The cost of jackfruit based vermicelli and instant *payasam* mix varied from 132.70 to 154.12 Rs/Kg and 286.70 to 308.12 Rs/Kg (Ajisha, 2018). Kumari (2015) reported the cost of raw jackfruit flour based noodles was 108 Rs/Kg.

SUMMARY

SUMMARY

Convenience foods have become an integral part of our food habits. These nutrient-dense foods are becoming more and more common in modern society. They aid consumers in minimising the time, physical effort, and mental effort needed for meal preparation, eating, and cleanup. Therefore, it is necessary to design healthy foods in order to meet consumer demand for food products that are healthier.

Composite flour is a good new approach which is done by blending various sources of tubers, legumes, cereals and fruit flour in different percentages to produce variety of food products. Use of composite flours in pasta can improve its sensory quality, rheology characteristics, and nutritional values as well as its overall acceptance.

The addition of tuber flours and fruit flours to mushroom flour can be effectively utilized for developing products which can improve the overall diet quality. Considering the large yields, highly perishable nature and immense potential for product development, the present study entitled 'Process optimization of mushroom incorporated pastas" was proposed with the objectives to standardise mushroom incorporated nutri-rich pastas and to evaluate its nutritional, organoleptic and shelf life qualities.

Oyster mushroom (*Pleurotus florida*) was procured from the department of Plant Pathology, College of Agriculture, Vellanikkara. Cassava, elephant foot yam, jackfruit and breadfruit was procured from homesteads. These were dried, powdered and sieved to get a uniform flour as per the standard procedures. Pastas were prepared using various proportions of tuber/ fruit flours and mushroom flour. Pastas were subjected to organoleptic evaluation and the best treatment from each sets were selected. The selected treatments from each set were subjected to various analysis for estimating the nutritional qualities such as moisture, energy, total carbohydrate, protein, total fat, total fibre, starch, calcium, iron, sodium, magnesium and potassium; and health studies such as *in vitro* starch and protein digestibility, *in vitro* availability of Fe, Ca, P and Mg. The selected treatments were packed in HDPE covers and kept

for a period of three months. The aspects such as sensory qualities, enumeration of total micro flora and insect infestation were studied in the selected samples during storage at monthly intervals. The nutritional and health qualities were studied initially and at the end of storage period.

Composite flours were prepared in varying proportion. Pastas were prepared by using these composite flours. In the first set, pasta were prepared by varying the proportions of cassava flour and oyster mushroom flour. The control (T_0) was 100% cassava flour and the treatments was repeated by varying the proportions of cassava and mushroom flour. Organoleptic evaluation of the treatments were carried out to find the best treatment. The scored revealed that control pasta secured better scores in terms of appearance (7.80) and colour (7.66), while T_3 scored higher values for flavour (7.55), texture (7.28) and taste (7.21). While comparing with control, T_3 had better sensory qualities than other treatments. Treatment T_3 (70% CF + 30% OMF) attained highest mean total score of 7.29 for organoleptic attributes compared to other treatments. Based on the total scores; the control (T_0) and from the blended pastas the treatment (T_3) were selected for further studies.

In the second set, pasta was prepared in different combinations using elephant foot yam flour and mushroom flour and the organoleptic evaluation was carried out. In case of elephant foot yam incorporated mushroom pastas, the mean scores for the organoleptic qualities obtained was much lower than the acceptable levels. It was concluded that the pasta had very little acceptability and so the entire treatment was omitted from the further studies.

Third and fourth set of pasta preparation was done by using the composite flours made of fruit flours and mushroom flour. Pastas were prepared by incorporating jackfruit and mushroom in varying proportions. The treatments T_1 to T_4 varied from 90 per cent jackfruit flour to 60 per cent jackfruit flour and 10 to 40 per cent mushroom flour. When compared to the control, all the sensory qualities were quoted high for the T_1. The treatment (T_1) scored high in appearance (8.15), colour (7.71), flavor (7.28), texture (7.14), taste (7.02) and overall acceptability (7.35). The treatment, T_1 (90% JF + 10% OMF) attained higher mean total score of 7.04 for organoleptic attributes compared to other treatments and so was selected as best treatment in third set for further studies.

In the fourth set, pastas were prepared by incorporating breadfruit flour and mushroom flour in varying proportions from 100% breadfruit flour to 60% breadfruit flour and 10% mushroom flour to 40% mushroom flour. All the sensory qualities were scored high for T_1 (90% JF + 10% OMF) while for appearance, control scored high. Among the different treatments tried for the breadfruit and mushroom flour pastas the highest mean score of overall acceptability was noticed in T_1 with the mean rank score of 7.46. The lowest mean score of 7.06 was noticed in T_4 (60% BF + 40% OMF). Treatment T_0 attained higher total score of 44.39 for organoleptic attributes, whereas in blended pasta the treatment T_1 attained the mean highest score of 7.25 compared to other treatments. The lowest total score was observed in T_4.

The selected pastas along with control (T_0) from each set were utilised for the further studies. The pastas were subjected to various analysis which includes the nutritional qualities, health studies and shelf life studies.

The moisture content of pasta made with 100% cassava flour was 7.92 per cent and that with 70% cassava flour and 30% mushroom flour was 6.85 per cent. The energy content of pasta made with 100% cassava (T_0) was 386.78 k Cal and that with 70% cassava with 30% mushroom flour (T_3) was 391.52 k Cal. Carbohydrate content in control was 88.1g/100g of sample whereas in T_3 it was 80.6g/100g. Protein content in control was 7.92g/100g and in T_3 it increased to 9.36g/100g. Fat content of pasta made with 100% cassava (T_0) was 0.30 g/100g and that with 70% cassava and 30% mushroom flour (T_3) was 0.20g/100g. Fibre content in control was 1.89g/100g of sample whereas it increased to 2.86g/100g. Starch content in control pasta was 79.03g/100g of sample and in T_3 it was 67 g/100g. Reducing sugar content of pasta made with 100% cassava (T_0) was 0.84% and that with 70% cassava and 30% mushroom (T_3) was 0.94%.

The mineral contents in cassava based pasta (T_0) and the selected treatment (T_3) was estimated. The calcium content in control was 50.80 mg/100g and in T_3 was 54.90 mg/100g. Iron content increased from 2.91 to 3.60 mg/100g. The sodium content in T_0 was 9.88 mg/100g and in selected pasta (T_3) it was 12.48 mg/100g. Magnesium content in T_0 was 38.20 mg/100g and in T_3 it increased to 40.80 mg/100g in cassava and mushroom flour incorporated pasta. Potassium content in T_3 was 292.01 mg/100g and in T_0 it was 255.00mg/100g.

The nutrients such as energy, carbohydrate, protein, fat, fibre, starch, reducing sugar and mineral content of pastas prepared with jackfruit flour and mushroom flour incorporated pastas was estimated. The moisture content of pasta made with 100% jackfruit (control T_0) was 6.29 and that with 90% jackfruit and 10% mushroom (best treatment T_1) was 6.67%. The energy content of pasta made with 100% jackfruit (control T_0) was 324.79 k Cal and that with 90% jackfruit flour and 10% mushroom flour (T_1) was 334.99 k Cal. Pasta made with 100% jackfruit flour had a total carbohydrate content of 85.07 g/100g while the treatment T_1 had a total carbohydrate content of 78.63 g/100g of sample. The protein content of pasta made with 100% jackfruit (control T_0) was 6.29 g/100g of sample and that with 90% jackfruit flour and 10% mushroom flour (best treatment T_1) was 9.48 g/100g of sample. Total fat content of the pasta were also estimated and was found that T_1 had a slightly higher fat content (0.39 g/100g of sample) than the control pasta (0.35 g/100g of sample). The fibre content of pasta made with 100% jackfruit (T_0) was 3.52 g/100g of sample and that with 90% jackfruit flour and 10% mushroom flour (T_1) was 3.60 g/100g of sample. The starch content of pasta made with 100% jackfruit flour (T_0) was 74.12 g/100g of sample and that with 90% jackfruit flour and 10% mushroom flour (T_1) was 73.39 g/100g of sample. The reducing sugar content of T_0 was 1.10 per cent and $T_1$was 0.37 per cent.

Minerals in the jackfruit and mushroom incorporated pasta were analysed. Calcium content in T_0 and T_1 was 32.24 and 26.10 mg/100g, respectively. Iron content in T_0 was 1.03mg/100g and in T_1 it increased to 1.64mg/100g. The sodium content in T_0 and T_1 was 7.25 and 6.85mg/100g, respectively. Magnesium content in T_1 was 56.02mg/100g and for T_0it was found to be 48.08mg/100g. The potassium content in T_0 was 283.00mg/100g and it increased in treatment T_1 to 324.70mg/100g. On statistically analysing the data, it was found that there were significant difference between calcium, iron, sodium, magnesium and potassium among between the treatments.

The nutrient content of pastas prepared with jackfruit flour and mushroom flour incorporated pastas was estimated. The moisture content of pasta made with 100% breadfruit (T_0) was 7.16% and that with 90% breadfruit flour and 10% mushroom flour (T_1) was 6.03%. The energy content of pasta made with 100% breadfruit (T_0) was 343.52 k Cal and that with 90% breadfruit flour and 10% mushroom flour (T_1) was 320.69 k Cal. Pasta made with 100% breadfruit flour was 80.37g/100g while that with 90% breadfruit and 10% mushroom flour decreased to 73.49g/100g of sample. The protein content of pasta T_0 was 4.30g/100g and for T_1 it was 5.40g/100g of sample. Total fat content of the pasta were also estimated and was found that T_1 had a slightly higher fat content (0.57g/100g of sample) than the control pasta (0.56g/100g of sample), but was non significant on statistical interpretation. The fibre content of pasta made with 100% breadfruit flour (T_0) was 7.69g/100g and that with 90% breadfruit flour and 10% mushroom flour (T_1) was 7.52g/100g. The starch content of T_0 and T_1 was 75.02g and 69.64g/100g, respectively. The reducing sugar content of pasta made with 100% breadfruit flour (control - T_0) was 1.10 per cent and that with 90% breadfruit flour and 10% mushroom flour (best treatment - T_1) was 2.12 per cent.

The pastas were analysed for mineral content. In breadfruit flour based pasta, the calcium content of control (T_0) was 48.00 mg/100g and T_1 was 37.80mg/100g. Iron content in the treatment, T_0 and $T_1$was 0.06mg/100g and 0.10mg/100g, respectively and was found to have no significant difference between the pastas. Sodium content in breadfruit flour based pasta (T_0) was 9.80 mg/100g and in T_1 it was 12.03 mg/100g. Magnesium content in T_0 was 18.68mg/100g and T_1 had a content of 19.72 mg/100g. The potassium content in T_0 was 426.03mg/100g and in T_1 it was 511.00 mg/100g. On statistically analysing the data, it was found that there were significant difference between calcium, sodium, magnesium and potassium content among the treatments.

The *in vitro* digestibility of the starch and protein and *in vitro* availability of minerals of pastas are detailed in health studies.

In vitro digestibility of protein content in cassava based pasta (T_0) is 67.52% and in treatment T_3 it increased to 83.10%. The *in vitro* digestibility of starch content in pasta prepared with 100% cassava flour was 64.03% and on incorporating of mushroom flour it decreased to 61.13%. On statistical interpretation, there were significant difference between the *in vitro* digestibility of the starch and protein content of the pastas.

In vitro availability of the minerals of pastas prepared with cassava flour and mushroom flour incorporated pastas were estimated. No significant difference was observed in the *in vitro* availability of iron content, but the per cent availability was found to be 37.09 and 37.80 % for T_0 and T_3, respectively. A significant difference was observed in the calcium, phosphorous and magnesium contents. The *in vitro* availability of calcium for T_0 and T_3 was found to be 40.80 and 41.10%, respectively. The treatment with cassava flour alone had an *in vitro* availability for phosphorus as 64.05 % and for blended pasta it was 63.17 %. The *in vitro* availability of magnesium for T_0 and T_3 was found to be 67.02 and 68.12 %, respectively.

In jackfruit flour based pasta, *in vitro* digestibility of protein content T_0 was 50.39% and for T_1 it was 57.76%. The *in vitro* digestibility of starch content in T_0 and T_1 were 71.00 and 61.10% respectively.

In vitro availability of minerals of pastas prepared with jackfruit flour and mushroom flour were also estimated. *In vitro* availability of iron content in T_0 and T_1 was 28.80 and 29.40%, respectively. The *in vitro* calcium availability of jackfruit based pasta (T_0) was 40.60 per cent and $T_1$was 41.50 per cent. The highest *in vitro* mineral availability was seen in phosphorous with 84.90% and 83.48% in T_0 and T_1, respectively. On statistically analysing the data, there were significant difference between iron, calcium and phosphorous contents among the treatments. No significant difference was observed in the mineral availability of magnesium with an *in vitro* availability of 39.80% for T_0 and 40% for T_1.

In vitro digestibility of protein content in breadfruit based pasta (T_0) is 62.98% and it increased in T_1 to 69.23% with a statistical significant difference. The *in vitro* digestibility of starch content in (T_0) was found as 58.32% and for T_1 as 52.56%. On statistically analysing the data, there were significant difference in the *in vitro* digestibility of starch content of these pastas.

The *in vitro* availability of minerals of pastas prepared with breadfruit flour and mushroom flour were estimated. *In vitro* availability of iron content in T_0 and T_1 was 38.50 and 39.00 per cent, respectively. The *in vitro* calcium availability of breadfruit based pasta (T_0) was 40.00 per cent and T_1 was 40.50 per cent. The *in vitro* availability for phosphorous was 68.60% and 69.00 per cent in T_0 and T_1, respectively. On statistically analysing the data, there were significant difference between calcium, phosphorous and magnesium contents among the treatments.

Pasta made with tuber flour/ fruit flours were packed in HDPE covers and were kept for three months storage in room temperature. The pastas were organoleptically evaluated and based on organoleptic scores the pasta selected in the first set using cassava and mushroom flour, T_3 (70% CF + 30% OMF) were acceptable upto three months of storage with gradual decline in all sensory attributes. A gradual decrease was also observed for organoleptic scores of flavour, texture, taste and overall acceptability.

The mean organoleptic scores of pastas prepared with fruit flours (90% JF +10% OMF and 90 % BF + 10 % OMF) and mushroom flours were calculated and was found that in both the pasta the scores decreased gradually through the storage period.

Even though, all the selected pastas were acceptable, jackfruit flour and mushroom added pasta were observed to have better score compared to breadfruit flour and mushroom flour pasta.

The nutrients such as energy, carbohydrate, protein, fat, fibre, starch, reducing sugar and mineral content of pastas prepared with cassava flour and mushroom flour was estimated during storage. The moisture content of pasta made with 70% cassava flour and 30% mushroom flour (T_3) was 6.85% and at the end of the storage the moisture content increased to 8.60%. The energy content of selected pasta was 391.52 k Cal initially and at the end of the storage the energy content decreased to 344.62 k Cal. The total carbohydrate content of pasta made with 70 % cassava and 30% mushroom flour (T_3) was 80.6g/100g and at the end of the storage period it decreased 78.03g/100g. Pasta prepared with 70% cassava flour and 30% mushroom flour had an initial protein content of 9.36 g/100g which decreased during storage to 7.72g/100g. Fat content of pasta prepared with 70% cassava flour and 30% mushroom flour was 0.20g/100g and at the end of the storage period it was 0.18g/100g. The fibre content of pasta decreased from 2.86g/100g to 1.07g/100g. The starch content of pasta made with70 % cassava flour and 30% mushroom flour was 67.00 g/100g and at the end of the storage the starch content was 66.18g/100g. Reducing sugar content of fresh pasta was 0.94% and at the end of the storage the reducing sugar content was 0.98%.

The calcium content of the pasta made with 70% cassava flour and 30% mushroom flour was 54.90 mg/100g and at the end of the storage it was 54.00 mg/100g. The iron content of the pasta was 3.60 mg /100g which decreased to 2.18 mg/100g at the end of storage. A slight decrease with statistically significant difference was seen in the sodium, magnesium and potassium content after the storage period of three months.

The nutrients such as energy, carbohydrate, protein, fat, fibre, starch , reducing sugar and mineral content of pastas prepared with jackfruit flour and mushroom flour incorporated pastas was estimated during storage. The moisture content of pasta made with 90% jackfruit flour and 10% mushroom flour was 6.67% and at the end of the storage it was 8.10%. The energy content of pasta made with 90% jackfruit flour and 10% mushroom flour was 355.95 k Cal, initially and at the end of the storage it decreased with a statistically significant difference to 345.60 k Cal. The total carbohydrate content of pasta made with 90% jackfruit flour and 10% mushroom flour was 78.63 and at the end of the storage it was 77.42 g/100g. The protein content decreased from 9.48 to 8.35% at the end of third month of storage. The total fat content of pasta made with 90% jackfruit flour and 10% mushroom flour was 0.39g/100g at initial and at the end of the storage it was 0.28g/100g. The fibre content of pasta decreased from 3.60g/100g to 2.55g/100g during storage. The starch content of pasta made with 90% jackfruit flour and 30% mushroom flour was 73.39g/100g which decreased to 72.09g/100g at the end of the third month of storage. The reducing sugar content of pasta made with 90% jackfruit flour and 30% mushroom flour was 0.37, which increased to 0.49% at the end of the storage.

The calcium content of pasta made with 90% jackfruit flour and 10% mushroom flour was 26.10mg/100g and at the end of the storage it was 25.20mg/100g. The iron content of the pasta was 1.64 mg/100g which decreased to 1.50mg/100g at the end of the storage. A slight decrease with statistically significant difference was seen in the sodium, magnesium and potassium content after the storage period of three months.

The nutrients such as energy, carbohydrate, protein, fat, fibre, starch, reducing sugar and mineral content of pastas prepared with breadfruit flour and mushroom flour incorporated pastas was estimated during storage. The moisture content of pasta made with 90% breadfruit flour and 10% mushroom flour increased from 6.03 % to 7.80 % at the end of the storage. The energy content of pasta made with 90% breadfruit flour and 10% mushroom flour was 320.69 k Cal initially and at the end of the storage it decreased with a statistically significant difference to 309.21 k Cal. The total carbohydrate content of pasta made with 90% jackfruit flour and 10% mushroom flour was 73.49g/100g initially and at the end of the storage it was 71.90g/100g. The protein content of pasta decreased from 5.40g/100g initially and at the end of the storage it was decreased to 4.30 g/100g. The total fat content of pasta made with 90% breadfruit flour and 30% mushroom flour was 0.57g/100g initially and at the end of the storage it decreased without any statistically significant difference to 0.49g/100g. The fibre content of selected pasta was 7.52 g/100g at initially and at the end of the storage it was decreased to 6.18 g/100g. The starch content of pasta made with 90% breadfruit flour and 10% mushroom flour was 69.64 g/100g which decreased to 67.55 g/100g at the end of the third month of storage. The reducing sugar content of selected pasta was 2.12 % which increased to 3.01% at the end of the storage.

The calcium content of pasta made with 90% breadfruit flour and 10% mushroom flour was 37.80mg/100g and at the end of the storage it was 36.55mg/100g. The iron content of the pasta was 0.10 mg/100g which decreased to 0.09 mg/100g at the end of the storage. A slight decrease with statistically significant difference was seen in the sodium, magnesium and potassium content after the storage period of three months.

Initially, *in vitro* digestibility of protein content in cassava based pasta was 83.10 and at the end of storage it was 82.58%. On statistically analysing the data, it was found that there is significant difference between the *in vitro* digestibility of protein content of both these pasta. Initial *in vitro* digestibility of starch content in cassava based pasta was 61.13% and it decreased to 60.00% on storage.

In vitro availability of calcium content was 41.10 per cent at first month and 39.05 at end of the storage period. The iron content availability through *in vitro* at the end of the storage is 37.01% and at the first month it was 37.80%. The *in vitro* availability of phosphorous content in the selected treatment was 63.17 per cent, initially and it reduced to 61.12 per cent at end of the storage period. A slight decrease in the *in vitro* availability of magnesium content in selected pasta was observed at the end of the storage period.

In shelf life study the *in vitro* digestibility of protein content in jackfruit based pasta was 57.76 % an it decreased to 56.00 % at end of the storage. The *in vitro* digestibility of starch in jackfruit based pasta was 61.10% and after storage it decreased to 59.00%.

In vitro availability of the calcium content was 41.50 per cent with a slight decrease to 40.85% at end of the storage period. The *in vitro* availability of iron content at the end of the storage was only 28.95 per cent and at the first month it was 29.40 per cent. A high *in vitro* availability in phosphorus content was noted with 83.48 per cent at initial level and 82.05% at end of the storage period. *In vitro* availability of magnesium content in selected pasta was 40.00 % and in 39.05 % at the end of the storage period.

In shelf life study the *in vitro* digestibility of protein content in breadfruit based pasta was 69.23 and in at the end of the storage period the protein digestibility decreased to 67.80%. The *in vitro* digestibility of starch content in breadfruit based pasta was 52.56 and in the end of the storage it was 51.95 per cent.

In vitro availability of calcium in breadfruit based pasta was 40.50 per cent which decreased to 39.18 per cent at end of the storage period. The *in vitro* availability of iron content was only 39.00 per cent and 38.54 per cent, whereas the availability of phosphorus content in the selected treatment was 69.17 per cent and 68.25 per cent, initially and at end of the storage period. *In vitro* availability of magnesium content in selected pasta was 78.24 per cent initially and 77.98 per cent at the end of the storage period.

The insect infestation of the selected pasta were assessed at monthly intervals for a period of three month and was found that no insect infestation observed throughout the storage period in any of the selected treatments.

The microbial populations of the selected pastas were assessed at monthly intervals for a period of three months. In the case of cassava and mushroom flour incorporated pasta, the initial bacterial count was found to be 1.00 $x10^5$cfu g^{-1}, which increased gradually to 2.33 $x10^3$ cfu g^{-1} during the end of third month. The first and second month had 1.4 $x10^5$cfu g^{-1} and 2.00 $x10^5$cfu g^{-1} respectively. The fungal growth was not detected in initial, first month and second month of storage. During the end of third month a fungal growth of 1 $x10^3$cfu g^{-1} was detected. Yeast growth was not detected throughout the storage period.

The bacterial count in the jackfruit and mushroom based pasta was enumerated. The initial bacterial count was found to be 1.00 $x10^5$cfu g^{-1}, which increased gradually to 2.53 $x10^5$cfu g^{-1} during the end of third month. The first and second month had 1.23 $x10^5$cfu g^{-1} and 2.18 $x10^5$cfu g^{-1} respectively.

In case of breadfruit and mushroom based pasta, the initial bacterial count was found to be 1.00 $x10^5$cfu g^{-1}, which increased gradually to 2.15 $x10^5$cfu g^{-1} during the end of third month. The first and second month had 1.20 $x10^5$cfu g^{-1} and 1.40 $x10^5$ cfu g^{-1} respectively. The fungal growth was not detected in initial, first month and second month of storage in the jackfruit and mushroom based pasta. During third month a fungal growth of 1 $x10^3$cfu g^{-1} was detected in the pasta. A fungal growth of 1.20 $x10^3$cfu g^{-1} was detected at the end of the storage period of three months, in pasta prepared with breadfruit flour. Yeast growth was not detected throughout the storage period in the pasta prepared using fruit flours.

The cost of production of the selected pasta was calculated based on cost of raw ingredients, fuel charges and electricity charges.The cost of 100g pasta prepared with cassava flour and mushroom flour was Rs 98.50, whereas it was Rs 50.50, Rs 52.00 for jackfruit flour and mushroom flour, breadfruit flour and mushroom flour pastas, respectively.

The current research found that healthy pastas can be prepared from cassava flour, breadfruit flour and jackfruit flour. Incorporation of mushroom flour to pastas enrich the nutritional qualities of the products. These products are a better alternative and could be more healthier than commercially available pastas.

Future line of work

- Development of pasta flour underexploited fruit flours, vegetable flours and millet flours.
- Enrichment of pasta flour suitable nutrient rich plant and animal sources.
- Consumers acceptability of ready to cook extruded foods.

REFERENCES

REFERENCES

A.O.A.C. 1980. *Official and Tentative Methods of Analysis* (13th Ed.). Association of Official Analytical Chemists., Washington. D. C, 1018p.

Adebowale, O. J., Salaam, H. A., Komolafe, O. M., Adebiyi, T. A., and Ilesanmi, I. O. 2017. Quality characteristics of noodles produced from wheat flour and modified starch of African breadfruit (*Artocarpus altilis*) blends. *J. Culinary Sci. Technol.* 15(1): 75-88.

Agarwal, G. P. and Hasija, S. K. 1986. *Microorganisms in the Laboratory* Print House India Ltd, Lucknow, 155p.

Aishah, M. S. and Wan Rosli, W. I. 2013. Effect of Different Drying Techniques on the Nutritional Values of Oyster Mushroom (*Pleurotus sajor-caju*). *Malaysian Sci.* 42(7): 937–941.

Ajani, A. O., Oshundahunsi, O. F., Akinoso, R., Arowora, K. A., Abiodun, A. A., and Pessu, P. O. 2012. Proximate composition and sensory qualities of snacks produced from breadfruit flour. *Glob. J. Sci. Front. Res. Biol. Sci.* 12 (7):1-9.

Aji, N. R., Wibowo, E. A. P., and Mayasiri, T. 2016. Meat analoge based necklace crickets and fruit (jackfruit and pumpkin) as an alternative source of animal protein ingredients food in Gunung Kidul. *J. Sci. Innov. Res.* 5(5): 179-181.

Ajisha, K. H. 2018. Process optimization and quality evaluation of jackfruit (*Koozha* type) based vermicelli. M. Sc (Home Science) thesis, Kerala Agricultural University, Vellanikkara, Kerala, 126p

Akanbi, T. O., Nazamid, S., Adebowale, A. A., Farooq, A., and Olaoye, A. O. 2011. Breadfruit starch-wheat flour noodles: preparation, proximate compositions and culinary properties. *Int. Food Res. J.* 18(4): 1283.

Akeem, T. A., Emmanuel, O. K., Henry, B. A., and Tawakalitu, T. R. 2017. Quality evaluation of instant noodles produced from composite breadfruit flour. *Researcher* 9(1): 21-26.

Akhmad, A. Z., Cinantya, D., and Adeline. 2013. Development of Wet Noodles Based on Cassava Flour. *J. Engineer. Technol. Sci.* 45(1): 97-111.

Alvarez-Jubete, L., Arendt, E. K., and Gallagher, E. 2010. Nutritive value of pseudocereals and their increasing use as functional gluten-free ingredients. *Trends Food Sci. Technol.* 21(2): 106-113.

Amadi, J. A., Ihemeje, A., and Afam-Anene, O. C. 2018. Nutrient and phytochemical composition of jackfruit (*Artocarpus heterophyllus*) pulp, seeds and leaves. *Int. J. Innovative Food Nutr. Sustainable Agric.* 6(3): 27-32.

Amandikwa, C., Iwe, M. O., Uzomah, A., and Olawuni, A. I. 2015. Physico-chemical properties of wheat-yam flour composite bread. *Nigerian Food J.* 33(1): 12-17.

Anila, H. L. and Divakar, S. 2018. Development of textured vegetable protein (TVP) based on raw jackfruit. *Food Sci. Res. J.* 9(2): 289-293.

Arya, S. S. 1992. Convenience foods-emerging scenario. *Ind. Food Ind.*11: 31-31.

Babajide, J. M., Oyebanjo, A. A. and Oyewole, O. B. 2010. Effect of storage on microbial and sensory qualities of packaged yam-cassava "*poundo*" flour. *J. Nat. Sci. Eng. Technol.* 9(1): 69-78

Baliga, M. S., Shivashankara, A. R., Haniadka, R., Dsouza, J., and Bhat, H. P. 2011. Phytochemistry, nutritional and pharmacological properties of Artocarpus heterophyllus Lam (jackfruit): A review. *Food Res. Int.* 44(7): 1800-1811.

Barcelon, E. G., Chua, J. N., Encinas, J. B., Montemayor, J. E., Nagalinngam, M. G., Ocampo, A. E., and Ong, R. M. G. 2014. Online Consumer Preference and Sensory Acceptability of Vegetable-Added Pasta Noodles. *Food Public Health.* 4(6): 301-305.

Baruah, 2014. Processing and value addition of jackfruit (*Artocarpus heterophyllus* . Lam.). Ph.D (Ag) thesis, Assam Agricultural University, Jorhat, 155p.

Baskaran, D., Pandian, D. M., Gnanalaksshmi, K. S., and Ayyadurai, K. 2011. Chemical and sensory attributes of noodles supplemented with skim milk powder. *Tamilnadu J. Vet. Anim. Sci*. 7(5): 239-242.

Behera, S. S. and Ray, R. C. 2017. Nutritional and potential health benefits of konjac glucomannan, a promising polysaccharide of elephant foot yam, *Amorphophallus konjac* K. Koch: A review. *Food Rev. Int.* 33(1): 22-43.

Bjorck, I., Liljeberg, H., and Ostman, E. 2000. Low glycaemic-index foods. *Br. J. Nutr*. 83(S1): S149-S155.

Brodnjak, U. V., Jordan, J., and Trematerra, P. 2020. Resistance of packaging against infestation by *Sitophilus zeamais*. *Int. J. Food Sci. Technol.* 55(8): 2970-2980.

Buckley, M., Cowan, C., and McCarthy, M. 2007. The convenience food market in Great Britain: Convenience food lifestyle (CFL) segments. *Appetite*49(3): 600-617.

Burkill, H. M. 1997. The Useful Plants of West Tropical Africa. Royal Botanic Gardens, Kew 4(2): 160-161.

Chandra, S., Singh, S., and Kumari, D. 2015. Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. *J. Food Sci. Technol.* 52(6): 3681-3688.

Chandrasekara, A. 2019. Roots and tubers as functional foods. In *Bioactive Molecules in Food* (pp. 1441-1469). Springer, Cham.

Chandrasekara, A., and Josheph, K. T. 2016. Roots and tuber crops as functional foods: a review on phytochemical constituents and their potential health benefits. *Int. J. Food Sci.* 1-15.

Chisenga, S. M., Workneh, T. S., Bultosa, G., and Alimi, B. A. 2019. Progress in research and applications of cassava flour and starch: a review. *J. Food Sci. Technol.* 56(6): 2799-2813.

Contini, C., Boncinelli, F., Gerini, F., Scozzafava, G., and Casini, L. 2018. Investigating the role of personal and context-related factors in convenience foods consumption. *Appetite* 126: 26-35.

da Silva, E. M. M., Ascheri, J. L. R., and Ascheri, D. P. R. 2016. Quality assessment of gluten-free pasta prepared with a brown rice and corn meal blend via thermoplastic extrusion. *LWT-Food Sci. Technol.* 68: 698-706.

Dada, T. A., Barber, L. I., Ngoma, L., and Mwanza, M. 2018. Formulation, sensory evaluation, proximate composition and storage stability of cassava strips produced from the composite flour of cassava and cowpea. *Food Sci. Nutr.* 6(2): 395-399.

Daemo, B. B., Yohannes, B. D., Beyene, M. T., and Abtew, G.W. 2022. Biochemical Analysis of Cassava (Manihot esculenta Crantz) Accessions in Southwest of Ethiopia. *J. Food Quality* 2022:1-12.

Dandago, M. A. 2009. Changes in nutrients during storage and processing of foods - A review. *Technol. Sci. Africana. J.* 3 (1): 23-37

Das, S. C. and Prakash, J. 2011. Jackfruit for improving livelihood opportunities in hilly tribal areas of Tripura. *J. Hortic.* 890: 71-76.

De Boer, M., McCarthy, M., Cowan, C., and Ryan, I. 2004. The influence of lifestyle characteristics and beliefs about convenience food on the demand for convenience foods in the Irish market. *Food Quality Preference.* 15(2): 155-165.

De Noni, I.. and Pagani, M. A. 2010. Cooking properties and heat damage of dried pasta as influenced by raw material characteristics and processing conditions. *Critical Rev. Food Sci. Nutr.* 50(5): 465-472.

Divya, S. L. 2016. Development, packaging and storage of intermediate moisture jackfruit (*Artocarpus heterophyllus L.)*. MSc. (Processing Technology) thesis, Kerala Agricultural University, Thrissur, 132 p.

Duhan, A., Khetarpaul, N., and Bisnoi, S. 2001. HCl extractability of zinc and copper as affected by soaking, dehulling, cooking and germination of high yielding pigeon pea cultivars. *J. Food. Sci. Technol.* 17(5): 279-304.

Ekunseitan, O. F., Obadina, A. O., Sobukola, O. P., Omemu, A. M., Adegunwa, M. O., Kajihausa, O. E., Adebowale, A. A., Sanni, S. A., Sanni, L. O., and Keith, T. 2017. Nutritional composition, functional and pasting properties of wheat, mushroom, and high quality cassava composite flour. *J. Food Processing Preserv.* 41(5): 13150 – 13155.

Emery, A. 2013. Attitudes towards healthful, inexpensive and convenient foods in relation to multiple measures of diet quality among Seattle-King County adults Ph.D thesis.Western Australia, 210p.

Emmanuel, N. O., Olufunmi, A. O., and Elohor, E. P. 2015. Effect of fermentation time on the physico–chemical, nutritional and sensory quality of cassava chips (kpo-kpo garri) a traditional nigerian food. *Am. J. Biosci.* 3(2): 59-63.

Ferreira, S. M. R., de Mello, A. P., dos Anjos, M. D. C. R., Krüger, C. C. H., Azoubel, P. M., and de Oliveira Alves, M. A. 2016. Utilization of sorghum, rice, corn flours with potato starch for the preparation of gluten-free pasta. *Food Chem.* 191: 147-151.

Fiorda, F. A., Soares Junior, M. S. S., da Silva, F. A., Souto, L. R. F., and Grosmann, M. V. E. 2013. Amaranth flour, cassava starch and cassava bagasse in the production of gluten free pasta: technological and sensory aspects. *Int. J. Food Sci. Technol.* 48(9): 1977-1984.

Geetha, P. S. Thirumaran, S. A., and Maheswar, I. 2013. Probiotic enriched noodles and bread from fermented cassava flour. *Probiotics in Sustainable Food*

Production: Current Status and Future Prospects - Probiotic Food page no 136-142.

Gelencser, T., Gal, V., Hodsagi, M., and Salgo, A. 2008. Evaluation of quality and digestibility characteristics of resistant starch-enriched pasta. *Food Bioprocess Technol.* 1(2): 171-179.

George, R. J. 2005. Supermarket shopping: what is this thing called "customer service"?. *J. Food Prod. Market.* 11(2):1-20.

Gopalan, C., Sastri, B. V. R., and Balasubramanian, S. C. 1989. *Nutritive Value of Indian Foods.* Indian Council of Medical Research, Hyderabad, 114p.

Hafid, H., Agustina, D., Ananda, S. H., Anggraini, D. U., and Nurhidayati, F. 2019. Chicken nugget nutrition composition with an additional variation of breadfruit flour [abstract] *In: IOP Conference Series: Earth and Environmental Science;* 3-4 December, 2019, United Kingdom, p.012004. Abstract No. (382):1.

Harris, J. M. and Shiptsova, R. 2007. Consumer demand for convenience foods: Demographics and expenditures. *J. Food Distribution Res.* 38(856-2016-57845): 22-36.

Hettiaratchi, U. P. K., Ekanayake, S., and Welihinda, J. 2011. Nutritional assessment of jackfruit (*Artocarpus heterophyllus*) meal. *Ceylon Med. J.* 56(2):1-17.

Hurst, W. C. Reynolds, A. E., Schuler, G. A. and Christian, J. A. 1993. Maintaining food quantity in storage. *University Of Georgia Cooperative Extension Service Bulletin.* 914p.

IPO (International Pasta Organisation), 2021. Annual report. [Online]. Available: https://internationalpasta.org/annual-report [2 June 2022].

Ishera, L. R., Mahendran, T., and Roshana, M. R. 2021. Incorporating breadfruit flour to prepare high-quality cookies with health benefits. *Tropic. Agric. Res.* 32(1): 114-123.

Jackson, M. L. 1973. *Soil Chemical Analysis*, Prentice Hall of India Private Ltd, New Delhi, 299p.

Jalgaonkar, K. and Jha, S. K. 2016. Influence of particle size and blend composition on quality of wheat semolina-pearl millet pasta. *J. Cereal Sci.* 71: 239-245.

James, S. and Nwabueze, T. U. 2013. Effect of extrusion condition and defatted soybean inclusion on the physico-chemical, *in vitro* digestibility and sensory acceptability of African breadfruit (*Treculia africana*) blends. *Int. J. Sci. Technol. Res.* 2(9):207-211.

Jaworska, D., Krolak, M., and Jezewska-Zychowicz, M. 2020. Reformulation of bread rolls using oat fibre: An acceptable way of dietary fibre enrichment. *Nutr. Bull.* 45(2): 189-198.

Jellinek, G. 1985. *Sensory Evaluation of Food. Theory and Practice*. Ellis Horwood, Chichester, England, 596p.

Kaur, C. and Maini, S. B. 2001. Fruits and Vegetables : Health foods for new millennium. *Indian Hort.* 45(4): 29-32.

Kaur, M., Sandhu, K. S., Ahlawat, R., and Sharma, S. 2015. *In vitro* starch digestibility, pasting and textural properties of mung bean: effect of different processing methods. *J. Food Sci. Tsechnol.* 52(3): 1642-1648.

Kill, R. C. and Turnbull, C. 2002. *Pasta and Semolina Technology*, Blackwell Science, 25p.

Krishnan, M. and Prabhasankar, P. 2012. Health based pasta: redefining the concept of the next generation convenience food. *Crit. Rev. Food Sci. Nutr.* 52(1): 9-20.

Kumar, R. and Kumar, M. 2004. *Guide to Prevention of Lifestyle Diseases*, Deep and Deep Publications, New Delhi, 278p.

Kumar, S. and Saini, C. S. 2016. Study of various characteristics of composite flour prepared from the blend of wheat flour and gorgon nut flour. *Int. J. Agric. Environ. Biotechnol.* 9(4): 679-689.

Kumari, V. 2015. Development of an extruded food from raw jackfruit. M. Sc. (Home Science) thesis, Kerala Agricultural University, Thiruvananthapuram, Kerala, 191p.

Kumari, V., Divakar, S., Ukkuru, M., and Nandini, P. V. 2015. Development of raw jackfruit based noodles. *Food Sci. Res. J.* 6(2): 326-332.

Lakmali, H. D. S. and Arampath, P. C. 2021. Development of jackfruit (*Artocarpus heterophyllus*) bulb and seed flour-based pasta. *J. Dry Zone Agric.* 7(2): 7-19.

Lila, M. A. 2007. From beans to berries and beyond: Teamwork between plant chemicals for protection of optimal human health. *Ann. New York Acad. Sci.* 1114(1): 372-380.

Lopez, H.W., Leenhardt, F. Coundray, C. and Remeshy, C. 2002. Minerals and phytic acid interactions: is it a real problem for human nutrition? *Int. J. Food Sci. Technol.* 33(7): 727 – 739.

Marshall, W. E. and Chrastil, J. 1992. Interaction of food proteins with starch. In:Hudson, B. J. F. (ed.), *Biochemistry of Food Proteins*, Springer Applied Science, Switzerland, 75 – 97.

Marti, A., Seetharaman, K., and Pagani, M. A. 2010. Rice-based pasta: A comparison between conventional pasta-making and extrusion-cooking. *J. Cereal Sci.* 52(3): 404-409

McCleary, B. V. and Blakeney, A. B. 1999. Measurement of inulin and oligofructan. *Cereal Food World.* 44:394-406.

Mogra, R., and Midha, S. 2013. Value addition of traditional wheat flour vermicelli. *J. Food Sci. Technol.* 50(4): 815-820.

Mohan, G. 2019. Antioxidant and anticarcinogenic potential of jackfruit based ready to cook (RTC) curry mixes. M. Sc. (Home Science) thesis, Kerala Agricultural University, Thiruvananthapuram, 100p.

Montagnac, J. A., Davis, C. R. and Tanumihardjo, S. A. 2009. Nutritional value of cassava for use as a staple food and recent advances for improvement. *Compr Rev. Food - Sci. Food Saf.* 8: 181-188.

Moorthy, S. N. 2002. Physicochemical and functional properties of tropical tuber starches: a review. *Starch* 54: 559-592.

Munishamanna, K. B., Suresh, K. B., Chandru, R., Palanimuthu, V., and Ranganna, B. 2012. Development of value added products from jackfruit bulb. *Mysore J. Agric. Sci.* 46(2): 426-428.

Murugkar, D. A. and Jha, K. 2011. Influence of storage and packaging conditions on the quality evaluation of sensory attribute biscuits developed using single and multiple bend nutraceuticals. *Int. J. Pure Appl. Biosci.* 5(2):433-440.

Mustapha, N. F., Rahmat, F. F., Ibadullah, W. Z., and Hussin, A. 2015. Development of jackfruit crackers: effects of starch type and jackfruit level. *Int. J. Adv. Sci. Eng. Technol.* 5(5):330-336.

Nandkule, V. D., Masih, D., Sonkar, C., Devendrasing, D., and Patil, D. D. 2015. Development and quality evaluation of jackfruit seed and soy flour noodles. *Int. J. Sci.Eng. Technol.* 3(3):802-806.

Nanjundaswamy, A. M. 1990. Processing of untapped indigenous fruits. *In: Proceedings of National Seminar on Production, Processing, Marketing and Export of Untapped Indigenous Fruits and Vegetables*, 7 April, 1992, IARI, New Delhi, pp.84-87.

NHB (National Horticultural Board), 2014. Indian Horticultural Data Base. In: Kumar, B. (ed.) National Horticulture Board, Gurgaon, 269p.

Nochera, C. L. 2016. Preparation of a breadfruit flour bar. *Foods* 5: 1-7.

Nochera, C. L. and Ragone, D. 2016. Preparation of a breadfruit flour bar. *Foods* 5: 37- 42.

Noorfarahzilah, M., Lee, J. S., Sharifudin, M. S., Mohd Fadzelly, A. B., and Hasmadi, M. 2014.0 Applications of composite flour in development of food products. *Int. Food Res. J.* 21(6): 2061-2074.

Nousheen, I. 2013. Development of low glycemic functional pasta products. Ph.D Thesis Tamil Nadu Agricultural University, Coimbatore, India, 301p.

Nuani, F. O., Gido, E. O., and Ayuya, O. I. 2022. Consumer preference for selected roots and tubers among urban households. *Int. J. Vegetable Sci.* 28(6): 589-602.

Ojo, M. O., Ariahu, C. C., and Chinma, E. C. 2017. Proximate functional and pasting properties of cassava starch mushroom (*Pleurotus pulmonarius*) flour blends. *Am. J. Food Sci. Technol.* 5(1): 11-18.

Ojokoh, A. O., Fayemi, O. E., Ocloo, F. C. K., and Alakija, O. 2014. Proximate composition, antinutritional contents and physicochemical properties of breadfruit (*Treculia africana*) and cowpea (*Vigna unguiculata*) flour blends fermented with *Lactobacillus plantarum*. *Afr.J. Microbiol. Res.* 8(12): 1352-1359.

Osella, C., de La Torre, M., and Sanchez, H. 2014. Safe foods for celiac people. *Food Nutr. Sci.* 5(9): 787-800.

Padalino, L., Mastromatteo, M., Lecce, L., Spinelli, S., Contò, F., and Del Nobile, M. A. 2014. Chemical composition, sensory and cooking quality evaluation of durum wheat spaghetti enriched with pea flour. *Int. J. Food Sci. Technol.* 49(6): 1544-1556.

Perkin-Elmer. 1982. *Analytical Methods for Atomic Absorption Spectrophotometry*, Perkin- Elmer Corporation, USA, 114p.

Petitot, M., Abecassis, J., and Micard, V. 2009. Structuring of pasta components during processing: impact on starch and protein digestibility and allergenicity. *Trends Food Sci. Technol.* 20(11-12): 521-532.

Purwani, E. Y., Widaningrum, W., Thahir, R., and Muslich, M. 2006. Effect of heat moisture treatment of sago starch on its noodle quality. *Indonesian J. Agric. Sci.* 7(1):8-14.

Rachman, A., Brennan, M. A., Morton, J., Torrico, D., and Brennan, C. S. 2022. *In-vitro* digestibility, protein digestibility corrected amino acid, and sensory properties of banana-cassava gluten-free pasta with soy protein isolate and egg white protein addition. *Food Sci. Hum. Wellness* 12(2): 520-527.

Rafed, R. 2017. Evaluation of commercially available millets based processed foods. MSc (Food Science and Nutrition) thesis, University of Agricultural Sciences Bengaluru, India, 45p.

Ray, B. and Bhunia, A. K. 2001. *Fundamental Food Microbiology*, Boca Raton: CRC press. 109p.

Rehman, S. U., Paterson, A., and Piggott, J. R. 2007. Chapatti quality from British wheat cultivar flours. *LWT-Food Sci. Technol.* 40(5): 775-784.

Rekha, M. N., Chauhan, A. S., Prabhasankar, P., Ramteke, R. S., and Rao, G. V. 2013. Influence of vegetable purees on quality attributes of pastas made from bread wheat (*T. aestivum*). *CyTA-J. Food* 11(2): 142-149.

Rincón, A. M. and Padilla, F. C. 2004. Physicochemical properties of Venezuelan breadfruit (*Artocarpus altilis*) starch. *Latin Am. Nutr. Archives* 54(4):449-456.

Robert, U. W., Etuk, S. E., Umoren, G. P., and Agbasi, O. E. 2019. Assessment of thermal and mechanical properties of composite board produced from coconut (*Cocos nucifera*) husks, waste newspapers, and cassava starch. *Int. J. Thermophys.* 40(9): 8-12.

Robin, F., Dubois, C., Pineau, N., Schuchmann, H. P., and Palzer, S. 2011. Expansion mechanism of extruded foams supplemented with wheat bran. *J. Food Eng.* 107:80-89.

Rocha-Guzman, N. E., Gallegos-Infante, J. A., Delgado-Nieblas, C. I., de Jesus Zazueta-Morales, J., Gonzalez-Laredo, R. F., Cervantes-Cardoza, V., Martinez-Bustos, F., and Aguilar-Palazuelos, E. 2012. Effect of extrusion cooking on the antioxidant activity of extruded half product snacks made of yellow corn and pumpkin flours. *Int. J. Food Eng.* 8(4) . 5 - 9

Ryan, I., Cowan, C., McCarthy, M., and O'sullivan, C. 2004. Food-related lifestyle segments in Ireland with a convenience orientation. *J. Int. Food Agribus. Mark.* 14(4): 29-47.

Sadasivam, S. and Manickam, A. 1997. *Biochemical Methods* (2nd Ed.), New Age International Private Limited, New Delhi and Tamil Nadu Agricultural University, Coimbatore, 254p.

Sahoo, A. 2016. Value added baked products from raw jackfruit. MSc. (Home Science) thesis, Kerala Agricultural University, Thiruvananthapuram, 179p.

Saklani, A. and Kaushik, R. 2020. Development of elephant foot yam cake and its evaluation. *Food Technol.* 44(2):159-172.

Sanni, L. O., Bamgbose, C. A., Babajide, J. M., and Sanni, S. A. 2007. Production of instant cassava noodles. In *Proceedings of the 13th Triennial Symposium of the International Society for Tropical Root Crops (ISTRC): Opportunities for Poverty Alleviation and Sustainable Livelihoods in Developing Countries* Proceedings of the 13th ISTRC Symposium, 2007, ISTRC (pp. 466-472).

Sarah, S., Bornare, T. and Ayesha, S. 2017. Process optimization for making unripe banana flour and its utilization in vermicelli. *Int. J. Adv. Sci. Res. Eng. Trends.* 2(10): 229-237.

Schober, T. J., Messerschmidt, M., Bean, S.R., Park, S. H. and Arendt, E. K. 2005. Gluten-free bread from sorghum: quality differences among hybrids. *Cereal Chem.* 82: 394–404.

Seema, B. R., Sudheer, K. P., Ranasalva, N., Vimitha, T., and Sankalpa, K. B. 2016. Effect of storage on cooking qualities of millet fortified pasta products. *Adv. Life Sci.* 5(17):6658-6662.

Sengupta, S., Chowdhary, B. M., Singh, B. N. and Ray R. N. (2008). Status of elephant foot yam cultivation in Jharkhand. In Palaniswami, M. S. et al., ed., National Seminar on Amorphophallus: Innovative Technologies, July19-20, 2008, Patna, Bihar-abstract book, status papers and extended summary.pp.30-34.

Shanthi, P., Kennedy, J. Z., Parvathi, K., Malathi, D., Thangavel, K., and Raghavan, G.S. V. 2005. Studies on wheat based composite flour for pasta products. *Indian J. Nutr. Diet.* 42:503–508.

Sharon, C. L. 2020. Nutritional and organoleptic evaluation of value added products from bread fruit (*Artocarpus altilis*). MSc. (Home Science) thesis, Kerala Agricultural University, Thrissur, 67p.

Shobha, D, Prasanna, kumar, M. K., Puttaramanaik, and Sreemasetty T. A. 2011. Effect of antioxidant on the shelf life of quality protein maize flour. *Indian J. Fund. App. Life Sci.* 1: 129-140.

Shobha, D. and Asha, K. J. 2015. Evaluation of maize flour incorporated vermicelli for nutritional, sensory and storage quality. *J. Food Sci. Technol.* 52(11): 7173-7181.

Sibian, M. S. and Riar, C. S. 2020. Formulation and characterization of cookies prepared from the composite flour of germinated kidney bean, chickpea, and wheat. *Legume Sci.* 2(3).

Singh, D. R., Singh, S., Salim, K. M., and Srivastava, R. C. 2012. Estimation of phytochemicals and antioxidant activity of underutilized fruits of Andaman Islands (India). *Int. J. Food Sci. Nutr*. 63(4): 446-452.

Singh, I. S. and Srivastava, A. K. 2000. Genetic variability in jackfruit. *IPGRI Newsletter for Asia, the Pacific and Oceania* 31: 22-23.

Singh, N., Singh, J., Kaur, L., Sodhi, N. S., and Gill, B. S. 2003. Morphological, thermal and rheological properties of starches from different botanical sources. *Food Chem.* 81(2): 219-231.

Sowmya, P. S. 2022. Development and quality evaluation of a jackfruit flour based nutri - flour. PhD. (Community Science) thesis, Kerala Agricultural University, Thiruvananthapuram, 159p.

Srinivasan, S. and Shende, K. M. 2015. A study on the benefits of convenience foods to working women. *Atithya: J. Hospitality* 1(1): 56-63.

Sunday, F. O. and Dayo, F. E. 2012. Effect of storage on the proximate, mineral composition and microflora of tinco. *Global J. Biosci. Biotechnol.* 1(1): 54-58.

Suriya, M., Baranwal, G., Bashir, M., Reddy, C. K., and Haripriya, S. 2016. Influence of blanching and drying methods on molecular structure and functional properties of elephant foot yam (*Amorphophallus paeoniifolius*) flour. *LWT-Food Sci. Technol.* 68: 235-243.

Susan, F. T. and Hurrel, R. F. 1996. Bioavailability of minerals and trace elements: members of EC flair concerted action no. 10: Measurements of micronutrient absorption and status. *Nutri. Res. Rev.* 9: 295-324.

Susanna, S. and Prabhasankar, P. 2013. A study on development of gluten free pasta and its biochemical and immunological validation. *LWT-Food Sci. Technol.* 50(2): 613-621.

Swami, S. B., Thakor, N. J., Haldankar, P. M., and Kalse, S. B. 2012. Jackfruit and its many functional components as related to human health: A review. *Compr. Rev. Food Sci. Food Saf.* 11(6): 565-576.

Swathi, B. S., Lekshmi, G. P. R., and Sajeev, M. S. 2019. Cooking quality, nutritional composition and consumer acceptance of functional jackfruit pasta enriched with red amaranthus. *Environ. Conserv. J.* 20(3): 89-97.

Swati, B. S. 2019. Development of functional jackfruit pasta. MSc. (Community Science) thesis, Kerala Agricultural University, Thiruvananthapuram, 116p.

Tharani, S. 2018. Value added products from jackfruit rind. MSc. (Community Science) thesis, Kerala Agricultural University, Thiruvananthapuram, 185p.

Tharise, N., Julianti, E., and Nurminah, M. 2014. Evaluation of physico-chemical and functional properties of composite flour from cassava, rice, potato, soybean and xanthan gum as alternative of wheat flour. *Int. Food Res. J.* 21(4):1641-1649.

Thilagavathi, T., Banumathi, P., Kanchana, S., and Ilamaran, M. 2015. Effect of heat moisture treatment on functional and phytochemical properties of native and modified millet flours. *Plant Archives* 15(1): 15-20.

Thomas, B., Sudheer, K. P., Saranya, S., Kothakota, A., Pandiselvam, R., and Joseph, M. 2022. Development of protein enriched cold extruded pasta products using hybrid dried processed mushroom powder and defatted flours: A study on nutraceutical, textural, colour and sensory attributes. *LWT*. 170:113991-113998.

Thomas, R., Yeoh, T. K., Wan-Nadiah, W. A., and Bhat, R. 2014. Quality evaluation of flat rice noodles (Kway Teow) prepared from Bario and Basmati rice. *Sains Malaysiana* 43(3): 339-347.

Tiwari, A. K. and Vidyarthi, A. S. 2015. Nutritional evaluation of various edible fruit parts of Jackfruit (*Artocarpus heterophyllus*) at different maturity stages. *Int. J. Chem. Pharmac. Rev. Res.* 1(1): 21-26.

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

Veena, K., Suma, D., Mary, U., and Nandini, P. V. 2015. Development of raw jackfruit based noodles. *Food Sci. Res. J.* 6(2): 326-332.

Wahyono, A. and Bakri, A. 2018. Physicochemical and sensorial characteristics of noodle enriched with oyster mushroom (*Pleorotus ostreatus*) powder. *J. Phy. Conf. Ser.* 953(1) :14-21.

Wang, L., Duan, W., Zhou, S., Qian, H., Zhang, H., and Qi, X. 2016. Effects of extrusion conditions on the extrusion responses and the quality of brown rice pasta. *Food Chem.* 204: 320-325.

Wang, X., Chen, L., Li, X., Xie, F., Liu, H., and Yu, L. 2011. Thermal and rheological properties of breadfruit starch. *J. Food Sci.* 76(1): 55-61.

Wankhede, D. B. and Sajjan, S. U. 1981. Isolation and physico chemical properties of starch extracted from yam, elephant (*Amorphophallus campanulatus*). *Starch Starke* 3(5):153-157.

Worsley, A. 2000. Food and consumers: Where are we heading?. *Asia Pacific J. Clin. Nutr.* 9(S1): 103-107.

Wu, V. Y., Hareland, G. A. and Warner, K. 2001. Protein- enriched spaghetti fortified with corn gluten meal. *J. Agric. Food Chem.* 49: 3906–3910.

Yang, Y., and Tao, W. Y. 2008. Effects of lactic acid fermentation on FT-IR and pasting properties of rice flour. *Food Res. Int.* 41(9): 937-940.

Zacharia, R. K. 2020. Standardisation and quality evaluation of millet based nutri - flakes. M.Sc. (Community Science) thesis, Kerala Agricultural University, Thrissur, 90p.

APPENDICES

APPENDIX I

KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF AGRICULTURE, VELLANIKKARA, THRISSUR

Score card for the organoleptic evaluation of pasta from cassava flour and mushroom flour

No	Parameters	Treatments				
		T_0	T_1	T_2	T_3	T_4
1	Appearance					
2	Colour					
3	Flavour					
4	Texture					
5	Taste					
6	Overall acceptability					

9 point Hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Date: **Signature:**

Name:

KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF AGRICULTURE, VELLANIKKARA, THRISSUR

Score card for the organoleptic evaluation of pasta from jackfruit and mushroom flour

No	Parameters	Treatments				
		T_0	T_1	T_2	T_3	T_4
1	Appearance					
2	Colour					
3	Flavour					
4	Texture					
5	Taste					
6	Overall acceptability					

9 point Hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Date: **Signature:**

Name:

KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF AGRICULTURE, VELLANIKKARA, THRISSUR

Score card for the organoleptic evaluation of pasta from breadfruit and mushroom flour

No	Parameters	Treatments				
		T_0	T_1	T_2	T_3	T_4
1	Appearance					
2	Colour					
3	Flavour					
4	Texture					
5	Taste					
6	Overall acceptability					

9 point Hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Date: **Signature:**

Name:

PROCESS OPTIMIZATION OF MUSHROOM INCORPORATED PASTAS

By

SOMITHA N. S.

(2019-16-005)

ABSTRACT

Submitted in partial fulfilment of the

requirement of the degree of

☛ଓ⑩⓿ᢌ⑨⑩ ⓪⑤ ☞⑥④④❶⑤⑩❺ ☒ଋ⓪ᢌ⑤ଋᢌ

(FOOD AND NUTRITION)

Faculty of Agriculture

KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF COMMUNITY SCIENCE

COLLEGE OF AGRICULTURE

VELLANIKKARA, THRISSUR – 680656

KERALA, INDIA

2022

ABSTRACT

Convenience foods have become an integral part of our food habits. Composite flour technology is a new approach which is done by blending variety of flours to produce various food products. Aiming to develop better quality extruded products, the present study entitled "Process optimization of mushroom incorporated pastas" was proposed with the objectives to standardise mushroom incorporated nutri-rich pastas and to evaluate its nutritional, organoleptic and shelf life qualities.

Oyster mushroom (*Pleurotus florida*) was procured from the Department of Plant Pathology, College of Agriculture, Vellanikkara. Cassava, elephant foot yam, jackfruit and breadfruit was procured from homesteads. These were dried, powdered and sieved to get uniform flour as per the standard procedures. Pastas were prepared using various proportions of tuber or fruit flours and mushroom flour. Pastas were subjected to organoleptic evaluation and the best treatment from each set was selected for nutritional evaluation and health studies. The selected treatments were packed in HDPE covers and stored for a period of three months. The sensory qualities, total microflora and insect infestation were recorded in selected samples during the storage at monthly intervals. The nutritional and health qualities were studied initially and at the end of the storage period.

From the first set, cassava and mushroom flour incorporated pasta, T_3 (70% cassava flour and 30% mushroom flour), was selected. From the second set, pasta prepared using elephant foot yam was excluded due to the low acceptability of the pastas. Third and fourth sets were prepared using jackfruit and breadfruit flours, respectively. In both, T_1 (90% fruit flour and 10% mushroom flour) were selected as the best. Three best treatments were carried forward to further studies.

Cassava and mushroom flour pastas had 6.85% moisture, 391.52 k Cal energy, 80.60 g/100g carbohydrate, 9.36 g/100g protein, 0.20 g/100g fat, 2.86 g/100g fibre, 67.00 g/100g starch and 0.94 % reducing sugar. Pasta had the mineral content of 54.90 mg/100g calcium, 3.60 mg/100g iron, 12.48 mg/100g sodium, 40.80 mg/100g magnesium and 292.01 mg/100g potassium.

Jackfruit and mushroom pasta had 6.67% moisture, 334.99 k Cal energy, 78.63 g/100g carbohydrate, 9.48 g/100g protein, 0.39 g/100g fat, 3.60 g/100g fibre,

73.39 g/100g starch and 0.37% reducing sugar. Pasta had the mineral content of 26.10 mg/100g calcium, 1.64mg/100g iron, 6.85 mg/100g sodium, 56.02 mg/100g magnesium and 324.70 mg/100g potassium.

Breadfruit and mushroom pasta had 6.03% moisture, 320.69 k Cal energy, 73.49 g/100g carbohydrate, 5.40 g/100 g protein, 0.57 g/100 g fat, 7.52 g/100 g fibre, 69.64 g/100 g starch and 2.12 % reducing sugar. Pasta had the mineral content of 37.80 mg/100 g calcium, 0.10 mg/100 g iron, 12.03 mg/100 g sodium, 19.72 mg/100 g magnesium and 511 mg/100 g potassium.

All the selected treatments were subjected to health studies including the in vitro digestibility of starch and protein and availability of minerals. Cassava and mushroom pasta had protein and starch digestibility of 83.10 and 61.13 %, respectively. In vitro availability of the minerals iron, calcium, phosphorous and magnesium was 37.80, 41.10, 63.17 and 68.12 %, respectively.

Jackfruit and mushroom pasta had protein and starch digestibility of 57.76 and 61.10 %, respectively. In vitro availability of the minerals iron, calcium, phosphorous and magnesium was 29.40, 41.50, 83.48 and 40.00 %, respectively. Breadfruit and mushroom pasta had protein and starch digestibility of 69.23 and 52.56 %, respectively. In vitro availability of the minerals iron, calcium, phosphorous and magnesium was 39.00, 40.50, 69.00 and 78.24 %, respectively.

Pastas made with tuber flour/ fruit flours were packed in HDPE covers and were kept for three months of storage in ambient conditions. Organoleptic evaluation had shown its acceptability up to three months, with gradual decline in all sensory attributes. In the case of pastas with fruit flour, jackfruit flour and mushroom flour added pasta were observed to have better score compared to breadfruit flour and mushroom flour incorporated pastas.

During storage, nutrients, mineral content and in vitro digestibility of starch and protein of the tuber/fruit flour and mushroom flour pastas decreased.

No insect infestation was observed throughout the storage period. The microbial population of the selected pastas were assessed at monthly intervals for a period of three months and was found to be within the safe limits. The cost of pastas (100g) prepared with cassava flour and mushroom flour was Rs 98.50, whereas it was

Rs 50.50, Rs 52.00 for jackfruit flour and mushroom flour, breadfruit flour and mushroom flour pastas, respectively.

The current research found that healthy pastas can be prepared with cassava flour, breadfruit flour and jackfruit flour. Incorporation of mushroom flour to pastas enhance the nutritional qualities of the products. These products are a better alternative and could be healthier than commercially available pastas.

സംക്ഷിപ്തം

സൗകര്യപ്രദമായ ഭക്ഷണങ്ങൾ നമ്മുടെ ഭക്ഷണശീലങ്ങളുടെ അവിഭാജ്യ ഘടകമായി മാറിയിരിക്കുന്നു. വിവിധതരം പൊടികൾ സംയോജിപ്പിച്ചു വിവിധ ഭക്ഷ്യ ഉൽപ്പന്നങ്ങൾ ഉൽപ്പാദിപ്പിക്കുന്ന് ഒരു പുതിയ സമീപനമാണ് കോമ്പോസിറ്റ് ഫ്ലോർ സാങ്കേതികവിദ്യ. മികച്ച ഗുണമേന്മയുള്ള ഭക്ഷ്യ ഉൽപ്പന്നങ്ങൾ വികസിപ്പിക്കുക എന്ന ലക്ഷ്യത്തോടെ, "കൂൺ സംയോജിത പാസ്തകളുടെ രൂപകൽപനയും അവയുടെ ഗുണ നിലവാരം വിലയിരുത്തലും എന്ന തലക്കെട്ടിലുള്ള പഠനം നടത്തി , കൂൺ സംയോജിത പോഷക സമ്പുഷ്ടമായ പാസ്തകളുടെ ഗുണ നിലവാരം, അതിന്റെ പോഷക, രുചിഗുണ സവിശേഷതകൾ , സംഭരണ ശേഷി ഗുണങ്ങൾ വിലയിരുത്തുന്നതിനും ലക്ഷ്യമിട്ടാണ്.

പഠനത്തിന് ആവശ്യമായ ചിപ്പിക്കൂൺ (പ്ലൂറോട്ടസ് ഫ്ലോറിഡ) വെള്ളാനിക്കര കാർഷിക കോളേജിലെ പ്ലാന്റ് പത്തോളജി വിഭാഗത്തിൽ നിന്നാണ് സംഭരിച്ചത്. മരച്ചീനി, ചേന , ചക്ക കടല എന്നിവ വീട്ടുവളപ്പിൽ നിന്ന് സംഭരിച്ചു. ഇവ ഉണക്കി പൊടിച്ച് അരിച്ചെടുത്താണ് സാധാരണ നടപടിക്രമങ്ങൾക്കനുസരിച്ച് പാസ്ത ഉൽപ്പാദിപ്പിക്കുന്നതിനുള്ള ഉപ്പാദിപ്പിച്ചെടുത്ത് . കിഴങ്ങുവർഗ്ഗങ്ങൾ. ചക്ക, കടല , ചിപ്പിക്കൂൺ എന്നിവയുടെ പൊടികൾ വിവിധ അനുപാതത്തിൽ സംയോജിപ്പിച്ചാണ് പാസ്തകൾ തയ്യാറാക്കിയത്. പാസ്തകൾ രുചി ഗുണ മൂല്യനിർണ്ണയത്തിന് വിധേയമാക്കി, പോഷകാഹാര മൂല്യനിർണ്ണയത്തിനും ആരോഗ്യ പഠനത്തിനുമായി ഓരോ സെറ്റിൽ നിന്നും മികച്ച പാസ്തകൾ തിരഞ്ഞെടുത്തു തിരഞ്ഞെടുത്ത പാസ്തകൾ എച്ച്ഡിപിഇ കവറുകളിൽ പായ്ക്ക് ചെയ്യുകയും മൂന്ന് മാസത്തേക്ക് സൂക്ഷിക്കുകയും ചെയ്തു. അതിനോടൊപ്പം പ്രതിമാസ ഇടവേളകളിൽ അവയുടെ രുചി ഗുണങ്ങൾ, സൂക്ഷ്മ ജീവികളുടെ യും ഗുണ സംവേദന ഗുണങ്ങൾ, പ്രാണികളുടെ ആക്രമണം എന്നിവ തിരഞ്ഞെടുത്ത സാമ്പിളുകളിൽ പ്രതിമാസ മൂല്യ നിർണയം നടത്തി . കൂടാതെ ആദ്യഘട്ടത്തിലും സംഭരണ കാലയളവിന്റെ അവസാനഘട്ടത്തിലും

പോഷകഗുണങ്ങളും

ആരോഗ്യഗുണങ്ങളും വിശകലനം ചെയ്തു ആരോഗ്യഗുണങ്ങളും പഠിച്ചു.

ആദ്യ സെറ്റിൽ നിന്ന്, മര□ീനിയും ചി□ി കൂണും കൂൺ
ഉൾപ്പെടുത്തിയ പാസ്ത, T3 (70% മര□ീനി പൊടിയും 30% ചി□ി കൂൺ പൊടിയും) തിരഞ്ഞെടുത്തു. രണ്ടാം സെറ്റിൽ നിന്ന് ഞണ്ട്
പൊടി ഉപയോഗി□് തയ്യാറാ□ിയ പാസ്തകൾ□് സ്വീകാര്യത കുറവായതിനാൽ അവ പഠന ത്തിൽ നിന്ന് പൂർണമായും ഒഴിവാ□ □ി. ച□, കട□ □ പൊടി എന്നിവ ഉപയോഗി□് യഥാക്രമം മൂന്നാമത്തെയും നാലാമത്തെയും സെറ്റുകൾ തയ്യാറാ□ി. രണ്ടിലും T 1 (90% കട□ □ പൊടിയും 10% കൂൺ
പൊടിയും) മികച്ചതായി തിരഞ്ഞെടുത്തു. മൂന്ന് മികച്ച പാസ്തകൾ തുടർ പഠനത്തിനായി മുന്നോട്ട് കൊണ്ടുപോയി.

മര□ീനി, കൂൺ പാസ്തകളിൽ 6.85% ഈർപ്പം, 391.52 കെ കേലാറി
ഊർജം, 80.60 ഗ്രാം/100 ഗ്രാം കാർബോഹൈഡ്രേറ്റ്, 9.36 ഗ്രാം/100
ഗ്രാം പ്രോട്ടീൻ, 0.20 ഗ്രാം/100 ഗ്രാം കൊഴു, 2.86 ഗ്രാം/100 ഗ്രാം
നാരുകൾ, 67.00 ഗ്രാം പഞ്ചസാര, 67.00 ഗ്രാം അന്നജം , 67.00 ഗ്രാം റെഡ്യൂസിങ് ഷുഗർ /100 ഗ്രാം
എന്നിവ അട□ ിയിട്ടുണ്ട് .
കൂടാതെ പാസ്തയിൽ 54.90 mg/100g കാൽസ്യം, 3.60 mg/100g ഇരുമ്പ്,
12.48 mg/100g സോഡിയം, 40.80 mg/100g മ□ീഷ്യം, 292.01 mg/100g
പൊട്ടാസ്യം എന്നി ധാതു□ളും അട□ിയിട്ടുണ്ട്.

ച□, കൂൺ സമ്മിശ്ര പാസ്തയിൽ 6.67% ഈർപ്പം, 334.99 കെ കേലാറി ഊർ□ം, 78.63 ഗ്രാം/100 ഗ്രാം കാർബോഹൈഡ്രേറ്റ്, 9.48
ഗ്രാം/100 ഗ്രാം മാംസ്യം , 0.39 ഗ്രാം/100 ഗ്രാം കൊഴു, 3.60 ഗ്രാം/100
ഗ്രാം നാരുകൾ, 73.39 ഗ്രാം അന്നജം , 0 .3 7 ഗ്രാം /100 ഗ്രാം റെഡ്യൂസിങ് ഷുഗർ, കൂടാതെ പാസ്തയിൽ 26.10 mg/100g
കാൽസ്യം, 1.64mg/100g ഇരുമ്പ്, 6.85 mg/100g സോഡിയം, 56.02 mg/100g മ□ീഷ്യം, 324.70 mg/100g പൊട്ടാസ്യം എന്നിവയും അട□ിയിട്ടുണ്ട്.

കട□ □ , ചി□ി കൂൺ സംയോജിത പാസ്തയിൽ 6.03% ഈർപ്പം, 320.69 കെ കേലാറി ഊർജം, 73.49 ഗ്രാം/100

ഗ്രാം കാർബോഹൈഡ്രേറ്റ്, 5.40 ്ഗാം/100 ്ഗാം മാംസ്യം , 0.57 ്ഗാം/100
്ഗാം ൊകാഴു, 7.52 ്ഗാം/100 ്ഗാം നാരുകൾ, 69.64 ്ഗാം അജം
/100 ്ഗാം 2 .12 % ൈറഡ്യൂസിങ് ഷുഗർ എ്വ അട □ിയിരി□ു്ു . കൂടാൊത 37.80 mg/100 g കാൽസ്യം, ൦0 mg/100 g ഇരു്, 12.03 mg/100 g േസാഡിയം, 19.72 mg/100 g മ□ീഷ്യം, 511 mg/100 g ൊപാ൧ാസ്യം എ്ി ധാതു □ ളും അട □ിയിപു്്.

തിരെ‿ടു്‌ എ◌ാ പാ◌്കളിലും അജ്‌◌ിന്റെയും മാംസ്യ◌ിന്◌െറയും ഇൻ വി◌േ◌്ടാ ദഹന◌◌മത , ധ◌ാത◌ു□ള◌ു◌െട ലഭ◌്ത എ◌്ിവ ഉൾ◌െ◌െടയുട ആേരാഗ◌് പഠന□ൾ□◌് വ◌ിേധയമ◌ാ□◌ി. മര□◌ീനി, ചി◌ി ,കൂൺ പാ◌്◌് എ◌്ിവയിൽ മാംസ്യ◌ിന്◌െറയും അജ്‌◌ിന്◌െറയും ദഹന◌◌മത യഥാ◌്കമം 83.10, 61.13% ആണ് . ഇരു◌്, കാൽസ◌്◌ം, േഫാ◌്റസ്, മ□◌ീഷ◌്◌ം എ◌്ീ ധ◌ാത◌ു□ള◌ു◌െട ഇൻ വി◌േ◌്ടാ ലഭ◌്ത യഥാ◌്കമം 37.80, 41.10, 63.17, 68.12 % ആയിരു◌്ു

ച□, ചി◌ി കൂൺ സം◌േയാജിത പാ◌്◌് യിൽ യഥാ◌്കമം 57.76, 61.10% മാംസ്യ◌ിന്◌െറയും അജ്‌◌ിന്◌െറയും ദഹന◌◌മത കാണ◌ി□◌ു◌്ു. കൂടാ◌െത ഇര◌ു◌്, കാൽസ◌്◌ം, േഫാ◌്റസ്, മ□◌ീഷ◌്◌ം എ◌്ീ ധ◌ാത◌ു□ള◌ു◌െട ഇൻ വി◌േ◌്ടാ ലഭ◌്ത യഥാ◌്കമം 29.40, 41.50, 83.48, 40.00 % ആയിരു◌്ു. കട□□ , ചി◌ി കൂൺ സം◌േയാജിത പാ◌്യിൽ യഥാ◌്കമം 69.23, 52.56 ശതമാനം മാംസ◌്വും അജവും ഇൻ വി◌േ◌്ടാ ദഹന ◌◌മത കാണി□◌ു◌്ു . ഇരു◌്, കാൽസ◌്◌ം, േഫാ◌്റസ്, മ□◌ീഷ◌്◌ം എ◌്ീ ധ◌ാത◌ു□ള◌ു◌െട ഇൻ വി◌േ◌്ടാ ലഭ◌്ത യഥാ◌്കമം 39.00, 40.50, 69.00, 78.24% ആയിരു◌്ു.

ക◌ിഴ□◌് ◌െപ◌ാട◌ി /ച□, ഇടി□□ ◌െപ◌ാടികൾ സ◌ം◌േയ◌ാജ◌ി◌ി□◌ു ന◌ിർ◌ി□ പ◌ാ◌്കൾ എ□◌്ഡ◌ിപ◌ിഇ കവറ◌ുകളിൽ പ◌ായ്◌□◌് ◌െച◌്◌ുകയും

സാധാരണ താപനിലയിൽ മൂ◌് മാസ◌െ്‌ സംഭരണ◌ിനായി സൂ◌◌ി□◌ുകയ◌ു◌ം ◌െച◌്◌്ു. എ◌ാ രുചി ഗ◌ുണ□ള◌ു◌ം ◌്കമ◌ാന◌ുഗതമ◌ായ◌ി കുറ◌െ‿□◌ിലു◌ം മ◌ൂ◌്ുമ◌ാസ കാലഘ◌്േയും അതിന്◌െറ സ◌്◌ീക◌ാര◌്ത ന◌ിലന◌ിർ◌്‌◌ി .ച□ ◌െപ◌ാട◌ി , ക◌ൂൺ ◌െപാടി എ◌്ിവ സം◌േയാജി◌ി□ പാ◌്യു◌െട കാര്യ◌ിൽ കട□□ ◌േ◌ാർ, കൂൺ ◌െപാടി എ◌്ിവ സംേയാജി◌ി□◌ു വികസി◌ി◌െ□ടു്‌ പാ◌്◌് ◌െയ അ◌േപ◌◌ി□◌് മികച്ച ഫല◌്ള◌െ◌്◌് നിരീ◌ി□◌െ◌ു.

സംഭരണ സമയ◌്◌്, ക◌ിഴ□◌ുവർ□ൾ/ച□, ഇടി□□ , കൂൺ പാ◌്◌് എ◌്ിവയു◌െട അജ്‌◌ിന്◌െറയും ◌േ◌്പാ◌ീനിന്◌െറയും മ◌ു

േപാഷക ളുെടയുംധാതു ളുെട ഇൻ വിേ ടാ ദഹന മതയും കുറ തായി ക ു .

സംഭരണ കാലയളവിലുടനീളം പാണികളുെട ആ കമണം ക ിബ. തിരെ ടു പാ കളിെല സൂ ജീവികളുെട എ ം മൂ് മാസേ ് തിമാസ ഇടേവളകളിൽ വിലയിരു ി സുര ിതമായ തു ി

കെ്ി. മര□ീനി, കൂൺ എ്ിവ ഉപേയാഗി□് ത്ത്യ പാ്് (100 ്ഗാം) യഥാ്കമം 98.50 രൂപയും ച□ , കൂൺ , കട□ □ ,
കൂൺ പാ്് എ്ിവയ□ ് യഥാ്കമം 50.50 രൂപയും 52.00 രൂപയുമാണ് വില.

മര□ീനി, കട□ □ , ച□ ൊടി എ്ിവ ഉപേയാഗി□്
ആേരാഗ്കരമായ പാ് ത്യാറാ□ാൈമ് നിലവിെല
ഗേവഷണം കെ്ി. പാ്യിൽ കൂൺ ൊപാടി േചർ□ുത്
ഉൽ□ളുെട േപാഷക ഗുണ□ൾ വർ്ി□ു ഈ ഉൽ□ൾ വാണിജ്പരമായി ലഭ്മായ പാ്കേള□ാൾ ആേരാഗ്കരവുമാണ്.