DEVELOPMENT OF FUNCTIONAL JACKFRUIT PASTA

By

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THESIS

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2019

DECLARATION

I, hereby declare that this thesis entitled **"DEVELOPMENT OF FUNCTIONAL JACKFRUIT PASTA"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship or other similar title, of any other University or Society.

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LIST OF ABBREVIATIONS

et al.	Co-workers/ Co-authors
%	Per cent
@	at the rate of
μg	Micro gram
μmol	Micromol
ANOVA	Analysis of variance
CD (0.05)	Critical difference at 5 % level
CF	Cassava flour
CRD	Completely Randomised Design
CTCRI	Central Tuber Crops Research Institute
DPPH	2, 2- diphenyl-1-picrylhydrazyl
DW	Dry weight
Eq.	Equivalent
Fig	Figure
g	Gram
$g\ g^{-1}$	Gram per gram
JBF	Jackfruit bulb flour
JSF	Jackfruit seed flour
kg	Kilogram
KW	Kruskall-Wallis
m M	Millimolar
mg	Milligram

min	Minute
mL	Millilitre
mm	Millimetre
N	Newton
nm	nanometre
No.	Number
NS	Not significant
Ns	Newton second
°C	Degree Celsius
s^{-1}	Per second
SEm	Standard error of mean
TE	Trolox equivalent
V	Volume
viz.,	Namely
χ^2	Chi-square

Introduction

1. INTRODUCTION

Pasta is traditionally an Italian food made of refined wheat flour that has crossed international borders and is now a popular form of fast food of India also. The extruded product, pasta, is an excellent source of complex carbohydrates, which provide a slow release of energy. Pasta products are widely accepted by the children but is not accepted as a healthy food due to low nutrient content (Mishra and Bhatt, 2016).

Reasons for the enrichment of pasta have been pointed out as nutritional improvement, use of local raw materials, and use of cereal by-products, production of gluten-free pasta or development of products with additional health benefits (da Silva, 2013). Pasta enriched with plant derived bioactive compounds may confer health benefits to consumers. It is possible to incorporate flours other than refined flour or other ingredients into pasta to increase its nutritive value and antioxidant properties (Padalino *et al.*, 2017). The demand for pasta enriched with functional ingredients such as cereal bran, vegetables, fruits and pseudo cereals are increasing due to its health benefits (Meena *et al.,* 2019). As a food rich in complex carbohydrates with low glycemic index, pasta is gaining wide acceptance in the recent years and research on development of functional pastas is gaining momentum.

Jackfruit is one of the most popular tropical fruits grown in India and profusely bearing in homesteads of Kerala. The jackfruit bulb and seeds are not fully utilized and faces postharvest losses. It is worthwhile to utilize the edible seeds and bulb by processing it into flour for the production of acceptable products which will help to increase the utilization of jackfruit among consumers (Collins, 2006). Jackfruit is an underutilized crop which is not considered as a commercial fruit crop due to its lower shelf life and inadequate post handling facilities in the regions they are grown (Ranasinghe *et al.,* 2019).

Jack fruit seeds make up around 10-15 percentage of the total fruit weight and have high content of carbohydrate, protein, dietary fibre, vitamins, minerals and phytonutrients. Jackfruit seed flour has high water absorption capacity, bulk density with less gelation capacity of 17 percentage (Abraham and Jayamuthunagai, 2014). Jackfruit bulb and seed are rich in carbohydrates, proteins, fibre and other bioactive compounds and can be utilized for the development of value added products with health benefits.

Hence the present study entitled 'Development of functional jackfruit pasta' was conducted with the objective to develop functional pasta from jackfruit bulb and seed flour enriched with vegetables and to study the storage stability.

Review of Literature

2. REVIEW OF LITERATURE

Development of food with additional health benefits is gaining importance nowadays and functional food sector is growing rapidly. The present study focused on developing functional pasta from jackfruit bulb and seed flour and with addition of vegetables to improve the nutritional quality. The research work on jackfruit pasta is meager and this chapter describes the research work done in the development of extruded products with functional properties in previous years.

2.1. JACKFRUIT AND ITS HEALTH BENEFITS

Jackfruit (*Artocarpus heterophyllus* Lam.) is the biggest tree born fruit in the world. The word 'Artocarpus' is derived from the Greek words "artos" meaning (bread) and "carpos" meaning (fruit). The fruit received its name "jackfruit" from the Portuguese word "jaca" which was actually derived from the malayalam word "chaka" (Bailey, 1949).

Jackfruit is known for its nutritional and health benefits. It is rich in carbohydrates, dietary fibre, proteins, minerals, vitamins, phytochemicals with higher antioxidant activity and less calories (Amit and Ambarish, 2010). Jackfruit pulp and seeds contain more protein, calcium, iron thiamine and it also possess anticarcinogenic, antimicrobial, antifungal, anti-inflammatory, wound healing, and hypoglycemic properties when compared to other tropical fruits (Ranasinghe *et al.,* 2019).

Every 100g edible portion of unripe jackfruit bulb contains 76.2 to 85.2g of water, 2.0 to 2.6g of protein, 0.1 to 0.6g of fat, 9.4 to 11.5g of carbohydrates, 2.6 to 3.6g fibre, 0.9% total minerals, 30.0 to 73.2mg calcium, 20.0 to 57.2mg phosphorous, 287 to 323mg potassium, 3.0 to 35.0mg sodium, 0.4 to 1.9mg iron, 30 IU vitamin A, 0.05 to 0.15mg thiamine, 0.05to 0.2mg riboflavin and 12.0 to 14.0 mg vitamin C(Azad, 2000).

Jackfruit seeds constitute about 10-15% of the fruit weight which have considerable nutritional and health benefits. The seeds are being underutilized due to the problems faced during the processing and storage, which eventually leads to the massive wastage annually (Waghmare *et al.,* 2019).

Every 100g edible portion of jackfruit seed contains 51.0 to 64.5g of water, 6.6 to 7.04g of protein, 0.40 to 0.43g of fat, 25.8 to 38.4g of carbohydrates, 1.0 to 1.5g fibre, 0.9 – 1.2% total minerals, 50.0mg calcium, 38.0 to 97.0mg phosphorous, 246mg potassium, 63.2mg sodium, 1.5mg iron, 10 to 17 IU vitamin A, 0.25mg thiamine, 0.11to 0.3mg riboflavin and 11.0 mg vitamin C (Azad, 2000).

According to Ranasinghe *et al.* (2019) every 100g of edible portion of jackfruit provide about 95 calories and is a good source the antioxidants and vitamins (13.7mg).Jackfruit seeds are rich source starch, protein and fibre. They also provide many minerals such as N, P, K, Ca, Mg, S, Zn, Cu, etc. Jackfruit seed flour is used as alternative flour along with wheat flour in bakery and confectionary.

2.2. PASTA AS A CONVENIENCE FOOD

Pasta and noodles are the most popular extruded products. The word extrusion is originated from the Latin word, 'Extrude' meaning 'press' or 'push out'. Pasta is generally prepared by the method of cold extrusion where the pasta dough is extruded through the die at high pressure and vacuum. Traditional cooking methods will lead to deterioration of nutritional quality due to high temperature` during the cooking process (Guy, 2001). While in extrusion cooking reduction in nutrient destruction along with starch and protein digestibility is obtained (Plahar *et al.*, 2003). Oxidation of pigments, enzymatic reduction, oxidative decompositions and appearance of bubbles in the dough can be minimized by maintaining vacuum. Advantages of extrusion include low production cost and production of end products with various shapes and sizes (Riaz *et al.,* 2007). During extrusion heating of food products along with creation of a cooked and shaped food product is accomplished and it is defined as a process where moistened, starchy and protein rich foods are cooked and made into a plastic like dough.

Extrusion enhances mineral absorption thus reducing the anti-nutritional factors and polyphenols. Due to wearing of metallic pieces like screws of the extruder, iron content was found to increase in the extruded products (Alonso *et al.,* 2001). Extrusion cooking solubilizes some fibre components without significant change in dietary fibre content. In several conditions an increase in dietary fibre content was observed as in case of barley flours (Vasanthan *et al.,* 2002). During the process of extrusion, fat splitting enzymes get destroyed, prevents rancidity and shelf life of products increases (Kumari, 2015). Singh *et al.* (2007) reported that extrusion prevents free fatty acid release by denaturation of hydrolytic enzymes, prevents lipid oxidation which has negative influence on the nutritional and sensory qualities, while carotenoids, tocopherol and ascorbic acid decreased with increase in extrusion temperature.

Pasta is traditionally an Italian food made of refined wheat flour that has crossed international borders and is now a popular form of fast food of India also. The extruded product, pasta, is an excellent source of complex carbohydrates, which provide a slow release of energy. Pasta products are widely accepted by the children but are not accepted as a healthy food due to low nutrient content (Mishra and Bhatt, 2016).

Convenience and palatability make pasta more popular worldwide and is gaining popularity among the common man in India too (Gull *et al.*, 2015). Nutritional fortification has been attempted in pasta by several researchers to impart different nutritional/ functional attributes to the products. Fortification of pasta with legume flours (Bahanassey and Khan, 1986; Petitot *et al.*, 2010), dietary fibre (Tudorica *et al.*, 2002), banana flour (Ovando-Martinez *et al.,* 2009) have been studied.

The word 'pasta' is an Italian word meaning 'dough' and is the staple food of Italy and is a healthy food with low fat, high carbohydrate and high protein content (Simmons, 1988). There are mainly two types of pasta *viz.,* fresh pasta and dried pasta. Fresh pasta possess eggs, higher water content, lesser cooking time, reduced shelf life and are softer than dried pasta since they are made with eggs. Fresh pasta has to be refrigerated till use. Dried pasta does not contain egg, has low water content and possess a higher shelf life when compared to fresh pasta (Padmaja *et al.*, 2015).

Commercial pasta is mainly made of durum wheat semolina flour which is rich in gluten type of proteins which provides yellow colour to the pasta (Sissons *et al.*, 2004). Gluten helps in entrapping of starch granules during the mixing and extrusion of pasta dough. The structure of pasta is maintained by the visco-elastic network created by starch swelling during cooking of pasta which prevents cooking loss (Padmaja *et al.*, 2015).Extrusion of pasta results in starch gelatinization, protein denaturation, inactivation of raw food enzymes which are responsible for deterioration during storage, destruction of trypsin like naturally occurring toxic substances and reduction of microbial count in the end product (Harper, 2019).

2.4. ENRICHED PASTA

Pastas enriched with plant derived bioactive compounds may confer health benefits to consumers. It is possible to incorporate flours other than refined flour or other ingredients into pasta to increase its nutritive value and antioxidant properties (Padalino *et al.*, 2017).

Enrichment of pasta with broccoli yielded pasta rich in phytochemicals with additional health benefits (da Silva, 2013). Padalino *et al.* (2013) reported that gluten-free spaghetti based on maize flour and different vegetable flours like artichoke, asparagus, pumpkin, zucchini, tomato, yellow pepper, red pepper, green pepper, carrot, broccoli, spinach, eggplant and fennel can influence homogeneity, color, fibrous, taste, odor and overall quality of the dry spaghetti.

Pastas enriched with elderberry juice concentrate and dietary fibre resulted in bioactive enhanced pastas (Sun-Waterhouse *et al.,* 2013). Das and Nirmala (2014) focused on the incorporation of fruit pulp *viz*., jackfruit, papaya, banana along with other ingredients such as green gram flour, wheat flour and tapioca starch for the production of pasta. Jin *et al.* (2014) reported that production of pasta enriched with vegetables help to increase vegetable intake and dried pasta is a very good matrix to stabilize phytochemicals that otherwise, in fresh vegetables, are easily degraded during storage, transportation etc. Slinkard (2014) studied the effects of non-traditional flours like quinoa and chickpea flours on cooking quality, texture, composition, and consumer acceptance of pasta and found acceptable.

Grape marc enriched spaghetti showed higher total phenolic and flavonoid content and higher antioxidant activity than the control pasta (Marinelli *et al.,* 2015). Oliviero and Fogliano (2015) reported that vegetable pasta can significantly contribute to the recommended vegetable intake per day. Se,czyk *et al.* (2015) reported that fortification with parsley leaves improved the nutraceutical and nutritional potential of the pasta. Anyobodeh *et al.* (2016) found out that composite flour of cassava and wheat could be used for pasta production. Dried amaranth leaves and amaranth seed flour are used as ingredients for functional pasta production (Cardinas-Hernandez *et al.,* 2016). Pasta prepared by replacing 20% of semolina with native and fermented quinoa flour improved nutritional composition of pasta (Lorusso *et al.,* 2016). Mishra and Bhatt (2016) developed pasta with ginger powder having more nutraceutical properties. Padalino *et al.* (2017) studied the addition of tomato peel flour to spaghetti and found that upto 15% of tomato peel incorporation increased carotenoid content and dietary fibre as compared to the control sample.

2.4.1. Nutritional benefits of amaranthus

Amaranth leaves and grains are a rich source of antioxidants (Barba de la Rosa *et al.,* 1992; Jung *et al.,* 2006).Amaranth is a rich source of fiber, protein, and cholesterol lowering substances (Johns and Eyzaguirre, 2007). Nutritive value of amaranth as a pseudo cereal and its use as gluten free functional ingredient was studied by Alvarez-Jubete *et al.* (2010). Mlakar *et al.* (2010) stated that amaranthus possess high quality grains and is used a leafy vegetable. Chlopicka *et al.* (2012) reported an increase in total phenols, flavonoids and antioxidant activity of amaranth enriched bread with decreased sensory acceptability. Venskutonis and Kraujalis (2013) reported that pseudocereals can be used to prepare gluten free products with acceptable sensory qualities for people suffering from celiac disease.

Amaranth leaves possess 2.5 to 3.5g protein, 0.31 to 0.5g of lipids,4-6g of carbohydrates, 2.3 to 3.21mg of iron, 215 to 260mg calcium and 43 to 55 mg of vitamin C (Uusiku *et al.,* 2010). Compared to other conventional cereal crops, grain amaranth possess higher protein, amino acid, minerals and vitamins (Topwal, 2019).

2.4.2. Nutritional benefits of beetroot

Beetroots (*Beta vulgaris*) are rich in valuable, active compounds such as betacyanines (Patkai *et al.*, 1997), glycine, betaine, (de Zwart *et al.*, 2003), folates (Jastrebova *et al.*, 2003), saponins (Atamanova *et al.*, 2005), betanin, polyphenols, flavonoids (Vali *et al.*, 2007) and carotenoids (Dias *et al.*, 2009).

Betalains, the natural pigments present in beetroots can prevent cancer incidence (Kapadia *et al.,* 1996), exhibit antimicrobial, antiviral activities (Strack *et al.,* 2003), inhibit human tumor cell proliferation (Reddy *et al.*, 2005) and antioxidant activities (Singh and Hathan, 2014).

2.4.3. Nutritional benefits of carrot

Carrot contains minerals such as Fe, Mg, Ca and P (Sharma *et al.*, 2012), bioactive compounds like carotenoids, phenolic compounds (Leja *et al.*, 2013) and carbohydrates, They are rich source of antioxidants like β carotene, possess anticarcinogenic and immune boosting properties (Fiedor and Burda, 2014).

Chu *et al.* (2002) reported that carrots release about half of their phytochemicals in the colon region. They contain phytochemicals, vitamins and provitamins which are important sources in preventing chronic diseases like cancer, diabetes and cardiovascular diseases (Jamuna *et al.*, 2011). Carotenoids present in carrots are source of antioxidants which can neutralize free radicals (da Silva, 2013).

Zaini *et al.* (2011) stated that falcarinol and β carotene in carrot can inhibit the progression and kill leukemia cells. da Silva (2014) reported that carrot juice possess anti-diabetic, anti-hypertensive, cholesterol lowering and cardiovascular disease lowering properties.

2.4.4. Cooking quality characteristics of enriched pasta

Bately and Curtin (2000) reported that protein quality of pasta and starch pasting properties influences cooking loss of pasta. Tudorica *et al.* (2002) stated that the uneven distribution of water in the macaroni matrix and fiber content disrupted the protein-starch network which resulted in an increase in cooking loss. Pasta enriched with inulin showed an increase in cooking loss with increase in level of inulin addition (Brennan *et al.,* 2004). Manthey *et al.* (2008) reported that non-wheat ingredients led to discontinuous gluten matrix which eventually weakened dough properties which resulted in high cooking loss of extruded products. Total solids present in the gruel after cooking of macaroni was referred as cooking loss by Fu (2008) and Tan *et al.* (2008). Perez and Perez (2009) reported an increased in cooking loss with addition of cassava flour and beetroot juice in conventional wheat pasta. Incorporation of mango peel powder in macaroni increased the cooking loss from 5.84% to 8.71% (Ajila *et al.,* 2010). . Cooking loss of pasta enriched with flaxseed flour was in the range of 6.10 to 9.45g $100g^{-1}$ was recorded by Konidena (2011). Aravind *et al.* (2012) reported that the starch-gluten network of the non-conventional pasta will be negatively affected by allowing the leaching of more gelatinized starch from the non-conventional pasta during cooking. Padalino *et al.* (2013) in a study on incorporating semolina pasta with yellow pepper flour found an increase in cooking loss due to starch gelatinization. In a comparative study of carrot, beetroot, tomato and spinach puree enriched pasta by Rekha *et al.* (2013) tomato enriched puree showed the highest cooking loss of 8.4% which was followed by beetroot pasta with 7.4% and carrot and spinach pasta with 7.1%. Elderberry juice on addition to semolina pasta recorded a cooking loss of 5.98 to 8.06% (Sun-Waterhouse *et al.*, 2013). An increased cooking loss on addition of chickpea and quinoa flour was observed by Slinkard (2014).Pasta enriched with millet flour and carrot pomace recorded an increase in cooking loss of 10.00% to 24.40% (Gull *et al.,* 2015). Ovando-Martinez *et al.* (2009) reported that the cooking loss of unripe banana flour enriched spaghetti increased with increase in level of substitution of banana flour. According to Padmaja *et al.* (2015) cooking loss of pumpkin fortified cassava-maida pasta ranged from 9.77% to 11.10% and pumpkin fortified cassava- rice pasta ranged from 9.10% to 10.24%. Cassava with carrot and beetroot as additives showed a cooking loss ranging from 7.55 to 14.54%.There was a significant increase in the cooking loss of the amaranth flour substituted pasta with the increase in level of substitution of amaranth leaf flour (Cardinas-Hernandez *et al*., 2016). Padalino *et al.* (2017) revealed that the cooking loss of tomato peel enriched spaghetti ranged from 9.00% to 9.30% which was lower than the control pasta. Minarovičová *et al.* (2018) reported an increase in cooking loss with increase in addition of celery root powder and sugar beet pulp powder.

Incorporation in pasta will lead to dilution of gluten network which helps diffusion of water easily through the dough matrix thereby reducing the cooking time (Chillo *et al.,* 2007). Cooking time of wheat pasta decreased with the addition of dried amaranthus leaf flour (Borneo and Aguirre, 2008). Pasta enriched with carrot leaf meal showed an increase in water absorption with increase in leaf meal concentration in pasta (Boroski *et al.,* 2011*)*. Aravind *et al*. (2012) reported reduction in cooking time of non-conventional pasta which is probably due to the reduction of gluten content and resulting inhibition of gluten development. Giménez *et al.* (2012) revealed that with the cooking time of spaghetti enriched with 35% broad bean flour was lesser than the control wheat spaghetti. Decrease in water absorption (131%) of spaghetti enriched with yellow pepper flour compared to the control spaghetti (141%) was observed by (Padalino *et al*., 2013). According to Abraham and Jayamuthunagai (2014) jackfruit seed flour possess good water absorption capacity. Rekha *et al.* (2013) reported lesser cooking time for pasta enriched with vegetables like carrot, beetroot, amaranthus and tomato. Sun-Waterhouse *et al.* (2013) explained that the amount of water absorbed by pasta is determined by the openness in the gluten structure of pasta and increase in elderberry juice concentrate in the wheat pasta led to increase in water absorption of the developed pasta. In a study conducted by Cemin *et al.* (2014) on enriching fresh pasta with broccoli leaves and spinach leaves water absorption of 183.9 and 182.6% was observed. Water absorption of pasta developed with multigrain flour decreased upon addition of non-wheat ingredients and it ranged from 260.30 to 158.60% (Gill, 2014). A decrease in cooking time of 11.5 minutes was observed for quinoa fortified pasta by Slinkard (2014).Marinelli *et al.* (2015) stated a decrease in cooking loss for grape marc enriched spaghetti compared to the control spaghetti. Cardinas-Hernandez *et al.* (2016) reported that with the addition of amaranth leaf flour to the conventional wheat pasta the cooking time of the non-conventional pasta decreased. Cooking time of pasta enriched with ginger powder was found to be less than the control samples (Mishra and Bhatt, 2016). Pasta enriched with celery root pasta and sugar beet pulp powder showed an increased cooking time of 4.80 to 6.75% and 6.52 and 6.68% respectively and the cooking time decreased with increase in addition of additives (Minarovičová *et al.*, 2018).

Swelling index ranged from 1.06% to 3.15% with no significant difference among the treatments. In a study conducted by Ajila *et al.* (2010) on incorporating mango peel powder in macaroni observed decrease in swelling index with increase in concentration of mango peel incorporated. Konidena (2011) reported a swelling index of 2.71 to 4.56g g^{-1} for pasta enriched with flaxseed flour. Swelling capacity of sweet potato flour incorporated sorghum pasta ranged from 4.79 to 5.21ml g^{-1} which was higher than the control sorghum pasta with 4.49 ml g^{-1} swelling index (Beerelly, 2012). da Silva (2013) reported 7.6 times increase in swelling index of broccoli enriched pasta. Swelling index of gluten free pasta increased with addition of yellow pepper flour to the pasta (Padalino *et al.*, 2013).Study conducted by Rekha *et al.* (2013) on influence of vegetable purees on quality attributes of pasta reported that beetroot enriched bread wheat pasta had a higher swelling index of 1.53% when compared to carrot (1.44%), spinach (1.32%) and tomato (1.24%) puree enriched pasta. Marinelli *et al.* (2015) reported a reduction in swelling index with the addition of grape marc in spaghetti. Swelling index of pumpkin fortified cassava pasta ranged from 2.24 to 2.41% in cassava- maida pasta and 2.03 to 2.56% in cassava- rice pasta (Padmaja *et al.*, 2015).They also reported that the swelling index of cassava pasta with carrot and beetroot as additives ranged from 1.72 to 2.51%. Padalino *et al.* (2017) reported that swelling index of tomato peel enriched spaghetti was lesser when compared to the conventional wheat spaghetti.

Functional properties of food stuff possess a direct relation with the hydration, dispersibility, water absorption and viscosity in foods. Borneo and Aguirre (2008) reported a cooking time of 3.1min for pasta enriched with dried amaranth leaf flour. According to Beerelly (2012) cooking time of sorghum pasta decreased with the addition of sweet potato flour and it ranged from 11 to 13 min. With the increase in level of substitution of broad bean flour in the spaghetti there was an increase in level of cooking loss Giménez *et al.* (2012). In a study conducted by Padalino *et al.* (2013) on developing gluten free spaghetti with incorporation of vegetables, it was found that addition of yellow pepper flour decreased the optimum cooking time than the control pasta. According to Rekha *et al.* (2013) on comparing the different vegetable puree enriched bread wheat pasta, beetroot puree enriched pasta showed a higher water absorption of 118.80% followed by carrot (116.50%), spinach (116.30%) and tomato (105.80%) puree enriched pasta. Cemin *et al.* (2014) observed a water absorption of 183.90% and 182.60% for broccoli and spinach leaf enriched pasta. Das (2014) reported a cooking time of 12.50 min for pasta prepared from jackfruit pulp. Pasta enriched with multigrain recorded an increase (7.05 min to 8 min) in cooking time as compared to pasta made from durum wheat semolina which might be due to the decrease in amount of wheat and increase in proportion of other cereals used in pasta (Gill, 2014). Addition of grape marc to the spaghetti decreased the water absorption of spaghetti (Marinelli *et al.,* 2015).Cooking time of pasta developed using non wheat whole grains ranged between 10.30 to 12.02 min was reported by Dolly (2016). Padalino *et al.* (2017) reported a decrease in water absorption in tomato peel enriched spaghetti compared to the control pasta ranging from 140.00% to 158.00%. Pasta enriched with celery root powder ranged between 60.16% to 76.53% and sugar beet pulp powder 70.10% 76.21% (Minarovičová *et al.,* 2018).

2.4.5. Nutritional parameters of enriched pasta

Ovando-Martinez *et al.* (2009) observed increase in starch content from 72.48% to 78.90% in pasta enriched with unripe banana flour. Prabhashankar *et al.* (2009) reported a decrease in carbohydrate content on addition of Japanese sea weed. Pasta enriched with mango peel powder increased the carbohydrate content of pasta upto 80.70% (Ajila *et al.,* 2010). Petitot *et al.* (2010) observed a starch content of 44.4 and 47.9g $100g^{-1}$ for pasta enriched with faba bean and split pea flour. A decrease in starch content with addition of broccoli leaves was observed by da Silva (2013).These results are in line with the findings of Devi (2015) in the development of jackfruit pasta using jackfruit bulb and seed flour where pasta developed from jackfruit bulb showed a higher carbohydrate content than pasta developed from jackfruit seed flour. Carbohydrate content of 66.57g $100g^{-1}$ to 68.89g $100g^{-1}$ was observed in millet flour and carrot pomace enriched pasta (Gull *et al.*, 2015). An increase of starch content and total sugars were observed in a study on enriching pasta with cassava flour and effect of different starches in enhancing the resistant starch content of sweet potato spaghetti by Padmaja *et al.* (2015) and reported that addition of lentil starch, black gram starch and sweet potato starch increased the starch content of the pasta and it ranged from 72.19 to 81.30%. Cardinas-Hernandez *et al.* (2016) observed a decrease in carbohydrate content with the addition of amaranthus leaf flour in pasta. Incorporation of non-wheat whole grains in pasta led to decrease in carbohydrate content of conventional pasta and it ranged from 63.10 to 63.26% (Dolly, 2016). Starch content decreased with increase in addition of quinoa flour in pasta (Lorusso *et al.*, 2016).Nataraja (2018) in a study on developing pasta with sprouted grains reported a decrease (65.62 to 69.71%) in carbohydrate content of pasta as compared to the control pasta (72.12%) with increase in concentration of sprouted grains.

Pasta enriched with Japanese seaweed, wakame (*Undaria pinnatifida*) recorded an increase in protein content of 18.92 to 21.68% with increase in sea weed concentration (Prabhashankar *et al.,* 2009). Increase in protein content of 3.6% was observed on addition of mango peel powder by Ajila *et al.* (2010). Jackfruit seed is a rich source of protein and Ocloo *et al.* (2010) reported 13.50% of protein in jackfruit seed flour. Pasta enriched with split pea and faba bean flour recorded an increased protein content of 21.4 to 29g $100g^{-1}$(Petitot *et al.,* 2010). Giménez *et al.* (2012) reported that with the increase in addition of broad bean flour to wheat flour the protein quality of the enriched pasta increased due to higher lysine content. The proposed ratio of leguminous: cereal protein being 30:70; 58% of protein substitution proved to be the greatest benefit. Rekha *et al.* (2013) reported that there was no variation in the protein content of the different vegetable puree enriched pasta. Das (2014) developed jackfruit pasta from jackfruit pulp reported a protein content of 8.05 g $100g^{-1}$. Slinkard (2014) reported an increase in protein content in pasta fortified with chickpea and quinoa flour. Protein content of 10.06 to 16.95g $100g^{-1}$ was observed for pasta developed from jackfruit bulb flour, jackfruit seed flour and cassava flour (Devi, 2015). Protein content of 0.70 to 7.3 g $100g^{-1}$ was observed by Gull *et al.* (2015) on enriching pasta with carrot pomace and millet flour. Kumari (2015), reported a protein content of 11.50% to 13.49% for noodles made from jackfruit bulb flour. According to Cardinas-Hernandez *et al.* (2016) the protein content of the pasta enriched with amaranth flour and amaranth leaves was higher compared to the semolina pasta. Protein content increased with the addition of quinoa flour on pasta (Lorusso *et al.*, 2016). Padalino *et al.* (2017) reported that there was a decrease in protein content in tomato peel enriched spaghetti compared to control spaghetti (10.00% to 10.35%).Minarovičová *et al.* (2018) reported a protein content of 7.72% for celery root powder enriched pasta and 10.31% for sugar beet pulp powder enriched pasta. Nataraja (2018) stated that an increase in protein content in wheat pasta could be observed with the addition of sprouted grains in pasta.

Addition of mango peel powder at 2.5,5 and 7.5% increased the carotenoid content to 26.5,41 and 84 µg $100g^{-1}$ (Ajila *et al.*, 2010).Beerelly (2012) observed an increase in orange colour of sweet potato flour enriched sorghum pasta due to the increase in carotenoid content in sweet potato. Rekha *et al.* (2013) reported an increase in carotenoid content with addition of vegetable purees like carrot, beetroot, amaranthus and tomato. Das (2014) reported an increase in β carotene content for jackfruit pulp incorporated pasta. Padmaja *et al.* (2015) found that the total carotenoids in the pumpkin fortified cassava pasta ranged from1.5 to 1.8 mg $100g^{-1}$. Cassava pasta with carrot and beetroot as additives reported a retention of 65% carotenoid after one month of storage. Padalino *et al.* (2017) reported that incorporation of tomato peel into spaghetti samples increased the carotenoid content of the spaghetti with increase in level of substitution.

Jackfruit bulb and seed flour are rich source of fibre and Ocloo *et al.* (2010) reported a crude fibre content of 3.16% in jackfruit seed flour. Fibre content of pasta enriched with split pea and faba bean flour increased to 13.4 and 7.3 g $100g^{-1}$ (Petitot *et al.*, 2010) . With the addition of every 10% of broad bean flour, fibre content in spaghetti increased by 2% (Giménez *et al.,* 2012). Spinach enriched pasta had a higher fibre content of 3.3% when compared to carrot (2.9%), tomato (2.9%) and beetroot (2.7%) enriched pasta (Rekha *et al.,* 2012). Pasta prepared from jackfruit pulp recorded a crude fibre content of 1.61g $100g^{-1}$ (Das, 2014). Spinach enriched pasta had a higher fiber content of 3.3% when compared to carrot (2.9%), tomato (2.9%) and beetroot (2.7%) enriched pasta. An increase in fiber content with increase in chickpea flour was observed by Slinkard (2014).Devi (2015) recorded a crude fibre content in the range of 3.54% to 4.50% for jackfruit pasta. Kumari (2015) reported that crude fibre content of jackfruit noodles ranged from 4.57% to 5.42%. Fibre content of the pasta incorporated with amaranth flour and amaranth leaves were higher compared to the conventional semolina pasta (Cardinas-Hernandez *et al.*, 2016). Mishra and Bhatt (2016) reported an increase in fiber content on addition of ginger powder. Lorusso *et al.* (2016) stated a decrease in fiber content with the addition of quinoa flour. Fibre content of the tomato peel enriched spaghetti found to increase from 16.80% to 22.67% compared to the control samples (Padalino *et al.,* 2017). Addition of micronutrients in conventional pasta enhanced the fibre content of pasta from 7.61 to 22.32% (Sharma, 2017) .Fibre content of pasta increased with the addition of sprouted whole grains like wheat, maize, soybean and bengal gram and it ranged from 8.76 to 9.23% (Nataraja, 2018).

Gupta *et al.* (2011) reported that jacalin present in the seeds of jackfruit is a rich source of antioxidant. Jackfruit bulb and seeds are considered as an excellent source of antioxidants as reported by Shanmugapriya *et al.* (2011); Gat and Ananthanarayan (2015); Maurya and Mogra (2016) which might have contributed to the increased antioxidant activities of developed jackfruit pasta. Pasta enriched with elderberry juice concentrate showed an increase in antioxidant activity compared to the control samples (Sun-Waterhouse *et al.,* 2013). The anti-oxidant capacity of unripe banana flour enriched pasta increased with increase in level of substitution (Ovando-Martinez *et al.,* 2015).Marinelli *et al.* (2015) also reported an increase in antioxidant content with addition of grape marc in spaghetti. Cardinas-Hernandez *et al.* (2016) reported that there was an increase in total phenolic content in amaranth flour and amaranth leaf incorporated pasta compared to the conventional semolina pasta which will eventually contribute to the increase in antioxidant activity of the incorporated pasta. Antioxidant capacity of the incorporated pasta decreased during the cooking process compared to the semolina pasta. The smaller size of the amaranth starch granules are more water soluble than the wheat starch granules which produces bioactive compounds in food matrix which can be leached during the cooking process. Sęczyk *et al.* (2015) reported that addition of parsley leaves in wheat pasta increased the antioxidant potential of the pasta with increase in concentration of leaf incorporated. Armellini *et al.* (2018)

reported an increase in antioxidant activity of pasta enriched with saffron (*Crocus sativus L.*).

2.4.6. Textural characteristics

Edwards *et al.* (1993) reported that internal structure of the cooked product decides hardiness of pasta and surface properties determines adhesiveness of pasta. Texture of the pasta is determined by gelatinization of starch and coagulation of protein (Steffe, 1996). Brennan *et al.* (2004) in a study on enriching pasta with inulin reported a decrease in pasta firmness with addition of inulin. del Nobile *et al.* (2005) observed that the protein level in the pasta has influence of the hardness of pasta. Firmness of pasta enriched with broad bean flour increased with incorporation (Giménez *et al.*, 2012). Rekha *et al.* (2013) stated that firmness of pasta decreased with the addition of vegetable purees *viz.*, carrot, tomato, beetroot and amaranthus. Pasta fortified with chickpea and quinoa flour showed an increased hardness and adhesiveness and decreased firmness with the increase in concentration of quinoa flour (Slinkard, 2014). Yadav *et al.* (2014) reported that the firm texture of vegetable incorporated pasta is due to the addition of non-starchy nature of vegetables. An increase in hardness for quinoa enriched pasta was observed by Lorusso *et al.* (2016). The tomato peel spaghetti showed poor and higher firmness compared to control pasta. (Padalino *et al.*, 2017).

2.4.7. Sensory qualities

Boroski *et al.* (2011) reported that sensory acceptance of pasta enriched with oregano and carrot leaf meal decreased with increasing concentration of oregano and carrot leaf meal. Rekha *et al.* (2013) in a study on enriching pasta with vegetable purees observed that appearance, mouthfeel and overall acceptability was the highest for pasta enriched with carrot puree compared to beetroot, amaranth and tomato pasta. Gill (2014) reported a decrease in sensory acceptance of pasta enriched with multigrain in terms of appearance, texture, flavour and acceptability compared to control durum wheat pasta. Pasta enriched with chickpea and quinoa flour showed a decreased consumer acceptance when compared to the control pasta (Slinkard, 2014).A slight decrease in overall accessibility of grape marc enriched pasta was observed by Marinelli *et al.* (2015). Cardinas-Hernandez (2016) reported there was a decrease in acceptance of pasta incorporated with amaranth flour and amaranth leaf with increase in concentration. Pasta enriched with tomato peel showed significantly lower sensory quality compared to traditional semolina pasta. Padalino *et al.*(2017) found that there was an increase in elasticity and adhesiveness for tomato peel enriched pasta compared to control pasta and a decrease in overall acceptability compared to the control pasta. Addition of non-wheat ingredients in pasta led to decreased sensory acceptance in studies conducted by Sharma (2017) and Nataraja (2018).

2.4.8. Storage stability characteristics

Storage stability studies of macaroni enriched with wheat germ for cooking quality characteristics was studied by Ilkay- Pinarli *et al.* (2004). Cooking quality remained constant and sensory score remained acceptable for storage period for noodles with cocoa, wheat and mung flour, pasta with variable cereal bran (Payumo *et al.*, 1969; Kaur *et al.*, 2011).For cooking time, cooking loss, water absorption and swelling index there was no significant difference observed during the storage period (Manthey *et al.*, 2008; Kaur *et al.*, 2011).

Decrease in carotenoid content during storage for sweet potato and soy flour added noodles was observed by Pangloli *et al.* (2000). Herken *et al.* (2007) reported decrease in total antioxidant activity of macaroni enriched with cowpea flour during storage of six months. Wani *et al.* (2011) reported decrease in crude fibre content, protein content and carbohydrate content during storage of roasted wheat and cauliflower leaf powder noodles. Yadav *et al.* (2014) reported that vegetable blended pearl millet pasta recorded acceptable sensory quality throughout the storage period of three months.

Yadav *et al.* (2014) analyzed total microbial count of pearl millet pasta enriched with vegetables and found that yeast and mold count were absent throughout the storage period. Kumari (2015) reported that there was no bacterial and fungal growth observed for noodles enriched with jackfruit during the first month of storage period but an increase in fungal growth was observed during second and third months of storage period.

Materials and Methods

3. MATERIALS AND METHODS

The materials used and methodologies adopted during the investigation "Development of functional jackfruit pasta" conducted with the objective to develop functional pasta from jackfruit bulb (flakes) and seed flour enriched with vegetables and to evaluate the quality of the product during storage are described in this chapter.

3.1 DEVELOPMENT OF JACKFRUIT PASTA

The experiment was conducted at Department of Post Harvest Technology, College of Agriculture, Vellayani, Kerala Agricultural University, Thiruvananthapuram during the year 2017-2019.

3.1.1. Selection of raw materials

Fully matured varikka jackfruit (90-110 days after fruit set) of good quality were taken from Instructional farm, Vellayani. The bulb (flakes) and seeds were separated, blanched, dried and powdered to get jackfruit bulb (flakes) flour and seed flour.

3.1.2. Preparation of flour

3.1.1.1 Preparation of jackfruit seed flour

The fresh and fully matured but un-ripened jackfruits were selected; bulb (flakes) and seeds were separated by cutting the fruit. Jackfruit seeds were washed and the outer cover was removed blanched, dried in hot air oven at 60-70°C and pulverized to fine powder (Plate 1).

3.1.1.2 Preparation of jackfruit bulb (flakes) flour

JACKFRUIT BULB (FLAKES)

JACKFRUIT SEED

DRIED JACKFRUIT BULB

DRIED JACKFRUIT SEED

PASTA DOUGH

Plate 1. Preparation of jackfruit pasta

The separated jackfruit bulb (flakes) were washed and made into uniform sized small pieces, blanched, dried in hot air oven at 60-70°C and pulverized to fine powder.

3.1.1.3 Preparation of cassava flour

Cassava tubers harvested from CTCRI, Sreekaryam were cleaned and outer and inner skin was removed manually. Then the tubers were washed and grated using 'Tapioca french fry cutter'. The grated cassava was sun dried till they become ready for powdering. Later it was pulverized into fine powder in cassava grinding machine.

3.2 DEVELOPMENT OF JACKFRUIT PASTA

Jackfruit bulb (flakes) flour and seed flour were used for the development of jackfruit pasta in different combinations along with cassava flour replacing a portion of refined flour contributing to 65% of total ingredients. The remaining 35% of total ingredients will be kept as constant with refined wheat flour, soy flour and cassava starch which were procured from supermarket (Plate 2).

T1 Jackfruit bulb (flakes) flour (30%) + cassava flour (35%)

T2 Jackfruit bulb (flakes) flour (40%) + cassava flour (25%)

T3 Jackfruit bulb (flakes) flour (50%) + cassava flour (15%)

T4 Jackfruit seed flour (30%) + cassava flour (35%)

T5 Jackfruit seed flour (40%) + cassava flour (25%)

T6 Jackfruit seed flour (50%) + cassava flour (15%)

T 7 Jackfruit bulb (flakes) flour (15%) + Jackfruit seed flour (15%) + cassava flour (35%)

Plate 2. Developed jackfruit pasta

T8 Jackfruit bulb (flakes) flour (20%) + Jackfruit seed flour (20%) + cassava flour (25%)

T9 Jackfruit bulb (flakes) flour (25%) + Jackfruit seed flour (25%) + cassava flour (15%)

T10 Jackfruit bulb (flakes) flour (10%) + Jackfruit seed flour (30%) + cassava flour (25%)

T11 Jackfruit bulb (flakes) flour (20%) + Jackfruit seed flour (30%) + cassava flour (15%)

T12 Jackfruit bulb (flakes) flour (30%) + Jackfruit seed flour (20%) + cassava flour (15%)

The kneaded pasta dough was extruded using single screw extruder La Monferrina s.r.l. Costell'Alfero (AT) Italy (Plate 4) with die for tubular pasta and cut into 2.5 cm length. The pasta were dried at 50^0C in hot air oven (Kemi Hot Air Oven, India) till the moisture content reached to 7 to 8%.

Developed jackfruit pasta were analysed for cooking quality characters. Nutritional and textural qualities were analysed for both raw (uncooked) and cooked jackfruit pasta and sensory qualities were analysed for cooked pasta. Cooking quality, and nutritional parameters were analysed for commercially available pasta purchased from super market.

3.2.1. Cooking quality of jackfruit pasta

Cooking quality of jackfruit pasta was determined based on the parameters, cooking loss, water absorption, swelling index and cooking time.

3.2.1.a Cooking loss (%)

Quantification of cooking loss is important to assess the quality of pasta and was determined by the method of Debbouz and Doetkott (1996) as described by Padmaja (2015). The water drained after cooking is separately dried in pre-weighed petri dishes and kept in an oven at 105°C for overnight drying. The weight of the dry residue is quantified (W2 g).

$$\text{Cooking loss (\%)} = \frac{W2 \times 100}{W1}$$

, where W1 is the initial weight of the pasta.

3.2.1.b Water absorption (g g-1)

Water absorption of pasta was analysed according to Cleary and Brennan (2006). Water absorption is the difference in weight of cooked pasta and uncooked pasta, expressed as the percentage of weight of uncooked pasta. Cooked pasta were rinsed with water and drained, then weighed to determine the gain in weight.

$$\text{Water absorption} = \frac{\text{Final weight of cooked pasta} - \text{Weight of raw pasta}}{\text{Weight of raw pasta}}$$

3.2.1.c Swelling index (%)

Swelling index of pasta was determined by the method described by Cleary and Brennan (2006). Approximately 50g of the dried pasta (W1) was cooked and the water is drained to a pre-weighed beaker. The cooked pasta is surface dried over a cloth and weight of the cooked pasta (W2) is taken.

$$\text{Swelling index} = \frac{W2 - W1}{W1}$$

3.2.1.d Cooking time (minutes)

Cooking quality of pasta were analysed according to Ojure and Quadri's method (2012). Ten gram of pasta were coked in 300 ml of boiling water in a covered beaker. Cooking time was determined by removing a piece of pasta every 2 minutes and pressing them between two pieces of glass slides. Optimum cooking was achieved when the centre of pasta became transparent or when the pasta were fully hydrated.

3.2.2. Nutritional parameters of jackfruit pasta

3.2.2.a. Starch (%)

The starch content was expressed as per cent in terms of invert sugar according to the following formula (Ranganna, 1986).

$$\text{Starch} = \frac{\text{Glucose Eq. (0.05) x Total volume made up (mL) x amount of starch in 1g solution (g) x 100}}{\text{Titre value (V) x Weight of sample taken (g)}}$$

3.2.2.b. Total sugar (%)

The total sugar content was expressed as per cent in terms of invert sugar according to the following formula (Ranganna, 1986).

$$\text{Total sugar} = \frac{\text{Glucose Eq. (0.05) xTotal volume made up (mL) x Volume made up after inversion (mL) x 100}}{\text{Titre valuex Weight of sample taken (g) x Aliquot taken for inversion (mL)}}$$

3.2.2.c. Reducing sugar (%)

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The titrimetric method of Lane and Eynon as described by Ranganna (1986) was adopted for the estimation of reducing sugar.

$$\text{Reducing sugar} = \frac{\text{Glucose Eq. (0.05) x Total volume made up (mL) x 100}}{\text{Titre value (mL) x Weight of the sample (g)}}$$

3.2.2.d. Protein (%)

Protein content of the jackfruit pasta was estimated using the method described by Bradford (1976). Amount of protein present in the sample was calculated by plotting a standard curve using the standard protein absorbance against the concentration obtained. From the graph the amount of protein present in the sample can be calculated.

3.2.2.e. Carotenoids (µg 100g⁻¹)

Carotenoids were estimated as per the procedures of Saini *et al.* (2001) and expressed as $\mu g\ 100g^{-1}$ of treated fruit.

3.2.2.f. Crude fibre (%)

Crude fibre content of the jackfruit pasta was estimated using the method described by Sadasivam and Manickam (1992). Percentage of crude fibre in the sample was calculated as follows:

$$\text{\% of Crude fibre} = \frac{\text{Loss in weight in ignition } \{(W_2-W_1) - (W_3-W_1)\} \times 100}{\text{Weight of the sample}}$$

W_1 - Weight of crucible

W_2 - Weight of crucible and sample after two hours

W_3 – Final weight of crucible

3.2.2.g. Antioxidant activity (%)

Total antioxidant activity of jackfruit pasta was determined using 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay. The scavenging effect on DPPH free radical was measured according to the procedure described by Sharma and Bhat (2009).

Pasta sample (1 g) was added to 2.0 mL 0.1 mM DPPH solution, mixed thoroughly and left for 30 minutes at room temperature. The absorbance was read at 517 nm. Scavenging effect was expressed as percent inhibition of DPPH as shown in the following equation:

$$\%\ \text{inhibition of DPPH} = \frac{\{A_{blank} - A_{sample}\} \times 100}{A_{blank}}$$

Where,

A_{blank} – Absorbance of DPPH solution without sample, read against ethanol blank.

A_{sample} – Absorbance of the test sample after 30 min.

3.2.3. Textural characteristics

The firmness of the jackfruit pasta was measured using a texture analyser TA.HD plus (Stable Microsystems, England) (Plate 3) using using compression mode. The machine was calibrated using the following test conditions.

Test mode – measure force in compression

Plate 3. Texture analyzer

Plate 4. Pasta making machine

Pre-test speed – 1 mm s^{-1}

Test speed – 1 mm s^{-1}

Post-test speed – 10 mm s^{-1}

Distance – 25 mm

Trigger force – 5g

Strain – 75%

After calibration of the equipment, the test was performed repeatedly for three samples. The compression test was carried out using HDP/LKB light knife blade probe to plot a corresponding force deformation curve. The maximum force obtained during probe travel was used as a measure of texture as pasta firmness and expressed in Newton (N) and the area under the curve in the graph is taken as the Toughness and expressed in Newton second (Ns).

3.2.4. Sensory qualities

Jackfruit pasta developed by different treatments were evaluated for sensory characteristics *viz*., appearance, taste, colour, flavour, odour, texture, elasticity, adhesiveness, mouthfeel and overall acceptability by 30 member semi trained panel comprising of research scholars of College of Agriculture, Vellayani. The panel were asked to score the appearance, taste, colour, flavour, odour, texture, elasticity, adhesiveness, mouthfeel and overall acceptability of the sample using 9-point hedonic scale (Ranganna, 1986) in the order of preference as shown below.

Like extremely -9

Like very much -8

Like moderately -7

Like slightly -6

Neither like nor dislike -5

Dislike slightly -4

Dislike moderately -3

Dislike very much -2

Dislike extremely -1

The score was statistically analysed using Kruskall-Wallis test (chi-square value) to find out whether treatments differed significantly (Shamrez *et al.*, 2013).

Based on cooking quality, textural, nutritional and sensory parameters, three best jackfruit pasta combinations were selected for the development of vegetable based functional jackfruit pasta.

3.2.5. Statistical analysis

The data generated from the experiment were statistically analysed using Completely Randomised Design (CRD). The sensory scores were statistically analysed using Kruskall-Wallis test (chi-square value) to find out whether treatments differed significantly (Shamrez *et al.*, 2013).

3.3 DEVELOPMENT OF VEGETABLE ENRICHED JACKFRUIT PASTA

The best three treatments selected from Part I of the study were taken for Part II of the experiment. Vegetables viz. carrot, beet root and red amaranthus were incorporated as paste to the selected combinations of jackfruit pasta @ 5 and 10 % (Plate 5).

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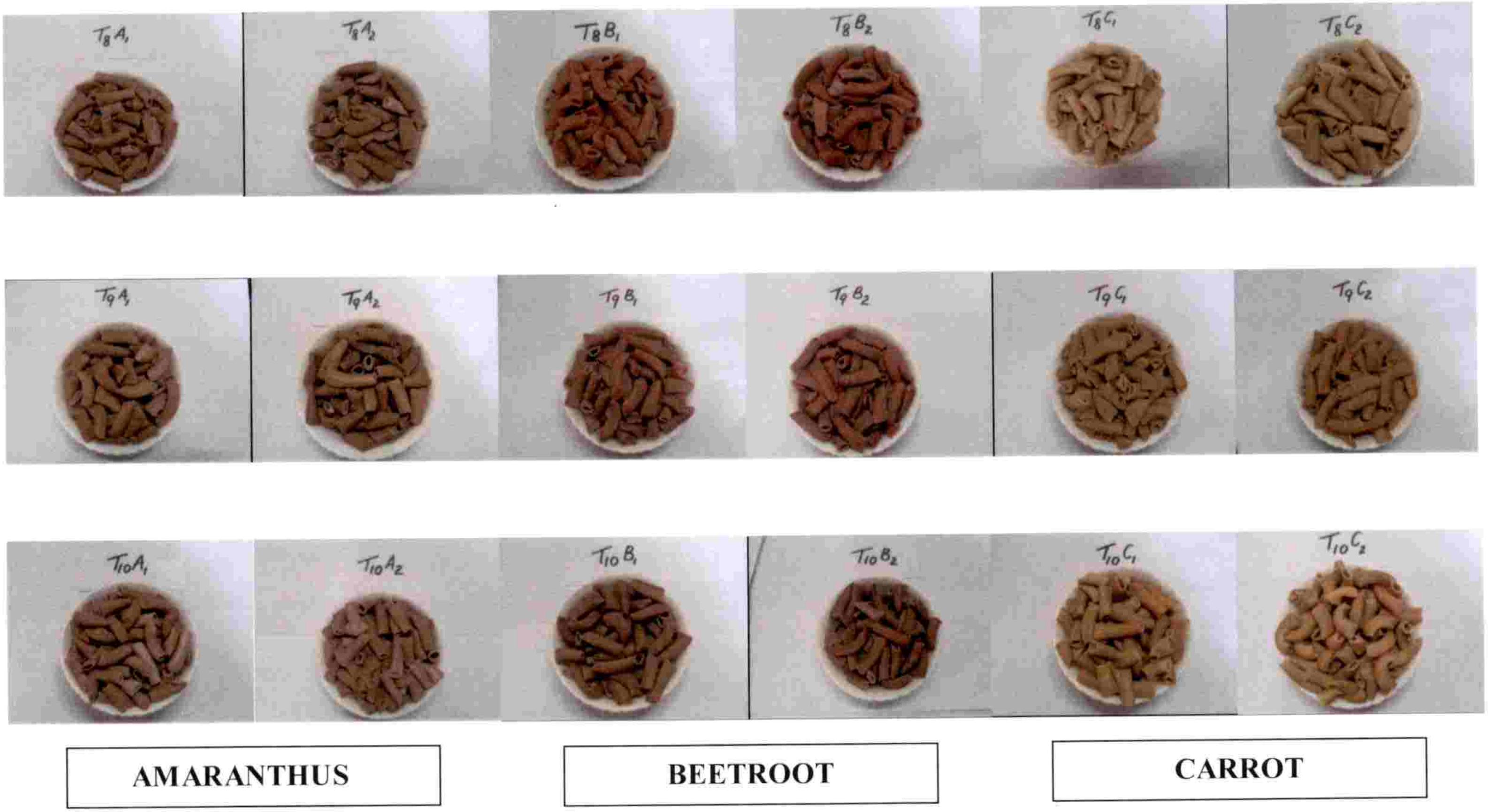

Plate 5. Vegetable based functional jackfruit pasta

3.3.1 Cooking quality of vegetable enriched jackfruit pasta

3.3.1.a. Cooking loss (%)

Cooking loss of the vegetable enriched pasta were calculated as described in 3.2.1.a.

3.3.1.b. Water absorption (%)

Water absorption of the vegetable enriched pasta were calculated as described in 3.2.1.b.

3.3.1.c. Swelling index (%)

Swelling index of the vegetable enriched pasta were calculated as described in 3.2.1.c.

3.3.1.d. Cooking time (minutes)

Cooking time of the vegetable enriched pasta were calculated as described in 3.2.1.d.

3.3.2 Nutritional parameters of vegetable enriched jackfruit pasta

3.3.2.a. Starch (%)

Starch content of the vegetable enriched pasta were calculated as described in 3.2.2.a.

3.3.2.b. Total sugar (%)

Total sugar content of the vegetable enriched pasta were calculated as described in 3.2.2.b.

3.3.2.c. Reducing sugar (%)

Reducing sugar content of the vegetable enriched pasta were calculated as described

3.3.2.d. Protein (%)

Protein content of the vegetable enriched pasta were calculated as described in 3.2.2.d.

3.3.2.e. Carotenoids (μg 100g^{-1})

Carotenoids content of the vegetable enriched pasta were calculated as described in 3.2.2.e.

3.3.2.f. Crude fibre (%)

Crude fibre content of the vegetable enriched pasta were calculated as described in 3.2.2.f.

3.3.2.g. Antioxidant activity (%)

Antioxidant activity in terms of DPPH assay (radical scavenging activity) for the vegetable enriched pasta were calculated as described in 3.2.2.g.

3.3.3. Textural characteristics

Textural characteristics of the vegetable enriched pasta were calculated as described in 3.2.3.g

3.3.4. Sensory qualities

Sensory evaluation of the vegetable enriched pasta were calculated as described in 3.2.4.

3.4 STORAGE STUDIES OF VEGETABLE ENRICHED PASTA

The three best functional jackfruit pasta obtained from Part II of the study were analysed for storage stability for 4 months. The developed pasta were packed in polypropylene and stored under room temperature. Pasta quality, nutritional, microbial and sensory analyses were done at monthly interval for a period of 4 months.

3.4.1 Cooking quality of vegetable enriched jackfruit pasta

3.4..1.a. Cooking loss (%)

Cooking loss during storage were calculated as described in 3.2.1.a.

3.4.1.b. Water absorption (%)

Water absorption during storage were calculated as described in 3.2.1.b.

3.4.1.c. Swelling index (%)

Swelling index during storage were calculated as described in 3.2.1.c.

3.4.1.d. Cooking time (minute)

Cooking time during storage were calculated as described in 3.2.1.d.

3.4.2 Nutritional parameters of vegetable enriched jackfruit pasta

3.4.2.a. Starch (%)

Starch content during storage were calculated as described in 3.2.2.a.

3.4.2.b. Total sugar (%)

Total sugar content during storage were calculated as described in 3.2.2.b.

3.4.2.c. Reducing sugar (%)

Reducing sugar content during storage were calculated as described

3.4.2.d. Protein (g)

Protein content during storage calculated as described in 3.2.2.d.

3.4.2.e. Carotenoids (μg $100g^{-1}$)

Carotenoids content during storage were calculated as described in 3.2.2.e.

3.4.2.f. Crude fibre (%)

Crude fibre content during storage were calculated as described in 3.2.2.f.

3.4.2.g. Antioxidant activity (%)

Antioxidant activity during storage were calculated as described in 3.2.2.g.

3.4.3. Textural characteristics

Textural characteristics during storage were calculated as described in 3.2.3.g

3.4.4. Sensory qualities

Sensory evaluation during storage were calculated as described in 3.2.4.

3.4.5. Evaluation of Microbial Counts during Storage

The quantitative assay of the micro flora in stored samples was carried out by serial dilution spread plate techniques. Nutrient agar and Rose Bengal agar medium were used for the enumeration of bacterial and fungal population of stored vegetable based functional jackfruit pasta.

$$\text{No. of colony forming units Per gram of samples} = \frac{\text{Total no. of colony formed x dilution factor}}{\text{Aliquot taken}}$$

Results

4. RESULTS

The experimental data collected for the present study on "Development of functional jackfruit pasta" were analyzed and the results are presented in this chapter under the following headings

4.1. Development of jackfruit pasta

4.2. Development of vegetable based functional jackfruit pasta

4.3. Storage stability studies of functional jackfruit pasta

4.1. DEVELOPMENT OF JACKFRUIT PASTA

Jackfruit bulb flour and seed flour were used for the development of jackfruit pasta in different combinations along with cassava flour replacing a portion of refined flour contributing to 65% of total ingredients. The remaining 35% of total ingredients were kept as constant with refined flour, soy flour and cassava starch.

Pasta developed from different combinations were subjected to analysis for cooking quality, textural, nutritional and sensory parameters. The commercial pasta from the market was analyzed for cooking quality and nutritional parameters.

4.1.1. Cooking quality of jackfruit pasta

Cooking quality of jackfruit pasta were analyzed based on the parameters; cooking loss (%), water absorption (g g^{-1}), swelling index (%) and cooking time (minutes) and are depicted in Table 1. The commercially available pasta recorded a cooking loss of 6.24%, 0.30g g^{-1} water absorption, 1.46% swelling index and a cooking time of 5.47% minutes.

4.1.1.1. Cooking loss (%)

Cooking loss of developed jackfruit pasta ranged from 14.16% to 21.97%. On comparing the treatments,T_7 [JBF (15%) + JSF (15%) + CF (35%)] showed the lowest cooking loss of 14.16%which showed no significant difference with the treatments T_1 [JBF (30%) + CF (35%)], T_2 [JBF (40%) + CF (25%)] and T_3 [JBF (50%) +CF (15%)].The highest cooking loss (21.97%) was observed for the treatment T_6 [JSF (50%) + CF (15%)].Cooking loss of commercially available pasta (control) was also determined and it was 6.24% only.

4.1.1.2. Water absorption (g g^{-1})

Water absorption of jackfruit pasta ranged from 0.80g g^{-1} to 1.34g g^{-1}.Among the treatments T_6 [JSF (50%) + CF (15%)] and T_5 [JSF (40%) + CF (25%)] showed the highest water absorption of1.34g g^{-1}which exhibited no significant difference with the treatments T_4 [JSF (30%) + CF (35%)],T_8 [JBF (20%) + JSF (20%) + CF (25%)], T_9 [JBF (25%) + JSF (25%) + CF (15%)], T_{10} [JBF (10%) + JSF (30%) + CF (25%)] and T_{11} [JBF (20%) + JSF (30%) + CF (15%)]. The lowest water absorption of 0.80g g^{-1} was observed for T_7 [JBF (15%) + JSF (15%) + CF (35%)] which showed no significant difference with the treatment T_1 [JBF (30%) + CF (35%)]whereas 0.30g g^{-1} water absorption was recorded by commercially available pasta.

4.1.1.3. Swelling index (%)

Swelling index of jackfruit pasta ranged from 1.38% to 2.86%. Among the treatments, T_6 [JSF (50%) + CF (15%)] had the highest swelling index of 2.86%which showed no significant difference with the treatments T_4 [JSF (30%) + CF (35%)], T_5 [JSF (40%) + CF (25%)] and T_{10} [JBF (10%) + JSF (30%) + CF (25%)].The lowest swelling index of 1.38% was noticed for T_1 [JBF (30%) + CF (35%)] whereas control pasta recorded a swelling index of 1.46%.

Table 1. Evaluation of cooking quality characters of jackfruit pasta

Treatments	Cooking loss (%)	Water absorption (g g^{-1})	Swelling index (%)	Cooking time (minutes)
T1 [JBF (30%) + CF (35%)]	14.18	0.94	1.38	6.32
T2 [JBF (40%) + CF (25%)]	15.01	1.02	1.70	6.33
T3 [JBF (50%) +CF (15%)]	15.08	1.09	1.73	6.48
T4 [JSF (30%) + CF (35%)]	18.98	1.27	2.69	7.15
T5 [JSF (40%) + CF (25%)]	19.02	1.34	2.76	7.31
T6 [JSF (50%) + CF (15%)]	21.97	1.34	2.86	7.44
T7 [JBF (15%) + JSF (15%) + CF (35%)]	14.16	0.80	1.47	6.12
T8 [JBF (20%) + JSF (20%) + CF (25%)]	16.09	1.19	1.78	6.56
T9 [JBF (25%) + JSF (25%) + CF (15%)]	16.50	1.19	2.18	6.57
T10 [JBF (10%) + JSF (30%) + CF (25%)]	18.89	1.25	2.58	6.60
T11 [JBF (20%) + JSF (30%) + CF (15%)]	16.69	1.21	2.23	6.58
T12 [JBF (30%) + JSF (20%) + CF (15%)]	16.01	1.10	1.75	6.55
SE (±m)	0.617	0.061	0.136	
CD (0.05)	1.813	0.180	0.399	NS

JBF- Jackfruit Bulb Flour JSF- Jackfruit Seed Flour CF- Cassava Flour

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4.1.1.4. Cooking time (minutes)

Cooking time for jackfruit pasta ranged from 6.12 min to 7.44 min with no significant difference among the treatments. The lowest cooking time was observed for T_7 [JBF (15%) + JSF (15%) + CF (35%)] with 6.12 min and the highest cooking time of 7.44 min was observed for the treatment T_6 [JSF (50%) + CF (15%)] even though the values were found statistically non-significant. Cooking time for commercial pasta was estimated as 5.47 min.

4.1.2. Nutritional parameters of jackfruit pasta

Nutritional parameters of jackfruit pasta *viz.,* starch, total sugar, reducing sugar, protein, carotenoid content, crude fibre and antioxidant activity were analyzed and depicted in Table 2. The nutritional parameters for raw and cooked commercially available pasta were also analyzed and given in Table 3.

4.1.2.1. Starch (%)

Starch content of raw jackfruit pasta ranged from 60.10% to 69.38%. The highest starch content of 69.38% was noticed for treatment T_{10} [JBF (10%) + JSF (30%) + CF (25%)] which showed no significant difference with the treatments T_1 [JBF (30%) + CF (35%)], T_5 [JSF (40%) + CF (25%)], T_6 [JSF (50%) + CF (15%)], T_7 [JBF (15%) + JSF (15%) + CF (35%)], T_8 [JBF (20%) + JSF (20%) + CF (25%)], T_9 [JBF (25%) + JSF (25%) + CF (15%)], T_{10} [JBF (10%) + JSF (30%) + CF (25%)] and T_{11} [JBF (20%) + JSF (30%) + CF (15%)]. The lowest starch content of 60.10% was registered for treatment T_3 [JBF (50%) +CF (15%)] which showed no significant difference with the treatments T_2 [JBF (40%) + CF (25%)], T_4 [JSF (30%) + CF (35%)] and T_{12} [JBF (30%) + JSF (20%) + CF (15%)].The commercial pasta recorded a starch content of 76.31%.

4.1.2.2. Total sugar (%)

Total sugar content of the jackfruit pasta were evaluated and it ranged from 5.09% to 7.22% with no significant difference among the treatments. Commercially available pasta recorded total sugar content of 4.13%.

4.1.2.3. Reducing sugar (%)

Reducing sugar content of the jackfruit pasta ranged from 3.24% to 5.40%.The highest reducing sugar content of 5.40% was recorded for the treatment T_3 [JBF (50%) +CF (15%)] which exhibited no significant difference with the treatments T_1 [JBF (30%) + CF (35%)], T_2 [JBF (40%) + CF (25%)],T_4 [JSF (30%) + CF (35%)], T_8 [JBF (20%) + JSF (20%) + CF (25%)]and T_9 [JBF (25%) + JSF (25%) + CF (15%)]. The lowest reducing sugar content (3.24%) was observed for treatment T_7 [JBF (15%) + JSF (15%) + CF (35%)] which was on par with the treatmentsT_6 [JSF (50%) + CF (15%)],T_{10} [JBF (10%) + JSF (30%) + CF (25%)], T_{11} [JBF (20%) + JSF (30%) + CF (15%)] and T_{12} [JBF (30%) + JSF (20%) + CF (15%)] and commercially available pasta recorded a reducing sugar content of 2.24%.

4.1.2.4. Protein (%)

` Protein content of jackfruit pasta ranged from10.08%to 14.99%. Treatment T_6 [JSF (50%) + CF (15%)] showed the highest protein content of 14.99% which showed no significant difference with treatmentsT_4 [JSF (30%) + CF (35%)], T_5 [JSF (40%) + CF (25%)], T_8 [JBF (20%) + JSF (20%) + CF (25%)], T_{10} [JBF (10%) + JSF (30%) + CF (25%)] and T_{11} [JBF (20%) + JSF (30%) + CF (15%)]. The lowest protein content of 10.08%was recorded for treatment T_7 [JBF (15%) + JSF (15%) + CF (35%)] which showed no significant difference with the treatments T_1 [JBF (30%) + CF (35%)],T_2 [JBF (40%) + CF (25%)], T_3 [JBF (50%) +CF (15%)], T_9 [JBF (25%) + JSF (25%) + CF (15%)]and T_{12} [JBF (30%) + JSF (20%) + CF (15%)]. The commercial pasta recorded a protein content of 8.60%.

4.1.2.5. Carotenoids (µg100g^{-1})

Carotenoid content of developed jackfruit pasta varied from 4.65 µg 100g^{-1} to 8.93 µg 100g^{-1}. The highest carotenoid content of 8.93 µg 100g^{-1} was recorded for treatment T_3 [JBF (50%) +CF (15%)] which exhibited significant difference with the treatments T_1 [JBF (30%) + CF (35%)] and T_2 [JBF (40%) + CF (25%)].The lowest carotenoid content was observed for the treatment T_4 [JSF (30%) + CF (35%)] with 4.65 µg 100g^{-1}which was on par with the treatments T_5 [JSF (40%) + CF (25%)], T_6 [JSF (50%) + CF (15%)] and T_{10} [JBF (10%) + JSF (30%) + CF (25%)]. Commercial pasta recorded a carotenoid content of 3.95 µg 100g^{-1}.

4.1.2.6. Crude fibre (%)

Fibre content of the jackfruit pasta ranged from 0.97% to 5.92%. The highest fibre content of 5.92% was noticed for the treatment T_3 [JBF (50%) +CF (15%)] which was on par with the treatments T_2 [JBF (40%) + CF (25%)] and T_1 [JBF (30%) + CF (35%)]. Treatment T_4 [JSF (30%) + CF (35%)] recorded the lowest fibre content of 0.97% which exhibited no significant difference with the treatments T_5 [JSF (40%) + CF (25%)], T_6 [JSF (50%) + CF (15%)], T_7 [JBF (15%) + JSF (15%) + CF (35%)] and T_8 [JBF (20%) + JSF (20%) + CF (25%)] whereas commercial pasta showed a fibre content of 1.20%.

4.1.2.7. Antioxidant activity (%)

Antioxidant activity of jackfruit pasta showed no significant difference among the treatments and it ranged from 88.26% to 91.60%. The highest antioxidant content was reported for the treatment T_6 [JSF (50%) + CF (15%)] with 91.60% and the lowest antioxidant content of 88.26% was reported for the treatment T_7 [JBF (15%) + JSF (15%) + CF (35%)] eventhough the difference was statistically non-significant.

Table 2. Evaluation of nutritional parameters of jackfruit pasta

Treatments	Starch (%)	Total sugar (%)	Reducing sugar (%)	Protein (%)	Carotenoids (µg $100g^{-1}$)	Crude fibre (%)	Antioxidant activity (%)
T1 [JBF (30%) + CF (35%)]	65.28	7.01	5.03	10.56	8.38	4.82	88.32
T2 [JBF (40%) + CF (25%)]	62.32	7.18	5.24	10.94	8.85	5.30	89.27
T3 [JBF (50%) +CF (15%)]	60.10	7.22	5.40	11.26	8.93	5.92	89.76
T4 [JSF (30%) + CF (35%)]	63.45	6.33	4.56	14.27	4.65	0.97	90.88
T5 [JSF (40%) + CF (25%)]	65.27	6.11	4.35	14.59	4.95	1.08	91.52
T6 [JSF (50%) + CF (15%)]	66.85	5.92	4.02	14.99	5.40	1.15	91.60
T7 [JBF (15%) + JSF (15%) + CF (35%)]	67.56	5.09	3.24	10.08	6.10	1.85	88.26
T8 [JBF (20%) + JSF (20%) + CF (25%)]	67.32	6.58	4.77	12.68	6.12	2.57	90.47
T9 [JBF (25%) + JSF (25%) + CF (15%)]	68.06	6.86	4.91	12.35	6.64	3.56	90.64
T10 [JBF (10%) + JSF (30%) + CF (25%)]	69.38	5.71	3.97	13.86	5.73	1.83	90.81
T11 [JBF (20%) + JSF (30%) + CF (15%)]	68.96	5.86	3.58	13.54	6.19	2.74	90.74
T12 [JBF (30%) + JSF (20%) + CF (15%)]	63.48	6.23	3.73	11.59	7.25	3.86	90.39
SE (± m)	1.515		0.290	0.875	0.298	0.505	
CD (0.05)	4.448	NS	0.852	2.568	0.876	1.481	NS

JBF- Jackfruit Bulb Flour JSF- Jackfruit Seed Flour CF- Cassava Flour

4.1.3. Nutritional parameters of cooked jackfruit pasta

Nutritional parameters of cooked jackfruit pasta were analyzed for starch, total sugar, reducing sugar, protein, carotenoids, crude fibre content and antioxidant activity and are depicted in Table 4.

4.1.3.1. Starch (%)

Starch content of cooked jackfruit pasta ranged from 22.52% to 53.28%. The highest starch content of 53.28% was noticed for treatment T_{10} [JBF (10%) + JSF (30%) + CF (25%)] which was at par with the treatment T_{11} [JBF (20%) + JSF (20%) + CF (25%)] with 50.06%. The lowest starch content of 22.52% was observed for the treatment T_3 [JBF (50%) +CF (15%)] which was found non-significant with the treatment T_2 [JBF (40%) + CF (25%)]. Commercial pasta upon cooking recorded a starch content of 60.18%.

4.1.3.2. Total sugar (%)

Total sugar content of cooked jackfruit pasta were evaluated and it ranged from 3.25% to 5.13% with no significant difference among the treatments. Commercially available pasta recorded a total sugar content of 1.57%.

4.1.3.3. Reducing sugar (%)

Reducing sugar content of cooked jackfruit pasta ranged from 0.94% to 1.96% with no significant difference among the treatments. Commercial pasta on cooking showed a reducing sugar content of 0.73%.

4.1.3.4. Protein (%)

` Protein content of cooked jackfruit pasta ranged from4.31% to 7.55%. Treatment T_6 [JSF (50%) + CF (15%)] showed the highest protein content of 7.55% which exhibited no significant difference with the treatments T_4 [JSF (30%) + CF (35%)], T_5 [JSF (40%) + CF (25%)], T_9 [JBF (20%) + JSF (20%) + CF (25%)], T_{10}

[JBF (10%) + JSF (30%) + CF (25%)] and T_{11}[JBF (20%) + JSF (20%) + CF (25%)].The lowest protein content of 4.31% was recorded for the treatment T_7 [JBF (15%) + JSF (15%) + CF (35%)] which was on par with the treatmentsT_1 [JBF (30%) + CF (35%)], T_2 [JBF (40%) + CF (25%)], T_3 [JBF (50%) +CF (15%)], T_8 [JBF (20%) + JSF (20%) + CF (25%)] and T_{12} [JBF (30%) + JSF (20%) + CF (15%)]. Commercially available pasta recorded a protein content of 4.80%.

4.1.3.5. Carotenoids (μg100g^{-1})

Carotenoid content varied from 2.05μg 100g^{-1} to 1.21μg 100g^{-1} with no significant difference among the treatments even though the highest carotenoid content of 2.05μg 100g^{-1} was noticed for the treatment T_3 [JBF (50%) +CF (15%)] and the lowest for the treatment T_4 [JSF (30%) + CF (35%)] with 1.21 μg100g^{-1}and commercial pasta recorded a carotenoid content of 1.16 μg 100g^{-1}.

4.1.3.6. Crude fibre (%)

Fibre content of cooked jackfruit pasta ranged from 0.07% to 0.49%. The highest fibre content of 0.49% was recorded for the treatment T_3 [JBF (50%) +CF (15%)] which showed no significant difference with the treatment T_2 [JBF (40%) + CF (25%)]. Treatment T_4 [JSF (30%) + CF (35%)] recorded the lowest fibre content of 0.07% which exhibited no significant difference with the treatments T_5 [JSF (40%) + CF (25%)], T_6 [JSF (50%) + CF (15%)], T_7 [JBF (15%) + JSF (15%) + CF (35%)], T_8 [JBF (20%) + JSF (20%) + CF (25%)], T_9 [JBF (20%) + JSF (20%) + CF (25%)], T_{10} [JBF (10%) + JSF (30%) + CF (25%)], T_{11} [JBF (20%) + JSF (30%) + CF (15%)] and T_{12} [JBF (30%) + JSF (20%) + CF (15%)]. The cooked commercial pasta recorded a crude fibre content of 0.06%.

4.1.3.7. Antioxidant activity (%)

Antioxidant activity of cooked jackfruit ranged from 51.51% to 79.29%. The highest antioxidant activity was reported for the treatment T_6 [JSF (50%) + CF (15%)]

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Table 3. Evaluation of nutritional parameters of commercial pasta

Control	Starch (%)	Total sugar (%)	Reducing sugar (%)	Protein (%)	Carotenoids (μg $100g^{-1}$)	Crude fibre (%)	Antioxidant activity (%)
Uncooked	76.31	4.13	2.24	8.60	3.95	1.20	48.37
Cooked	60.18	1.57	0.73	4.80	1.16	0.06	12.11

Table 4. Evaluation of nutritional parameters of cooked jackfruit pasta

Treatments	Starch (%)	Total sugar (%)	Reducing sugar (%)	Protein (%)	Carotenoids (μg $100g^{-1}$)	Crude fibre (%)	Antioxidant activity (%)
T1 [JBF (30%) + CF (35%)]	27.14	4.95	1.73	4.68	1.84	0.33	57.41
T2 [JBF (40%) + CF (25%)]	25.17	5.06	1.85	4.95	1.85	0.41	58.59
T3 [JBF (50%) +CF (15%)]	22.52	5.13	1.96	5.21	2.05	0.49	60.53
T4 [JSF (30%) + CF (35%)]	36.25	4.36	1.42	7.13	1.21	0.07	76.64
T5 [JSF (40%) + CF (25%)]	38.64	4.14	1.36	7.34	1.25	0.08	78.29
T6 [JSF (50%) + CF (15%)]	41.55	3.93	1.23	7.55	1.33	0.09	79.29
T7 [JBF (15%) + JSF (15%) + CF (35%)]	44.28	3.25	0.94	4.31	1.39	0.11	51.51
T8 [JBF (20%) + JSF (20%) + CF (25%)]	45.61	4.52	1.55	5.87	1.57	0.12	61.35
T9 [JBF (25%) + JSF (25%) + CF (15%)]	47.73	4.78	1.69	6.12	1.74	0.20	64.37
T10 [JBF (10%) + JSF (30%) + CF (25%)]	53.28	3.75	1.15	6.56	1.34	0.10	68.56
T11 [JBF (20%) + JSF (30%) + CF (15%)]	50.06	3.39	0.98	6.38	1.60	0.13	68.47
T12 [JBF (30%) + JSF (20%) + CF (15%)]	33.29	3.55	1.07	5.50	1.80	0.21	53.62
SE (± m)	1.422			0.533		0.082	2.971
CD (0.05)	4.175	NS	NS	1.565	NS	0.242	8.725

JBF- Jackfruit Bulb Flour JSF- Jackfruit Seed Flour CF- Cassava Flour

with 79.29% which showed no significant difference with the treatments T_5 [JSF (40%) + CF (25%)] and T_4 [JSF (30%) + CF (35%)]. The lowest antioxidant content of 51.51% was reported for the treatment T_7 [JBF (15%) + JSF (15%) + CF (35%)] which was statistically on par with the treatments T_{12} [JBF (30%) + JSF (20%) + CF (15%)], T_1 [JBF (30%) + CF (35%)] and T_2 [JBF (40%) + CF (25%)] while commercially available cooked pasta recorded an antioxidant activity of 48.37% only.

4.1.4. Textural characteristics of jackfruit pasta

Textural characteristics of jackfruit pasta for uncooked as well as cooked were analyzed for firmness and toughness and are depicted in Table 5. Firmness of uncooked jackfruit pasta ranged from 36.84N to 75.96N. The highest value for firmness was observed for the treatment T_3 [JBF (50%) +CF (15%)] with 75.96N which was followed by the treatment T_{12} [JBF (30%) + JSF (20%) + CF (15%)]. The lowest value for firmness was recorded for T_{10} [JBF (10%) + JSF (30%) + CF (25%)] with 36.84N. Pasta firmness for cooked pasta ranged from 0.16N to 0.62N. The highest value of firmness for cooked pasta was noticed for the treatment T_6 [JSF (50%) + CF (15%)] with 0.62N followed by the treatment T_{12} [JBF (30%) + JSF (20%) + CF (15%)]. The lowest value of firmness (0.16N) for cooked pasta was recorded for the treatment T_7 [JBF (15%) + JSF (15%) + CF (35%)].

Toughness of uncooked jackfruit pasta ranged from 15.07Ns to 47.92Ns. The highest value for toughness was noticed for the treatment T_1 [JBF (30%) + CF (35%)] with 47.92Ns followed by the treatment T_2 [JBF (40%) + CF (25%)]. The lowest value for toughness was observed for the treatment T_{10} [JBF (10%) + JSF (30%) + CF (25%)] with 15.07Ns. Toughness for cooked jackfruit pasta ranged from 0.13Ns to 0.25Ns. The highest value of toughness for cooked pasta was noticed for the treatment T_{12} [JBF (30%) + JSF (20%) + CF (15%)] with 0.25Ns followed by the treatment T_6 [JSF (50%) + CF (15%)]. The lowest value of toughness for cooked pasta was observed for the treatment T_7 [JBF (15%) + JSF (15%) + CF (35%)] with 0.13Ns.

Table 5. Evaluation of textural characteristics of jackfruit pasta

Treatments	Uncooked pasta		Cooked pasta	
	Firmness (N)	Toughness (Ns)	Firmness (N)	Toughness (Ns)
T1 [JBF (30%) + CF (35%)]	49.20	47.92	0.24	0.14
T2 [JBF (40%) + CF (25%)]	46.38	43.95	0.38	0.16
T3 [JBF (50%) +CF (15%)]	75.96	32.27	0.39	0.18
T4 [JSF (30%) + CF (35%)]	45.38	30.95	0.41	0.22
T5 [JSF (40%) + CF (25%)]	55.36	23.16	0.37	0.22
T6 [JSF (50%) + CF (15%)]	45.93	18.06	0.62	0.23
T7 [JBF (15%) + JSF (15%) + CF (35%)]	50.66	22.65	0.16	0.13
T8 [JBF (20%) + JSF (20%) + CF (25%)]	65.14	22.03	0.24	0.19
T9 [JBF (25%) + JSF (25%) + CF (15%)]	50.14	31.91	0.42	0.23
T10 [JBF (10%) + JSF (30%) + CF (25%)]	36.84	15.07	0.32	0.15
T11 [JBF (20%) + JSF (30%) + CF (15%)]	52.37	25.83	0.35	0.20
T12 [JBF (30%) + JSF (20%) + CF (15%)]	65.66	29.62	0.54	0.25
SE (± m)	2.519	2.389	0.015	0.018
CD (0.05)	7.398	7.015	0.045	0.055

JBF- Jackfruit Bulb Flour JSF- Jackfruit Seed Flour CF- Cassava Flour

4.1.4. Sensory qualities of jackfruit pasta

Cooked jackfruit pasta were analyzed for various sensory attributes using 9 point hedonic scale. Sensory scores obtained for various attributes like appearance, taste, colour, flavour, odour, texture, elasticity, adhesiveness, mouth feel and overall acceptability were analyzed statistically and described in Table6.

The highest mean score for appearance (8.67) was obtained for the treatment T_9 [JBF (20%) + JSF (20%) + CF (25%)] followed by the treatments T_{10} [JBF (10%) + JSF (30%) + CF (25%)] (7.64) and T_8 [JBF (20%) + JSF (20%) + CF (25%)] (7.60). The lowest mean score (7.13) for appearance was recorded for the treatment T_{12} [JBF (30%) + JSF (20%) + CF (15%)].

The highest mean score for taste (7.67) was noticed for the treatment T_{10} [JBF (10%) + JSF (30%) + CF (25%)] followed by the treatments T_9 [JBF (20%) + JSF (20%) + CF (25%)] (7.53) and T_8 [JBF (20%) + JSF (20%) + CF (25%)] (7.47). The lowest mean score (6.67) for taste was recorded for the treatment T_{11} [JBF (20%) + JSF (30%) + CF (15%)].

Among the treatments T_{10} [JBF (10%) + JSF (30%) + CF (25%)] recorded the highest mean value for colour (8.60) followed by the treatments T_9 [JBF (20%) + JSF (20%) + CF (25%)] (7.80) and T_8 [JBF (20%) + JSF (20%) + CF (25%)] (7.71). The lowest mean score (6.73) for colour was noticed for the treatment T_6 [JSF (50%) + CF (15%)].

The highest mean score for flavor (7.67) was noticed for the treatment T_{10} [JBF (10%) + JSF (30%) + CF (25%)] followed by the treatmentT_9 [JBF (20%) + JSF (20%) + CF (25%)] (7.60) and T_8 [JBF (20%) + JSF (20%) + CF (25%)] (7.47). The lowest mean score for flavor (6.70) was recorded for the treatment T_4 [JSF (30%) + CF (35%)].

For odour the highest mean score (7.45) was obtained for treatment T_1 [JBF (30%) + CF (35%)] followed by the treatments T_2 [JBF (40%) + CF (25%)] (7.42) and

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T_3 [JBF (50%) +CF (15%)] (7.40). The lowest mean score (6.80) for odour was recorded for the treatment T_4 [JSF (30%) + CF (35%)].

For texture the highest mean score (8.07) was noticed for the treatment T_{10} [JBF (10%) + JSF (30%) + CF (25%)] followed by the treatments T_9 [JBF (20%) + JSF (20%) + CF (25%)] (7.47) and T_8 [JBF (20%) + JSF (20%) + CF (25%)] (7.35). The lowest mean score (6.72) for texture was recorded for the treatment T_6 [JSF (50%) + CF (15%)].

Among the treatments T_{10} [JBF (10%) + JSF (30%) + CF (25%)] recorded the highest mean score (8.32) for elasticity followed by the treatments T_9 [JBF (20%) + JSF (20%) + CF (25%)] (8.00) and T_8 [JBF (20%) + JSF (20%) + CF (25%)] (7.65). For elasticity lowest mean score (6.67) was noticed for T_6 [JSF (50%) + CF (15%)].

The lowest mean score (6.52) for adhesiveness was recorded for the treatment T_7 [JBF (15%) + JSF (15%) + CF (35%)] followed by the treatments T_8 [JBF (20%) + JSF (20%) + CF (25%)] (6.75) and T_9 [JBF (20%) + JSF (20%) + CF (25%)] (6.66).The highest mean score for adhesiveness (7.93) was recorded for the treatment T_6 [JSF (50%) + CF (15%)].

For mouth feel the highest mean score (8.00) was noticed for the treatment T_{10} [JBF (10%) + JSF (30%) + CF (25%)] followed by the treatments T_9 [JBF (20%) + JSF (20%) + CF (25%)] (7.51) and T_8 [JBF (20%) + JSF (20%) + CF (25%)] (7.40). The lowest mean score (6.82) was recorded for the treatment T_6 [JSF (50%) + CF (15%)].

Overall acceptability was highest (8.49) for the treatment T_{10} [JBF (10%) + JSF (30%) + CF (25%)] followed by the treatments T_9 [JBF (20%) + JSF (20%) + CF (25%)] (8.26) and T_8 [JBF (20%) + JSF (20%) + CF (25%)] (8.13). Overall acceptability has lowest mean score for the treatment T_6 [JSF (50%) + CF (15%)].

Based on cooking quality, nutritional, textural and sensory parameters three best treatments selected for the development of jackfruit pasta are combinations of 20%

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Table 6. Evaluation of sensory parameters for cooked jackfruit pasta

Treatments	Appearance	Taste	Colour	Flavour	Odour	Texture	Elasticity	Adhesiveness	Mouth feel	Overall acceptability
	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score
T1 [JBF (30%) + CF (35%)]	7.50	7.27	7.33	7.13	7.45	7.13	6.93	7.00	7.18	7.31
T2 [JBF (40%) + CF (25%)]	7.48	7.24	7.27	7.30	7.42	6.93	6.86	6.94	7.04	7.24
T3 [JBF (50%) +CF (15%)]	7.44	7.20	7.13	7.27	7.40	6.85	6.80	6.86	7.01	7.19
T4 [JSF (30%) + CF (35%)]	7.40	7.13	6.93	6.70	6.80	6.87	6.77	7.40	6.98	7.13
T5 [JSF (40%) + CF (25%)]	7.33	7.07	6.80	6.83	6.89	6.80	6.73	7.65	6.87	7.05
T6 [JSF (50%) + CF (15%)]	7.27	7.00	6.73	6.87	6.85	6.72	6.67	7.93	6.82	7.01
T7 [JBF (15%) + JSF (15%) + CF (35%)]	7.53	7.33	7.40	6.93	7.07	7.27	7.58	6.52	7.35	8.06
T8 [JBF (20%) + JSF (20%) + CF (25%)]	7.60	7.47	7.71	7.47	7.18	7.35	7.65	6.75	7.40	8.13
T9 [JBF (25%) + JSF (25%) + CF (15%)]	8.67	7.53	7.80	7.60	7.20	7.47	8.00	6.66	7.51	8.26
T10 [JBF (10%) + JSF (30%) + CF (25%)]	7.64	7.67	8.60	7.67	6.93	8.07	8.32	7.02	8.00	8.49
T11 [JBF (20%) + JSF (30%) + CF (15%)]	7.14	6.67	7.48	7.20	7.13	7.20	7.46	7.15	7.29	7.68
T12 [JBF (30%) + JSF (20%) + CF (15%)]	7.13	6.87	7.07	7.33	7.27	7.18	7.23	7.32	7.23	7.54
KW Value	24.645	19.955	31.655	44.350	24.710	43.482	52.962	35.455	37.234	54.781
χ^2	19.675									

JBF- Jackfruit Bulb Flour JSF- Jackfruit Seed Flour CF- Cassava Flour

Jackfruit bulb flour + 20% Jackfruit seed flour + 25%cassava flour (T_8), treatment combination T_9 with Jackfruit bulb flour (25%), Jackfruit seed flour (25%), cassava flour (15%) and treatment combination T_{10} with 10% Jackfruit bulb flour, 30% Jackfruit seed flour and 25% cassava flour.

4.2. DEVELOPMENT OF VEGETABLE BASED FUNCTIONAL JACKFRUIT PASTA

The best three treatments selected from Part I of the study were taken for the development of vegetable based functional jackfruit pasta. Vegetables *viz.* carrot, beet root and red amaranthus were incorporated as paste to the selected combinations of pasta @ 5 and 10 %.

4.2.1. Cooking quality of vegetable based functional jackfruit pasta

Cooking quality of vegetable based functional jackfruit pasta were analyzed for cooking loss (%), water absorption (g g^{-1}), swelling index (%) and cooking time (minutes) and are depicted in Table 7.

4.2.1.1. Cooking loss (%)

Cooking loss of vegetable based jackfruit pasta ranged from 6.84% to 12.87% with no significant difference among the treatments. On comparing the treatments, F_1 [T8+5% Amaranthus] showed the lowest cooking loss of 6.84% and the highest cooking loss (12.87%) was observed for the treatment F_{16} [T10+10% Beetroot] eventhough there was no significant difference statistically.

4.2.1.2. Water absorption (g g^{-1})

Water absorption of vegetable based jackfruit pasta ranged from 1.03 to 1.68g g^{-1}. Among the treatments F_{16} [T10+10% Beetroot] showed the highest water absorption of 1.68 g g^{-1} which exhibited no significant difference with the treatments F_{10} [T9+10% Beetroot] and F_{12} [T9+10% Carrot].The lowest water absorption of 1.03 g g^{-1} was observed for the treatment F_1 [T8+5% Amaranthus] which showed no

Table 7. Evaluation of cooking quality characters of vegetable based functional jackfruit pasta

Treatments	Cooking loss (%)	Water absorption (g g^{-1})	Swelling index (%)	Cooking time (minutes)
F_1 [T8+5% Amaranthus]	6.84	1.03	1.06	5.23
F_2 [T8+10% Amaranthus]	7.46	1.19	1.55	5.49
F_3 [T8+5% Beetroot]	7.74	1.16	1.17	5.59
F_4 [T8+10% Beetroot]	9.75	1.41	1.36	6.04
F_5 [T8+5% Carrot]	7.25	1.07	1.15	5.48
F_6 [T8+10% Carrot]	7.72	1.37	1.57	5.50
F_7 [T9+5% Amaranthus]	7.69	1.09	1.45	6.00
F_8 [T9+10% Amaranthus]	7.81	1.34	1.66	6.12
F_9 [T9+5% Beetroot]	9.13	1.26	1.79	6.27
F_{10} [T9+10% Beetroot]	10.32	1.67	2.65	6.46
F_{11} [T9+5% Carrot]	7.34	1.43	1.84	6.15
F_{12} [T9+10% Carrot]	9.46	1.53	2.96	6.21
F_{13} [T10+5% Amaranthus]	7.55	1.17	1.66	6.12
F_{14} [T10+10% Amaranthus]	8.93	1.49	2.16	7.22
F_{15} [T10+5% Beetroot]	9.50	1.41	2.74	6.56
F_{16} [T10+10% Beetroot]	12.87	1.68	3.15	7.31
F_{17} [T10+5% Carrot]	8.72	1.32	1.62	6.18
F_{18} [T10+10% Carrot]	9.14	1.46	2.06	6.48
SE ($\pm$m)		0.090		
CD (0.05)	NS	0.258	NS	NS

T8 - [JBF (20%) + JSF (20%) + CF (25%)]

T9 - [JBF (25%) + JSF (25%) + CF (15%)]

T10 - [JBF (10%) + JSF (30%) + CF (25%)]

JBF- Jackfruit Bulb Flour

JSF- Jackfruit Seed Flour

CF- Cassava Flour

significant difference with the treatments F_2 [T8+10% Amaranthus],F_3 [T8+5% Beetroot], F_5 [T8+5% Carrot)], F_7 [T9+5% Amaranthus], F_9 [T9+5% Beetroot]and F_{13} [T10+5% Amaranthus].

4.2.1.3. Swelling index (%)

Swelling index of vegetable based jackfruit pasta did not show any significant difference and they ranged from 1.06% to 3.15%. Among the treatments, F_{16} [T10+10% Beetroot] recorded the highest swelling index of 3.15% and the lowest swelling index of 1.06% was noticed for F_1 [T8+5% Amaranthus] without difference statistically.

4.2.1.4. Cooking time (minutes)

Cooking time for vegetable based jackfruit pastas ranged from 5.23 min to 7.31 min with no significant difference among the treatments. The lowest cooking time was observed for F_1 [T8+5% Amaranthus] with 5.23 min and the highest cooking time of 7.31 min was observed for the treatment F_{16} [T10+10% Beetroot] eventhough the values were found statistically non-significant.

4.2.2. Nutritional parameters of vegetable based functional jackfruit pasta

Nutritional parameters of vegetable based functional jackfruit pasta were analyzed for starch, total sugar, reducing sugar, protein, carotenoid content, fibre content, antioxidant activity and are depicted in Table 8.

4.2.2.1. Starch (%)

Starch content of vegetable based functional jackfruit pasta ranged from 64.53% to 69.19% with no significant difference among the treatments.

4.2.2.2. Total sugar (%)

No significant difference among the treatments was observed for total sugar content of the functional jackfruit pasta and it ranged from 6.19% to 9.20%.

4.2.2.3. Reducing sugar (%)

Reducing sugar content of the functional jackfruit pasta ranged from 4.77% to 6.65% with no significant difference among the treatments.

4.2.2.4. Protein (%)

` Protein content of functional jackfruit pasta ranged from 12.98% to 15.06% with no significant difference among the treatments.

4.2.2.5. Carotenoids (μg $100g^{-1}$)

Carotenoid content varied from 5.87 μg $100g^{-1}$ to 10.68 μg $100g^{-1}$. The highest carotenoid content of 10.68 μg $100g^{-1}$ was recorded for treatment F_{12} [T9+10% Carrot] which was on par with the treatments F_6 [T8+10% Carrot], F_{11} [T9+5% Carrot] and F_5 [T8+5% Carrot]. The lowest carotenoid (5.87 μg 100^{-1}) content was observed for the treatment F_{13} [T10+5% Amaranthus] which showed no significant difference with the treatments F_1 [T8+5% Amaranthus], F_2 [T8+10% Amaranthus], F_3 [T8+5% Beetroot], F_7 [T9+5% Amaranthus], F_8 [T9+10% Amaranthus], F_9 [T9+5% Beetroot], F_{14} [T10+10% Amaranthus], F_{15} [T10+5% Beetroot], F_{16} [T10+10% Beetroot] and F_{17} [T10+5% Carrot].

4.2.2.6. Crude fibre (%)

Fibre content of functional jackfruit pasta ranged from 1.66% to 4.82% with no significant difference among the treatments. The highest fibre content of 4.82% was noticed for the treatment F_8 [T9+10% Amaranthus] and the lowest fibre content of 1.66% was observed for the treatment F_{17} [T10+5% Carrot].

4.2.2.7. Antioxidant activity (%)

Antioxidant activity of functional jackfruit pasta showed no significant difference and it ranged from 93.34% to 95.21%. The highest antioxidant content was reported for the treatment F_{14} [T10+10% Amaranthus] with 95.21% and the lowest

Table 8. Evaluation of nutritional parameters of vegetable based functional jackfruit pasta

Treatments	Starch (%)	Total sugar (%)	Reducing sugar (%)	Protein (%)	Carotenoids (μg 100g^{-1})	Crude fibre (%)	Antioxidant activity (%)
F_1 [T8+5% Amaranthus]	65.06	6.88	4.95	13.41	6.25	4.07	93.94
F_2 [T8+10% Amaranthus]	64.53	7.07	5.05	13.58	6.34	4.66	94.35
F_3 [T8+5% Beetroot]	65.93	8.17	6.21	13.35	7.86	2.97	93.34
F_4 [T8+10% Beetroot]	66.85	8.35	6.36	12.98	8.15	3.69	93.45
F_5 [T8+5% Carrot]	66.99	8.08	5.55	13.04	8.76	2.83	93.52
F_6 [T8+10% Carrot]	67.28	8.29	5.69	13.25	9.64	2.82	93.88
F_7 [T9+5% Amaranthus]	66.19	7.18	5.16	13.54	6.54	4.53	94.74
F_8 [T9+10% Amaranthus]	66.66	7.28	5.24	13.69	6.83	4.82	94.85
F_9 [T9+5% Beetroot]	67.26	8.52	6.58	13.72	7.98	4.02	93.45
F_{10} [T9+10% Beetroot]	68.08	9.20	6.65	13.38	8.29	4.23	93.58
F_{11} [T9+5% Carrot]	67.42	8.08	5.72	13.49	9.23	3.87	93.69
F_{12} [T9+10% Carrot]	67.73	8.12	5.88	13.16	10.68	3.93	93.95
F_{13} [T10+5% Amaranthus]	68.51	6.19	4.77	14.97	5.87	2.40	94.95
F_{14} [T10+10% Amaranthus]	68.71	6.22	4.83	15.06	5.92	2.89	95.21
F_{15} [T10+5% Beetroot]	68.98	7.03	6.03	14.79	6.51	2.18	93.64
F_{16} [T10+10% Beetroot]	69.19	7.18	6.14	14.82	6.65	3.34	93.75
F_{17} [T10+5% Carrot]	68.15	6.65	5.37	14.35	7.99	1.66	93.85
F_{18} [T10+10% Carrot]	68.67	6.89	5.46	14.68	8.55	1.83	93.96
SE (± m)					0.875		
CD (0.05)	NS	NS	NS	NS	2.148	NS	NS

T8 - [JBF (20%) + JSF (20%) + CF (25%)]

T9 - [JBF (25%) + JSF (25%) + CF (15%)]

T10 - [JBF (10%) + JSF (30%) + CF (25%)]

JBF- Jackfruit Bulb Flour

JSF- Jackfruit Seed Flour

CF- Cassava Flour

antioxidant content of 93.34% was reported for the treatment F_3 [T8+5% Beetroot] eventhough the difference was statistically non-significant.

4.2.3. Nutritional parameters of cooked vegetable based functional jackfruit pasta

Nutritional parameters *viz.*, starch, total sugar, reducing sugar, protein, carotenoid, fibre content and antioxidant activity of cooked vegetable based functional jackfruit pasta were analyzed and are depicted in Table 9.

4.2.3.1. Starch (%)

Starch content of cooked vegetable based functional jackfruit pasta ranged from 42.72% to 49.21% with no significant difference among the treatments.

4.2.3.2. Total sugar (%)

Total sugar content of the cooked vegetable based jackfruit pasta were evaluated and it ranged from 4.41% to 6.84% with no significant difference among the treatments.

4.2.3.3. Reducing sugar (%)

No significant difference was observed for the reducing sugar content of the cooked vegetable based jackfruit pasta and it ranged from 1.48% to 3.16%.

4.2.3.4. Protein (%)

` Protein content of the cooked vegetable based jackfruit pasta ranged from 6.04% to 7.57% with no significant difference among the treatments.

4.2.2.5. Carotenoids (μg $100g^{-1}$)

Carotenoid content varied from 1.96μg $100g^{-1}$ to 4.51 μg $100g^{-1}$ with no significant difference among the treatments. The highest carotenoid content of 4.51 μg $100g^{-1}$ was recorded for treatment F_{12} [T9+10% Carrot] and the lowest carotenoid (1.96 μg 100^{-1}) content was observed for the treatment F_{13} [T10+5% Amaranthus] .

Table 9. Evaluation of nutritional parameters of cooked vegetable based functional jackfruit pasta

Treatments	Starch (%)	Total sugar (%)	Reducing sugar (%)	Protein (%)	Carotenoids (μg $100g^{-1}$)	Crude fibre (%)	Antioxidant activity (%)
F_1 [T8+5% Amaranthus]	42.72	4.56	1.69	6.43	2.00	2.31	66.58
F_2 [T8+10% Amaranthus]	42.95	4.79	1.73	6.54	2.14	2.49	67.98
F_3 [T8+5% Beetroot]	44.11	5.95	2.85	6.28	2.49	1.52	62.85
F_4 [T8+10% Beetroot]	45.28	6.03	2.98	6.30	2.93	1.76	64.21
F_5 [T8+5% Carrot]	46.47	5.21	2.20	6.04	3.23	1.36	64.79
F_6 [T8+10% Carrot]	47.04	5.37	2.33	6.15	3.66	1.42	65.88
F_7 [T9+5% Amaranthus]	45.21	4.86	1.85	7.26	2.07	2.54	69.33
F_8 [T9+10% Amaranthus]	46.05	4.94	1.96	7.31	2.29	2.80	70.23
F_9 [T9+5% Beetroot]	47.09	6.26	3.04	7.08	2.54	1.66	63.96
F_{10} [T9+10% Beetroot]	47.25	6.59	3.16	7.14	2.97	1.85	65.36
F_{11} [T9+5% Carrot]	48.36	5.49	2.41	6.83	3.32	1.49	66.75
F_{12} [T9+10% Carrot]	48.95	5.54	2.57	6.95	4.51	1.95	67.96
F_{13} [T10+5% Amaranthus]	46.88	4.41	1.48	7.42	1.96	1.49	70.04
F_{14} [T10+10% Amaranthus]	46.07	4.53	1.55	7.57	2.11	2.19	71.32
F_{15} [T10+5% Beetroot]	48.08	5.76	2.63	7.25	2.43	1.43	66.74
F_{16} [T10+10% Beetroot]	49.09	6.84	2.72	7.38	2.66	1.62	68.25
F_{17} [T10+5% Carrot]	49.21	6.03	2.02	6.47	3.16	1.19	68.75
F_{18} [T10+10% Carrot]	44.19	6.14	2.16	6.59	3.43	1.23	69.36
SE (± m)							1.471
CD (0.05)	NS	NS	NS	NS	NS	NS	4.238

T8 - [JBF (20%) + JSF (20%) + CF (25%)]

T9 - [JBF (25%) + JSF (25%) + CF (15%)]

T10 - [JBF (10%) + JSF (30%) + CF (25%)]

JBF- Jackfruit Bulb Flour

JSF- Jackfruit Seed Flour

CF- Cassava Flour

4.2.2.6. Crude fibre (%)

Fibre content of the cooked vegetable based jackfruit pasta ranged from 1.19% to 2.80% with no significant difference among the treatments. The highest fibre content of 2.80% was noticed for the treatment F_8 [T9+10% Amaranthus] and the lowest fibre content of 1.19% was observed for the treatment F_{17} [T10+5% Carrot] eventhough values were of no difference statistically.

4.2.2.7. Antioxidant activity (%)

Antioxidant activity of cooked vegetable based jackfruit pasta ranged from 62.85% to 71.32%. The highest antioxidant content was reported for the treatment F_{14} [T10+10% Amaranthus] with 71.32% which was on par with the treatments F_7 [T9+5% Amaranthus], F_8 [T9+10% Amaranthus], F_{13} [T10+5% Amaranthus], F_{16} [T10+10% Beetroot] F_{17} [T10+5% Carrot] and F_{18} [T10+10% Carrot]. The lowest antioxidant content of 62.85% was reported for the treatment F_3 [T8+5% Beetroot] which exhibited no significant difference with the treatments F_1 [T8+5% Amaranthus], F_2 [T8+10% Amaranthus], F_4 [T8+10% Beetroot], F_5 [T8+5% Carrot], F_6 [T8+10% Carrot], F_9 [T9+5% Beetroot], F_{10} [T9+10% Beetroot], F_{11} [T9+5% Carrot], F_{12} [T9+10% Carrot] and F_{15} [T10+5% Beetroot].

4.2.4. Textural characteristics of vegetable based functional jackfruit pasta

Textural characteristics of vegetable based functional jackfruit pasta for uncooked as well as cooked were analyzed for firmness and toughness and are depicted in Table 10. Firmness of uncooked vegetable based functional jackfruit pasta ranged from 20.50N to 57.49N. The highest value for firmness was observed for the treatment F_{12} [T9+10% Carrot] with 57.49N which was followed by the treatment F_{10} [T9+10% Beetroot]. The lowest value for firmness was recorded for F_{17} [T10+5% Carrot] with 20.50N. Pasta firmness for cooked pasta ranged from 0.08N to 0.42N. The highest value of firmness for cooked pasta was noticed for the treatment F_1 [T8+5% Amaranthus] with 0.42N and the lowest value of firmness (0.08N) for cooked pasta

Table 10. Evaluation of textural characteristics of vegetable based functional jackfruit pasta

Treatments	Uncooked pasta		Cooked pasta	
	Firmness (N)	Toughness (Ns)	Firmness (N)	Toughness (Ns)
F_1 [T8+5% Amaranthus]	43.74	61.69	0.42	0.19
F_2 [T8+10% Amaranthus]	40.23	60.20	0.40	0.12
F_3 [T8+5% Beetroot]	35.60	8.34	0.19	0.14
F_4 [T8+10% Beetroot]	23.25	11.73	0.23	0.17
F_5 [T8+5% Carrot]	31.36	15.06	0.17	0.01
F_6 [T8+10% Carrot]	25.42	13.46	0.13	0.05
F_7 [T9+5% Amaranthus]	34.61	58.30	0.14	0.09
F_8 [T9+10% Amaranthus]	32.39	58.13	0.13	0.06
F_9 [T9+5% Beetroot]	43.65	15.20	0.19	0.07
F_{10} [T9+10% Beetroot]	52.15	24.16	0.14	0.06
F_{11} [T9+5% Carrot]	51.35	22.07	0.15	0.23
F_{12} [T9+10% Carrot]	57.49	29.31	0.26	0.09
F_{13} [T10+5% Amaranthus]	34.85	16.16	0.17	0.17
F_{14} [T10+10% Amaranthus]	36.50	29.33	0.18	0.04
F_{15} [T10+5% Beetroot]	27.08	13.93	0.23	0.20
F_{16} [T10+10% Beetroot]	30.29	15.66	0.08	0.06
F_{17} [T10+5% Carrot]	20.50	7.79	0.17	0.01
F_{18} [T10+10% Carrot]	38.15	19.22	0.14	0.03
SE ($\pm$ m)	1.437	1.392		
CD (0.05)	4.138	4.009	NS	NS

T8 - [JBF (20%) + JSF (20%) + CF (25%)]

T9 - [JBF (25%) + JSF (25%) + CF (15%)]

T10 - [JBF (10%) + JSF (30%) + CF (25%)]

JBF- Jackfruit Bulb Flour

JSF- Jackfruit Seed Flour

CF- Cassava Flour

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was recorded for the treatment F_{16} [T10+10% Beetroot] with no significant difference among the treatments.

Toughness of uncooked vegetable based functional jackfruit pasta ranged from7.79Ns to 61.69Ns. The highest value for toughness was noticed for the treatment F_1 [T8+5% Amaranthus] with 61.69Ns followed by the treatment F_2 [T8+10% Amaranthus]. The lowest value for toughness was observed for the treatment F_{17} [T10+5% Carrot] with 7.79Ns. Toughness for cooked jackfruit pasta ranged from 0.01Ns to 0.23Ns. The highest value of toughness for cooked pasta was noticed for the treatment F_{11} [T9+5% Carrot] with 0.23Ns and the lowest value of toughness for cooked pasta was observed for the treatment F_{17} [T10+5% Carrot] with 0.01Ns.

4.2.4. Sensory qualities of vegetable enriched functional jackfruit pasta

Cooked vegetable enriched functional jackfruit pasta were analyzed for various sensory attributes by using 9 point hedonic scale. Sensory scores obtained for various attributes like appearance, taste, colour, flavour, odour, texture, elasticity, adhesiveness, mouth feel and overall acceptability were analyzed statistically and described in Table 11.

The highest mean score for appearance (8.86) was obtained for the treatment F_{12} [T9+10% Carrot] for carrot incorporated jackfruit pasta and for beetroot added jackfruit pasta the highest mean score (8.19) was for the treatmentF_{16} [T10+10% Beetroot] and F_{14} [T10+10% Amaranthus] recorded the highest mean score (7.82) for amaranthus based jackfruit pasta.

The highest mean score for taste (8.16) was noticed for the treatment, F_{12} [T9+10% Carrot] for carrot incorporated jackfruit pasta, for beetroot added jackfruit pasta the highest mean score (7.85) was for the treatment F_{16} [T10+10% Beetroot] and amaranthus incorporated jackfruit pasta had the highest mean score (7.54 for F_{14} [T10+10% Amaranthus].

Among the treatments for carrot incorporated jackfruit pasta, F_{12} [T9+10% Carrot] recorded the highest mean value for colour (9.31) and for beetroot added jackfruit pasta the highest mean score (8.64) was for the treatmentF_{16} [T10+10% Beetroot] and F_{14} [T10+10% Amaranthus] obtained the highest mean score (8.27) for amaranthus based jackfruit pasta.

The highest mean score for flavor (8.11) was noticed for the treatment, F_{12} [T9+10% Carrot] for carrot incorporated jackfruit pasta, F_{16} [T10+10% Beetroot] (7.82) for beetroot added jackfruit pasta and F_{14} [T10+10% Amaranthus] (7.49) for amaranthus based jackfruit pasta.

For odour the highest mean score was obtained for treatment F_{12} [T9+10% Carrot] for carrot incorporated jackfruit pasta (8.57) and for beetroot added jackfruit pasta the highest mean score (7.94) was for the treatmentF_{16} [T10+10% Beetroot] and F_{14} [T10+10% Amaranthus] recorded the highest mean score (7.53) for amaranthus based jackfruit pasta.

For texture the highest mean score (8.16) was noticed for the treatment, F_{12} [T9+10% Carrot] for carrot incorporated jackfruit pasta, F_{16} [T10+10% Beetroot] for beetroot added jackfruit pasta (7.49) and amaranthus based jackfruit pasta had the highest mean score of 7.12 for the treatment F_{14} [T10+10% Amaranthus].

Among the treatments F_{12} [T9+10% Carrot]] recorded the highest mean score (8.22) for elasticity among carrot incorporated jackfruit pasta, for beetroot added jackfruit pasta, the highest mean score of 7.91 was observed for F_{16} [T10+10% Beetroot] and F_{14} [T10+10% Amaranthus] recorded the highest mean score (7.60) for amaranthus based jackfruit pasta.

The lowest mean score (7.49) for adhesiveness was recorded for the treatment F_{12} [T9+10% Carrot] for carrot incorporated jackfruit pasta and for beetroot added jackfruit pasta the lowest mean score (7.78) was recorded for F_{16} [T10+10% Beetroot]

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Table 11. Evaluation of sensory parameters for cooked vegetable enriched functional jackfruit pasta

Treatments	Appearance	Taste	Colour	Flavour	Odour	Texture	Elasticity	Adhesiveness	Mouth feel	Overall acceptability
	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score
F_1 [T8+5% Amaranthus]	7.42	7.36	7.87	7.31	7.13	6.72	7.42	8.29	7.13	7.78
F_2 [T8+10% Amaranthus]	7.66	7.43	8.11	7.38	7.37	6.96	7.49	8.19	7.37	7.85
F_3 [T8+5% Beetroot]	7.87	7.65	8.32	7.62	7.58	7.17	7.71	7.89	7.58	8.07
F_4 [T8+10% Beetroot]	7.94	7.76	8.39	7.71	7.65	7.24	7.82	7.98	7.65	8.18
F_5 [T8+5% Carrot]	8.22	7.99	8.67	7.94	7.93	7.52	8.05	7.67	7.93	8.41
F_6 [T8+10% Carrot]	8.64	8.08	9.09	8.03	8.35	7.94	8.14	7.60	8.35	8.50
F_7 [T9+5% Amaranthus]	7.55	7.41	8.01	7.36	7.26	6.85	7.47	8.23	7.26	7.83
F_8 [T9+10% Amaranthus]	7.73	7.49	8.18	7.44	7.44	7.03	7.55	8.14	7.44	7.91
F_9 [T9+5% Beetroot]	7.90	7.72	8.35	7.67	7.61	7.20	7.78	7.94	7.61	8.14
F_{10} [T9+10% Beetroot]	8.02	7.81	8.47	7.76	7.73	7.32	7.87	7.85	7.73	8.23
F_{11} [T9+5% Carrot]	8.47	8.06	8.92	8.01	8.18	7.77	8.12	7.56	8.18	8.47
F_{12} [T9+10% Carrot]	8.86	8.16	9.31	8.11	8.57	8.16	8.22	7.49	8.57	8.58
F_{13} [T10+5% Amaranthus]	7.76	7.47	8.21	7.42	7.47	7.06	7.53	8.21	7.47	7.89
F_{14} [T10+10% Amaranthus]	7.82	7.54	8.27	7.49	7.53	7.12	7.60	8.12	7.53	7.96
F_{15} [T10+5% Beetroot]	7.99	7.76	8.44	7.71	7.72	7.29	7.82	7.89	7.71	8.18
F_{16} [T10+10% Beetroot]	8.19	7.85	8.64	7.82	7.94	7.49	7.91	7.78	7.95	8.25
F_{17} [T10+5% Carrot]	8.38	8.01	8.83	7.96	8.09	7.68	8.07	7.62	8.09	8.43
F_{18} [T10+10% Carrot]	8.70	8.10	9.15	8.05	8.41	8.00	8.16	7.54	8.41	8.52
KW Value	79.57	65.67	68.12	59.42	33.73	52.36	45.98	64.12	37.88	69.23
χ^2	27.587									

T8 - [JBF (20%) + JSF (20%) + CF (25%)]

T9 - [JBF (25%) + JSF (25%) + CF (15%)]

T10 - [JBF (10%) + JSF (30%) + CF (25%)]

JBF- Jackfruit Bulb Flour

JSF- Jackfruit Seed Flour

CF- Cassava Flour

and F_{14} [T10+10% Amaranthus] obtained the lowest mean score (8.12) for adhesiveness among the amaranthus based jackfruit pasta combinations.

For mouth feel the highest mean score (8.57) was noticed for the treatmentsF_{12} [T9+10% Carrot] for carrot based jackfruit pasta, F_{16} [T10+10% Beetroot] recorded the highest mean score (7.95) for beetroot incorporated jackfruit pasta and for amaranthus based jackfruit pasta, F_{14} [T10+10% Amaranthus] obtained the highest mean score (7.53) for mouth feel.

Overall acceptability was highest for the treatment F_{12} [T9+10% Carrot] for carrot incorporated jackfruit pasta (8.58), for beetroot added jackfruit pasta F_{16} [T10+10% Beetroot] (8.25) and for amaranthus based jackfruit pasta F_{14} [T10+10% Amaranthus] recorded the highest mean score (7.96) for overall acceptability.

Based on cooking quality, nutritional and sensory qualities three best treatment combinations (each from one vegetable) were selected for the development of vegetable based functional jackfruit pasta. For amaranthus based jackfruit pasta, combination of 10% jackfruit bulb flour, 30% jackfruit seed flour, 25% cassava flour, and 10% Amaranthus (F_{14}) was recorded as the best combination. For beet root based jackfruit pasta, combination of 10% jackfruit bulb flour, 30% jackfruit seed flour, 25% cassava flour, and 10% Beetroot (F_{16}) was selected and it was 25% jackfruit bulb flour, 25% jackfruit seed flour, 15% cassava flour and 10% Carrot (F_{12}) for carrot incorporated jackfruit pasta.

4.3. STORAGE STUDIES OF VEGETABLE BASED FUNCTIONAL JACKFRUIT PASTA

The three best vegetable based functional jackfruit pasta selected from Part II of the study were analyzed for storage stability for four months. The developed pasta packed in polypropylene (200guage) and stored at room temperature were analyzed for cooking quality, nutritional, microbial and sensory analyses at monthly interval and results are described below.

4.3.1. Effect of storage on cooking quality of vegetable based functional jackfruit pasta

Cooking quality of vegetable based functional jackfruit pasta during storage were analyzed for cooking loss (%), water absorption (g g^{-1}), swelling index (%) and cooking time (minutes) and are depicted in Table 12.

4.3.1.1. Cooking loss (%)

Cooking loss of vegetable enriched functional jackfruit pasta did not show significant difference during the storage period. But the cooking loss of vegetable based pasta differed depending on the type of vegetable incorporated. Cooking loss of carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] was 9.46% at the time of storage and increased to 9.88% after four months of storage. It was 8.93% at the time of storage and 9.24% after four months in case of amaranthus enriched functional jackfruit pasta; V_2[T10+10% Amaranthus]. Cooking loss of 12.87% and 13.17% was noticed for beetroot enriched functional jackfruit pasta V_3 [T10+10% Beetroot] at the time of storage and four months after storage respectively.

4.3.1.2. Water absorption (g g^{-1})

Water absorption of vegetable enriched functional jackfruit pasta did not show significant difference during the storage period and the interaction effects were also non-significant. Water absorption of vegetable enriched pasta differed significantly depending on the type of vegetable during the storage period. Water absorption of 1.54g g^{-1} was observed for Carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] and amaranthus V_2 [T10+10% Amaranthus] and beetroot V_3 [T10+10% Beetroot] enriched functional jackfruit pasta recorded a mean water absorption of 1.51g g^{-1} and 1.68g g^{-1} respectively.

Table 12. Effect of storage on cooking quality of vegetable based functional jackfruit pasta

Cooking loss (%)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1 [T9+10% Carrot]	9.46	9.52	9.67	9.73	9.88	9.69
V_2 [T10+10% Amaranthus]	8.93	8.96	9.07	9.14	9.24	9.26
V_3 [T10+10% Beetroot]	12.87	12.89	12.91	13.08	13.17	13.00
Mean (M)	10.42	10.45	10.55	10.65	10.76	
SE (± m)	T-0.048				TxM-0.097	
CD (0.05)	T-0.142		M- NS		TxM-0.284	
Water absorption (g g^{-1})	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1 [T9+10% Carrot]	1.53	1.53	1.53	1.54	1.54	1.54
V_2 [T10+10% Amaranthus]	1.49	1.49	1.50	1.50	1.50	1.51
V_3 [T10+10% Beetroot]	1.68	1.68	1.69	1.69	1.69	1.68
Mean (M)	1.57	1.57	1.57	1.58	1.58	
SE (± m)	T-0.369					
CD (0.05)	T-1.071		M- NS		TxM-NS	
Swelling index (%)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1 [T9+10% Carrot]	2.06	2.08	2.11	2.23	2.31	2.15
V_2 [T10+10% Amaranthus]	2.16	2.18	2.25	2.36	2.48	2.28
V_3 [T10+10% Beetroot]	3.15	3.16	3.29	3.34	3.46	3.28
Mean (M)	2.45	2.47	2.55	2.64	2.75	
SE (± m)	T-0.124					
CD (0.05)	T- 0.365		M- NS		TxM-NS	
Cooking time (minutes)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1 [T9+10% Carrot]	6.21	6.24	6.29	6.33	6.38	6.36
V_2 [T10+10% Amaranthus]	7.22	7.26	7.31	7.37	7.40	7.41
V_3 [T10+10% Beetroot]	7.31	7.35	7.38	7.43	7.48	7.36
Mean (M)	10.37	7.01	7.03	7.08	7.04	
SE (± m)	T-0.198					
CD (0.05)	T-0.582		M- NS		TxM-NS	

T9 - [JBF (25%) + JSF (25%) + CF (15%)]

T10 - [JBF (10%) + JSF (30%) + CF (25%)]

JBF- Jackfruit Bulb Flour

JSF- Jackfruit Seed Flour

CF- Cassava Flour

4.3.1.3. Swelling index (%)

Swelling index of vegetable enriched functional jackfruit pasta did not show significant difference during the storage period and the interaction effects were also non-significant. The pasta incorporated with vegetables exhibited difference in swelling index initially and after the storage. Carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] recorded a swelling index of 2.15% and it was 2.28% for amaranthus enriched functional jackfruit pasta V_2 [T10+10% Amaranthus] while 3.28% was recorded for beetroot enriched functional jackfruit pasta V_3 [T10+10% Beetroot].

4.3.1.4. Cooking time (minutes)

Cooking time of vegetable enriched functional jackfruit pasta did not show significant difference during the storage period and the interaction effects were also non-significant. However cooking time varied significantly among the treatments. A cooking time of 6.36 min was observed for the carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] while it was 7.41 min and 7.36 min for amaranthus enriched functional jackfruit pasta V_2 [T10+10% Amaranthus] and beetroot enriched functional jackfruit pasta V_3 [T10+10% Beetroot] respectively.

4.3.2. Effect of storage on nutritional parameters of vegetable based functional jackfruit pasta

Nutritional parameters *viz.,* starch, total sugar, reducing sugar, protein, carotenoid content, fibre and antioxidant activity of vegetable based functional jackfruit pasta during storage were analyzed and are depicted in Table 13a and Table 13b.

4.3.2.1. Starch (%)

Vegetable enriched functional jackfruit pasta did not show any significant difference on the starch content during storage period. Eventhough the interaction effects were non-significant, the starch content varied significantly among the treatments. Carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] recorded a mean starch content of 67.55% and it was 68.54% for amaranthus enriched functional jackfruit pasta V_2 [T10+10% Amaranthus] while 68.97% was recorded for beetroot enriched functional jackfruit pasta V_3 [T10+10% Beetroot].

4.3.2.2. Total sugar (%)

Total sugar of vegetable enriched functional jackfruit pasta did not show significant difference during the storage period and the interaction effects were also non-significant. The pasta incorporated with vegetables exhibited difference in total sugar initially and after the storage. A mean total sugar content of 8.36% was observed for the carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] while it was 6.45% and 7.34% for amaranthus enriched functional jackfruit pasta V_2 [T10+10% Amaranthus] and beetroot enriched functional jackfruit pasta V_3 [T10+10% Beetroot] respectively.

4.3.2.3. Reducing sugar (%)

Reducing sugar content of vegetable enriched functional jackfruit pasta did not show significant difference during the storage period. The interaction effects being non-significant, the pasta incorporated with vegetables exhibited difference in reducing sugar initially and after the storage. Carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] recorded a mean reducing sugar content of 3.65%, amaranthus enriched functional jackfruit pasta V_2 [T10+10% Amaranthus] with 2.55% and 3.86% for beetroot enriched functional jackfruit pasta V_3 [T10+10% Beetroot].

4.3.2.4. Protein (%)

Protein content of vegetable enriched functional jackfruit pasta did not show significant difference during the storage period and the interaction effects were also non-significant. The pasta incorporated with vegetables exhibited difference in protein

Table 13a. Effect of storage nutritional parameters of vegetable based functional jackfruit pasta

Starch (%)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1 [T9+10% Carrot]	67.73	67.64	67.54	67.48	67.38	67.55
V_2 [T10+10% Amaranthus]	68.71	68.65	68.58	68.47	68.32	68.54
V_3 [T10+10% Beetroot]	69.19	69.05	68.98	68.87	68.79	68.97
Mean (M)	68.54	68.44	68.36	68.27	68.16	
SE (± m)	T- 1.322					
CD (0.05)	T- 3.835		M-NS		TxM-NS	
Total sugar (%)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1 [T9+10% Carrot]	8.12	8.22	8.34	8.45	8.69	8.36
V_2 [T10+10% Amaranthus]	6.22	6.36	6.45	6.58	6.66	6.45
V_3 [T10+10% Beetroot]	7.18	7.25	7.32	7.41	7.55	7.34
Mean (M)	7.17	7.27	7.37	7.48	7.63	
SE (± m)	T- 0.654					
CD (0.05)	T- 1.897		M- NS		TxM-NS	
Reducing sugar (%)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1 [T9+10% Carrot]	3.48	3.53	3.67	3.76	3.85	3.65
V_2 [T10+10% Amaranthus]	2.43	2.54	2.56	2.60	2.62	2.55
V_3 [T10+10% Beetroot]	3.74	3.85	3.87	3.90	3.94	3.86
Mean (M)	3.21	3.30	3.36	3.42	3.47	
SE (± m)	T-0.141					
CD (0.05)	T- 0.409		M- NS		TxM-NS	
Protein (%)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1 [T9+10% Carrot]	13.16	12.85	12.34	12.16	11.94	12.49
V_2 [T10+10% Amaranthus]	15.06	15.88	15.41	15.23	15.01	15.01
V_3 [T10+10% Beetroot]	14.82	14.51	14.37	14.12	13.89	14.34
Mean (M)	14.34	13.90	13.52	13.83	13.61	
SE (± m)	T-0.658					
CD (0.05)	T- 1.910		M- NS		TxM-NS	

T9 - [JBF (25%) + JSF (25%) + CF (15%)]

T10 - [JBF (10%) + JSF (30%) + CF (25%)]

JBF- Jackfruit Bulb Flour

JSF- Jackfruit Seed Flour

CF- Cassava Flour

content initially and after the storage. Carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] recorded a mean protein content of 12.49% and it was 15.01% for amaranthus enriched functional jackfruit pasta V_2 [T10+10% Amaranthus] while 14.34% was recorded for beetroot enriched functional jackfruit pasta V_3 [T10+10% Beetroot].

4.3.2.5. Carotenoids (μg100g^{-1})

Carotenoid content of the vegetable enriched functional jackfruit pasta differed significantly depending on the type of vegetable incorporated and the storage period. Carotenoid content of carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] was 10.68μg 100g^{-1} at the time of storage and decreased to 9.84μg 100g^{-1} after four months of storage. In case of amaranthus enriched functional jackfruit pasta V_2 [T10+10% Amaranthus] carotenoid was 5.92μg 100g^{-1} at the time of storage and 5.19μg 100g^{-1} after four months. Carotenoid content of 6.65μg 100g^{-1} and 5.81μg 100g^{-1} was noticed for beetroot enriched functional jackfruit pasta (V_3 [T10+10% Beetroot]) at the time of storage and four months after the storage respectively.

Among the treatments, carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] recorded a mean carotenoid content of 10.26 μg 100g^{-1} while amaranthus enriched functional jackfruit pasta V_2[T10+10% Amaranthus] exhibited a carotenoid content of 5.54μg 100g^{-1} and 6.23 μg 100g^{-1} for beetroot enriched functional jackfruit pasta V_3[T10+10% Beetroot]. During storage, the mean carotenoid content decreased from 7.75 μg 100g^{-1} at the time of storage to 6.94 μg 100g^{-1} after four months of storage.

4.3.2.6. Crude fibre (%)

Fibre content of vegetable enriched functional jackfruit pasta did not show significant difference during the storage period and the interaction effects were also non-significant. Carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] recorded a mean fibre content of 3.87%, and it was 2.83% for amaranthus enriched

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Table 13b. Effect of storage nutritional parameters of vegetable based functional jackfruit pasta (contd)

Carotenoids (µg $100g^{-1}$)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1 [T9+10% Carrot]	10.68	10.41	10.23	10.06	9.84	10.26
V_2 [T10+10% Amaranthus]	5.92	5.76	5.52	5.33	5.19	5.54
V_3 [T10+10% Beetroot]	6.65	6.45	6.20	6.07	5.81	6.23
Mean (M)	7.75	7.54	7.31	7.15	6.94	
SE ± (m)	T-0.009		M-0.012		TxM-0.020	
CD (0.05)	T- 0.026		M-0.034		TxM-0.058	
Crude fibre (%)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1 [T9+10% Carrot]	3.93	3.91	3.89	3.85	3.81	3.87
V_2 [T10+10% Amaranthus]	2.89	2.87	2.85	2.80	2.76	2.83
V_3 [T10+10% Beetroot]	2.18	2.17	2.16	2.14	2.09	2.14
Mean (M)	3.01	2.98	2.96	2.93	2.88	
SE (± m)	T-0.229					
CD (0.05)	T- 0.665		M- NS		TxM-NS	
Antioxidant activity (%)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1 [T9+10% Carrot]	93.95	93.86	93.72	93.61	93.55	93.73
V_2 [T10+10% Amaranthus]	95.21	95.17	95.05	94.92	94.81	95.03
V_3 [T10+10% Beetroot]	93.75	93.69	93.58	93.46	93.33	93.56
Mean (M)	94.30	94.24	94.11	93.99	93.89	
SE (± m)						
CD (0.05)	T- NS		M- NS		TxM-NS	

JBF- Jackfruit Bulb Flour

T9 - [JBF (25%) + JSF (25%) + CF (15%)]

JSF- Jackfruit Seed Flour

T10 - [JBF (10%) + JSF (30%) + CF (25%)]

CF- Cassava Flour

functional jackfruit pasta V_2 [T10+10% Amaranthus] while 2.14% was recorded for beetroot enriched functional jackfruit pasta V_3 [T10+10% Beetroot].

4.3.2.7. Antioxidant activity (%)

Vegetable enriched functional jackfruit pasta did not show any significant difference on antioxidant activity during storage period and interaction effects were also non-significant. Carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] recorded a mean antioxidant activity of 93.73% and it was 95.03% for amaranthus enriched functional jackfruit pasta V_2 [T10+10% Amaranthus] while 93.56% was recorded for beetroot enriched functional jackfruit pasta V_3 [T10+10% Beetroot].

4.3.3. Effect of storage on nutritional parameters of cooked vegetable based functional jackfruit pasta

4.3.3.1. Starch (%)

Vegetable enriched functional jackfruit pasta on cooking did not show any significant difference on the starch content during storage period. Eventhough the interaction effects were non-significant, the starch content of cooked pasta varied according to the vegetable incorporated. Carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] recorded a mean starch content of 48.81% and it was 45.92% for amaranthus enriched functional jackfruit pasta V_2 [T10+10% Amaranthus] while 48.93% was recorded for beetroot enriched functional jackfruit pasta V_3 [T10+10% Beetroot].

4.3.3.2. Total sugar (%)

Total sugar of cooked vegetable enriched functional jackfruit pasta did not show significant difference during the storage period and the interaction effects were also non-significant. The pasta incorporated with vegetables on cooking also exhibited no significant difference in total sugar initially and after the storage.

Table 14a. Effect of storage on nutritional parameters of cooked vegetable based functional jackfruit pasta

Starch (%)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1- [T9+10% Carrot]	48.95	48.92	48.82	48.75	48.63	48.81
V_2- [T10+10% Amaranthus]	46.07	46.04	45.95	45.83	45.75	45.92
V_3- [T10+10% Beetroot]	49.09	49.05	48.96	48.82	48.74	48.93
Mean (M)	48.03	48.00	47.91	47.80	47.70	
SE (± m)	T-1.322					
CD (0.05)	T-3.835		M- NS		TxM-NS	
Total sugar (%)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1- [T9+10% Carrot]	5.54	5.62	5.74	5.85	5.99	5.74
V_2- [T10+10% Amaranthus]	4.53	4.66	4.75	4.88	4.96	4.75
V_3- [T10+10% Beetroot]	6.84	6.95	7.02	7.11	7.25	7.03
Mean (M)	5.63	5.74	5.83	5.94	6.06	
SE (± m)						
CD (0.05)	T- NS		M- NS		TxM-NS	
Reducing sugar (%)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1- [T9+10% Carrot]	2.57	2.60	2.68	2.75	2.83	2.68
V_2- [T10+10% Amaranthus]	1.55	1.65	1.74	1.81	1.88	1.72
V_3- [T10+10% Beetroot]	2.72	2.76	2.85	2.93	3.02	2.85
Mean (M)	2.28	2.33	2.42	2.49	2.57	
SE (± m)	T-0.061					
CD (0.05)	T- 0.177		M- NS		TxM-NS	
Protein (%)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1- [T9+10% Carrot]	6.59	6.48	6.29	6.01	5.88	6.25
V_2- [T10+10% Amaranthus]	7.57	7.42	7.38	7.27	7.12	7.35
V_3- [T10+10% Beetroot]	7.38	7.23	7.16	7.05	6.91	7.14
Mean (M)	7.18	7.04	6.94	6.77	6.63	
SE (± m)						
CD (0.05)	T-NS		M- NS		TxM-NS	

T9 - [JBF (25%) + JSF (25%) + CF (15%)]

T10 - [JBF (10%) + JSF (30%) + CF (25%)]

JBF- Jackfruit Bulb Flour

JSF- Jackfruit Seed Flour

CF- Cassava Flour

4.3.3.3. Reducing sugar (%)

Reducing sugar content of vegetable enriched cooked functional jackfruit pasta on cooking did not show significant difference during the storage period. But the pasta incorporated with vegetables exhibited difference in reducing sugar initially and after the storage. Carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] recorded a mean reducing sugar content of 2.68%, amaranthus enriched functional jackfruit pasta V_2 [T10+10% Amaranthus] with 1.72% and 2.85% for beetroot enriched functional jackfruit pasta V_3 [T10+10% Beetroot] with storage.

4.3.3.4. Protein (%)

Protein content of vegetable enriched cooked functional jackfruit pasta did not show significant difference during the storage period and the interaction effects were also non-significant. The pasta incorporated with vegetables also exhibited no significant difference in protein content initially and after the storage.

4.3.3.5. Carotenoids ($\mu g 100g^{-1}$)

Carotenoid content of cooked vegetable enriched functional jackfruit pasta did not show significant difference during the storage period and the interaction effects were also non-significant. Mean carotenoid content of 4.14μg $100g^{-1}$ was observed for the carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] while it was 1.74μg $100g^{-1}$ and 2.25μg $100g^{-1}$ for amaranthus enriched functional jackfruit pasta V_2[T10+10% Amaranthus] and beetroot enriched functional jackfruit pasta V_3[T10+10% Beetroot] respectively after the storage period of four months.

4.3.3.6. Crude fibre (%)

Fibre content of vegetable enriched functional jackfruit pasta on cooking did not show any significant difference during the storage period and the interaction effects were also non-significant. Carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] recorded a mean fibre content of 1.35%, and it was 2.11% for amaranthus

Table 14b. Effect of storage on nutritional parameters of cooked vegetable based functional jackfruit pasta

Carotenoids (μg $100g^{-1}$)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1- [T9+10% Carrot]	4.51	4.32	4.16	3.97	3.74	4.14
V_2- [T10+10% Amaranthus]	2.11	1.99	1.76	1.52	1.36	1.74
V_3- [T10+10% Beetroot]	2.66	2.49	2.21	2.08	1.85	2.25
Mean (M)	3.09	2.93	2.71	2.52	2.31	
SE (± m)	T-0.314					
CD (0.05)	T- 0.913		M- NS		TxM-NS	
Crude fibre (%)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1- [T9+10% Carrot]	1.42	1.40	1.37	1.32	1.27	1.35
V_2- [T10+10% Amaranthus]	2.19	2.18	2.12	2.05	2.00	2.11
V_3- [T10+10% Beetroot]	1.62	1.60	1.57	1.51	1.45	1.55
Mean (M)	1.74	1.72	1.69	1.62	1.57	
SE (± m)	T-0.205					
CD (0.05)	T- 0.596		M- NS		TxM-NS	
Antioxidant activity (%)	Months after storage (M)					Mean (T)
	At the time of storage	1	2	3	4	
V_1- [T9+10% Carrot]	67.96	67.94	67.86	67.74	67.67	67.23
V_2- [T10+10% Amaranthus]	71.32	71.28	71.21	71.13	71.04	71.19
V_3- [T10+10% Beetroot]	68.25	68.21	68.14	68.06	67.98	68.12
Mean (M)	69.17	69.14	69.07	68.97	68.89	
SE (± m)	T-1.321					
CD (0.05)	T- 3.835		M- NS		TxM-NS	

JBF- Jackfruit Bulb Flour

T9 - [JBF (25%) + JSF (25%) + CF (15%)]

JSF- Jackfruit Seed Flour

T10 - [JBF (10%) + JSF (30%) + CF (25%)]

CF- Cassava Flour

enriched functional jackfruit pasta V_2 [T10+10% Amaranthus] while 1.55% was recorded for beetroot enriched functional jackfruit pasta V_3 [T10+10% Beetroot] after storage.

4.3.3.7. Antioxidant activity (%)

Vegetable enriched functional jackfruit pasta on cooking did not show any significant difference on antioxidant activity during storage period. Eventhough the interaction effects were non-significant, the antioxidant activity varied significantly according to the type of vegetables incorporated. Carrot enriched functional jackfruit pasta V_1 [T9+10% Carrot] recorded a mean antioxidant activity of 67.23% and it was 71.19% for amaranthus enriched functional jackfruit pasta V_2 [T10+10% Amaranthus] while 68.12% was recorded for beetroot enriched functional jackfruit pasta V_3 [T10+10% Beetroot].

4.3.4. Effect of storage on sensory parameters of stored vegetable based functional jackfruit pasta

Cooked vegetable based functional jackfruit pasta were analyzed for various sensory attributes; appearance, taste, colour, flavour, odour, texture, elasticity, adhesiveness, mouth feel and overall acceptability using 9 point hedonic scale. Sensory scores obtained for various attributes were analyzed statistically for a period of four months and described in Table 15.

The highest mean score for appearance (8.86) was obtained for the treatments V_1 - carrot incorporated jackfruit pasta and beetroot (V_3) added jackfruit pasta recorded a mean score of 8.19 and a mean score of 7.82 was recorded for amaranthus based jackfruit pasta (V_2) at the time of storage. After four months of storage, carrot (V_1) amaranthus (V_2) and beetroot (V_3) incorporated jackfruit pasta recorded a mean score of 8.03, 7.51 and 7.58 respectively. All the three functional pasta recorded acceptable score for appearance after four months of storage even though a slight decrease in sensory score was observed.

The highest mean score for taste (8.16) was noticed for carrot incorporated jackfruit pasta (V_1) followed by V_3 - beetroot added jackfruit pasta (7.85) and it was 7.54 was for amaranthus incorporated jackfruit pasta (V_2) at the time of storage. After four months of storage, carrot, amaranthus and beetroot incorporated jackfruit pasta recorded a mean score of 7.73, 7.24 and 7.68 respectively. All the three functional pasta recorded acceptable score for taste after four months of storage.

Among the treatments, carrot incorporated jackfruit pasta (V_1) recorded the highest mean value for colour (9.31) followed by beetroot added jackfruit pasta (8.64) and it was 8.27 for amaranthus based jackfruit pasta (V_2) at the time of storage which decreased slightly to 8.68, 7.88 and 8.50 respectively after four months of storage. All the three functional pasta recorded acceptable score for colour after four months of storage.

The highest mean score for flavour (8.11) was noticed for carrot incorporated jackfruit pasta (V_1) and it was 7.49 and 7.82 for amaranthus (V_2) and beet root (V_3) incorporated jackfruit pasta respectively which reduced to 7.85, 7.25 and 7.67, after four months of storage and were acceptable after the storage.

The highest mean score for odour (8.57) was obtained for carrot incorporated jackfruit pasta (V_1) followed by V_3- beetroot added jackfruit pasta (7.94) and it was 7.53 for amaranthus based jackfruit pasta (V_2). Carrot (V_1), beetroot (V_2) and amaranthus (V_3) incorporated jackfruit pasta recorded a mean score of 8.39, 7.37 and 7.76 respectively with acceptable sensory score after four months of storage.

For texture, the highest mean score (8.16) was noticed for carrot incorporated jackfruit pasta (V_1) followed by beetroot (V_3) and amaranthus (V_2) based jackfruit pasta with 7.49 and 7.12 mean score respectively at the time of storage. After four months of storage carrot, amaranthus and beetroot incorporated jackfruit pasta recorded a mean score of 8.39, 7.37 and 7.76 respectively. All the three functional pasta recorded acceptable score for texture after storage also.

Table 15. Effect of storage on sensory parameters of cooked vegetable based functional jackfruit pasta

Attributes	Months after storage				
Appearance	At the time of storage	1	2	3	4
	Mean score	Mean score	Mean score	Mean score	Mean score
V1 [T9+10% Carrot]	8.86	8.35	8.25	8.16	8.03
V2 [T10+10% Amaranthus]	7.82	7.70	7.64	7.54	7.51
V3 [T10+10% Beetroot]	8.19	7.80	7.74	7.67	7.58
KW value	13.05	12.23	14.71	16.02	13.14
Taste					
V1 [T9+10% Carrot]	8.16	8.13	8.02	7.92	7.73
V2 [T10+10% Amaranthus]	7.54	7.43	7.41	7.37	7.24
V3 [T10+10% Beetroot]	7.85	7.76	7.75	7.70	7.68
KW value	15.90	12.03	11.45	10.34	9.24
Colour					
V1 [T9+10% Carrot]	9.31	8.99	8.74	8.71	8.68
V2 [T10+10% Amaranthus]	8.27	8.13	7.97	7.92	7.88
V3 [T10+10% Beetroot]	8.64	8.60	8.58	8.54	8.50
Flavor					
KW value	13.50	12.55	10.66	9.68	8.39
V1 [T9+10% Carrot]	8.11	8.06	7.95	7.89	7.85
V2 [T10+10% Amaranthus]	7.49	7.41	7.36	7.28	7.25
V3 [T10+10% Beetroot]	7.82	7.77	7.74	7.71	7.67
KW value	5.51	6.44	7.83	8.74	8.10
Odour					
V1 [T9+10% Carrot]	8.57	8.53	8.49	8.43	8.39
V2 [T10+10% Amaranthus]	7.53	7.51	7.49	7.42	7.37
V3 [T10+10% Beetroot]	7.94	7.88	7.84	7.80	7.76
KW value	8.45	10.37	12.93	9.11	9.49
Texture					
V1 [T9+10% Carrot]	8.16	8.08	8.01	7.95	7.90
V2 [T10+10% Amaranthus]	7.12	7.09	6.98	6.92	6.87
V3 [T10+10% Beetroot]	7.49	7.45	7.38	7.34	7.32
KW value	9.43	8.23	8.99	11.05	10.92
Elasticity					
V1 [T9+10% Carrot]	8.22	8.18	8.13	8.06	8.05
V2 [T10+10% Amaranthus]	7.60	7.52	7.46	7.39	7.35
V3 [T10+10% Beetroot]	7.91	7.85	7.81	7.77	7.71
KW value	1.84	1.62	2.28	4.40	5.39
Adhesiveness					
V1 [T9+10% Carrot]	7.49	7.46	7.41	7.36	7.33
V2 [T10+10% Amaranthus]	8.12	8.05	7.98	7.93	7.88
V3 [T10+10% Beetroot]	7.78	7.75	7.72	7.67	7.63
KW value	0.34	0.73	0.92	1.22	1.49
Mouth feel					
V1 [T9+10% Carrot]	8.57	8.54	8.50	8.43	8.36
V2 [T10+10% Amaranthus]	7.53	7.48	7.44	7.39	7.35
V3 [T10+10% Beetroot]	7.95	7.92	7.86	7.81	7.78
KW value	0.89	1.19	0.40	0.92	0.66
Overall acceptability					
V1 [T9+10% Carrot]	8.58	8.54	8.50	8.46	8.40
V2 [T10+10% Amaranthus]	7.96	7.94	7.90	7.85	7.81
V3 [T10+10% Beetroot]	8.25	8.19	8.14	8.08	8.04
KW value	3.96	4.67	3.25	2.86	2.88
χ^2	5.99				

Among the treatments, highest mean score (8.22) for elasticity was observed for carrot incorporated jackfruit pasta (V_1) and it was 7.91 and 7.60 for beetroot (V_2) and amaranthus (V_3) based jackfruit pasta at the time of storage and it was 8.05, 7.71 and 7.35 respectively which were acceptable after four months of storage.

The lowest mean score (7.49) for adhesiveness was recorded for V_1- carrot incorporated jackfruit followed by V_2- beetroot added jackfruit pasta (7.78) and 8.12 for amaranthus based jackfruit pasta (V_2) at the time of storage. After four months of storage carrot, amaranthus and beetroot incorporated jackfruit pasta recorded a mean score of 7.33, 7.88 and 7.63 respectively with acceptable sensory score.

The highest mean score for mouth feel (8.57) was noticed for carrot based jackfruit pasta (V_1) followed by beetroot incorporated jackfruit pasta (7.95) and it was 7.53 for amaranthus based jackfruit pasta (V_2) at the time of storage. Carrot (V_1), beetroot (V_2) and amaranthus (V_3) incorporated jackfruit pasta recorded a mean score of 8.36, 7.35 and 7.78 respectively after four months of storage. All the three functional pasta recorded acceptable score for mouth feel after storage also eventhough a slight decrease in mean score was observed.

Overall acceptability recorded the highest mean score (8.58) for carrot incorporated jackfruit pasta (V_1) followed by beetroot added jackfruit pasta (V_3) with a mean score of 8.25 and a mean score of 7.96 was observed for amaranthus based jackfruit pasta (V_2) at the time of storage. After four months of storage for carrot (V_1), amaranthus (V_2) and beetroot (V_3) incorporated jackfruit pasta recorded a mean score of 8.40, 7.81 and 8.04 respectively and all the three functional pasta recorded acceptable score for overall acceptability even after storage.

4.3.4. Microbial analysis of vegetable based functional jackfruit pasta

Vegetable based functional jackfruit pasta was analyzed for bacteria and fungus at monthly interval during storage and no microbial load was detected till the end of four months of storage period.

Discussion

5. DISCUSSION

The results obtained from the investigation on “Development of functional jackfruit pasta” are discussed in this chapter under the following headings.

1. Development of jackfruit pasta
2. Development of vegetable based functional jackfruit pasta
3. Storage stability studies of functional jackfruit pasta

5.1. DEVELOPMENT OF JACKFRUIT PASTA

Jackfruit pasta developed were analyzed for cooking quality, nutritional and sensory parameters.

5.1.1. Cooking quality of jackfruit pasta

Cooking quality characteristics were analyzed for cooking loss (%), water absorption (g g^{-1}), swelling index (%) and cooking time (minutes).

Cooking loss of the developed jackfruit pasta increased with the increase in jackfruit seed flour concentration in the combinations. Cooking loss of developed pasta ranged from 14.16% to 21.97% and the lowest cooking loss (14.16%) was recorded for jackfruit pasta developed with the combination of jackfruit bulb (flakes) flour and seed flour each @ 15% and 35% cassava flour. The highest cooking loss (21.97%) was observed for the combination of 50% jackfruit seed flour and 15% cassava flour. Similar result of varied cooking loss was observed by various researchers. According to Manthey *et al.* (2008) in extruded products non-wheat ingredients led to discontinuous gluten matrix which eventually weakened dough properties which resulted in high cooking loss. Brennan *et al.* (2004) reported that pasta enriched with inulin showed an increase in cooking loss with increase in level of inulin addition. Cooking loss of pasta enriched with flaxseed flour was in the range of 6.10 to 9.45g $100g^{-1}$ was recorded by Konidena (2011). Devi (2015) reported a cooking loss of 9.4% for pasta developed with jackfruit bulb (flakes) flour, seed flour and cassava flour.

Kumari (2015) in a study on development of jackfruit noodles noticed a cooking loss of 9.13% to 15.37% which was more than the refined flour noodles.

According to Abraham and Jayamuthunagai (2014) jackfruit seed flour possess good water absorption capacity. In the present study, water absorption of jackfruit pasta increased with increase in seed flour concentration (Fig 1). The highest water absorption (1.34g g^{-1}) was observed for the treatments with highest seed flour concentration, 50% jackfruit seed flour and 15% cassava flour and 40% jackfruit seed flour and 25%cassava flour. The lowest water absorption (0.80g g^{-1}) was observed for the treatment with 15% jackfruit bulb (flakes) flour, 15% jackfruit seed flour and 35% cassava flour, Water absorption of pasta developed with multigrain flour decreased upon addition of non-wheat ingredients and it ranged from 260.30 to 158.60% (Gill, 2014). Water absorption of jackfruit noodles was in the range of 100.45% to 140.62% as reported by Kumari (2015).

The swelling index of developed jackfruit pasta ranged from 2.86% to 1.47% and varied with the percentage of incorporation of jackfruit seed flour and jackfruit bulb (flakes) flour. The highest swelling index of 2.86% was observed for treatment with 50% jackfruit seed flour and 15% cassava flour and the lowest (1.47%) was for the treatment with 15% jackfruit bulb (flakes) flour, 15% jackfruit seed flour and35% cassava flour. Konidena (2011) reported a swelling index of 2.71 to 4.56g g^{-1} for pasta enriched with flaxseed flour. Swelling capacity of sweet potato flour incorporated sorghum pasta ranged from 4.79 to 5.21ml g^{-1} which was higher than the control sorghum pasta with 4.49 ml g^{-1} swelling index (Beerelly, 2012). The study conducted by Devi (2015) on development of jackfruit pasta with jackfruit bulb (flakes) flour, jackfruit seed flour and cassava flour reported a swelling index of 3.73% for jackfruit based pasta. Kumari (2015) reported a swelling index of 1.26% for noodles developed from jackfruit bulb (flakes) flour. Padmaja (2015) reported that swelling index indicate the amount of water utilized by protein for hydration and gelatinization of starch during

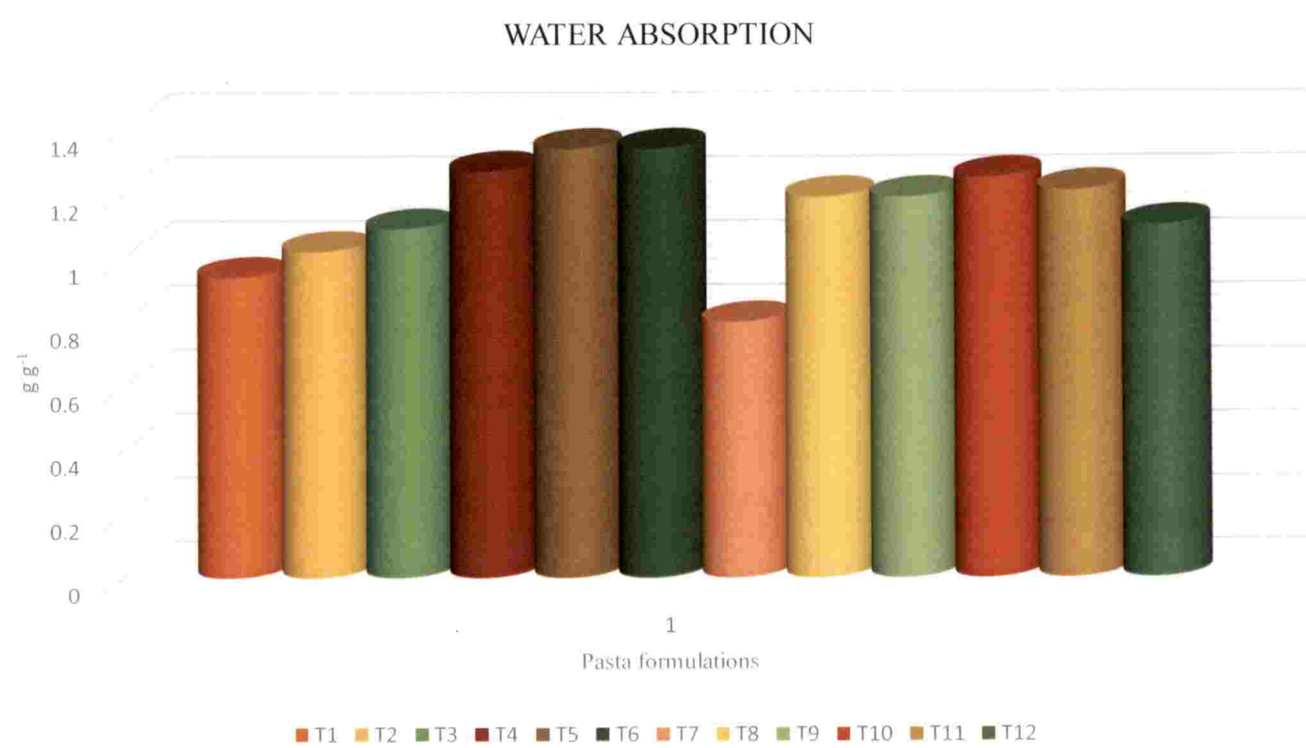

Fig 1. Water absorption (g g^{-1}) of jackfruit pasta

cooking and observed a swelling index of 1.86% to 2.03% for pasta developed from cassava flour.

Cooking time of pasta increased with increase in jackfruit seed flour concentration and it ranged from 6.12 to 7.14 min with no statistically significant difference among the treatments. According to Beerelly (2012) cooking time of sorghum pasta decreased with the addition of sweet potato flour and it ranged from 11 to 13 min. Das (2014) reported a cooking time of 12.50 min for pasta prepared from jackfruit pulp. Pasta enriched with multigrain recorded an increase (7.05 min to 8 min) in cooking time as compared to pasta made from durum wheat semolina which might be due to the decrease in amount of wheat and increase in proportion of other cereals used in pasta (Gill, 2014). In a study on development of jackfruit pasta from jackfruit bulb (flakes) and seed flour Devi (2015) reported an increased cooking time of 10.90 min as compared to control pasta. According to Kumari (2015), cooking time of jackfruit noodles ranged from 8.26 min to 9.36 min and cooking time of pasta developed using non wheat whole grains ranged between 10.30 to 12.02 min was reported by Dolly (2016).

5.1.2. Nutritional parameters of jackfruit pasta

Nutritional parameters *viz.,* starch, total sugar, reducing sugar, protein, carotenoids, crude fibre and antioxidant activity varied with the amount of jackfruit bulb (flakes) and seed flour concentration used in the treatment combinations for the development of jackfruit pasta.

Starch content of the jackfruit pasta increased with increase in jackfruit seed flour and cassava flour concentration and the treatment combination with 10% jackfruit bulb (flakes) flour, 30% jackfruit seed flour and 25% cassava flour recorded the highest starch content of 69.38% for raw jackfruit pasta (Fig 2) (uncooked) and it was 53.28% for cooked one (Fig 3). The lowest starch content was recorded by the treatment with 50% jackfruit bulb (flakes) flour and 15% cassava flour for raw (60.10%) and cooked

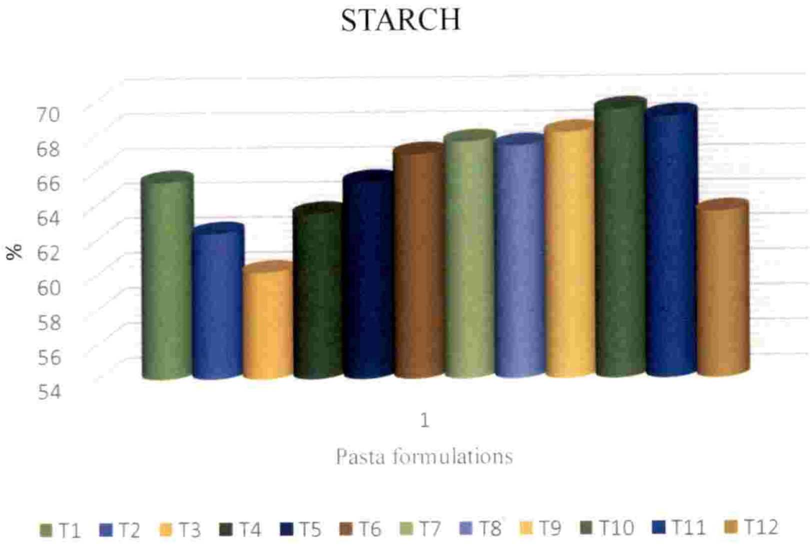

Fig 2. Starch content (%) of raw jackfruit pasta

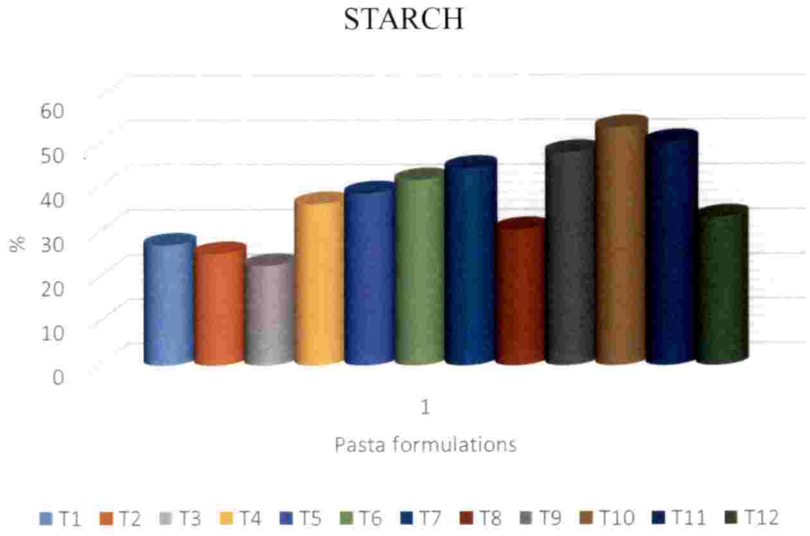

Fig 3. Starch content (%) of cooked jackfruit pasta

jackfruit pasta (22.52%).This was in line with the results of the study conducted by Padmaja *et al.* (2015) who reported that the starch content of cassava based pasta ranged from 74.23% to 76.30% and it was 50% to 60.64% for sweet potato enriched pasta.

Sugar content of pasta increased with the increase in jackfruit bulb (flakes) flour used in the treatment combinations. The total sugar content of raw jackfruit pasta ranged between 5.09% to 7.22% and it was from 3.25% to 5.13% for cooked jackfruit pasta. For raw jackfruit pasta reducing sugar content varied from 3.24% to 5.40% and it was 0.94% to 1.96% for cooked jackfruit pasta. Total sugar and reducing sugar content were observed the highest for treatment combination with 50% jackfruit bulb (flakes) flour and 15% cassava flour and lowest for the treatment with 15% jackfruit bulb (flakes) flour and 15% jackfruit seed flour and 35% cassava flour. These results are in line with the findings of Devi (2015) in the development of jackfruit pasta using jackfruit bulb (flakes) and seed flour where pasta developed from jackfruit bulb (flakes) showed a higher carbohydrate content than pasta developed from jackfruit seed flour. Kumari (2015) reported a carbohydrate content of 48.89% to 70.91% in noodles developed from jackfruit. Incorporation of non-wheat whole grains in pasta led to decrease in carbohydrate content of conventional pasta and it ranged from 63.10 to 63.26% (Dolly, 2016). Nataraja (2018) in a study on developing pasta with sprouted grains reported a decrease (65.62 to 69.71%) in carbohydrate content of pasta as compared to the control pasta (72.12%) with increase in concentration of sprouted grains.

Jackfruit seed is a rich source of protein and Ocloo *et al.* (2010) reported 13.50% of protein in jackfruit seed flour. Protein content of the jackfruit pasta ranged between 10.08% and 14.99% for raw jackfruit pasta and 4.31% to 7.55% for cooked jackfruit pasta. Protein content of jackfruit pasta increased with increase in jackfruit seed flour concentration in the treatment combinations. The highest protein content (14.99%) was noticed for the treatment with 50% of jackfruit seed flour and 15%

cassava flour and the lowest (10.08%) for the treatment with 15% jackfruit bulb (flakes) flour, 15% jackfruit seed flour and 35% cassava flour. Das (2014) developed jackfruit pasta from jackfruit pulp reported a protein content of 8.05 g $100g^{-1}$. Protein content of 10.06 to 16.95g $100g^{-1}$ was observed for pasta developed from jackfruit bulb (flakes) flour, jackfruit seed flour and cassava flour (Devi, 2015). Kumari (2015), reported a protein content of 11.50% to 13.49% for noodles made from jackfruit bulb (flakes) flour. Nataraja (2018) stated that an increase in protein content in wheat pasta could be observed with the addition of sprouted grains in pasta.

Carotenoid content of the jackfruit pasta increased with increase in jackfruit bulb (flakes) flour concentration in the treatment combinations. The carotenoid content of developed jackfruit pasta ranged from 4.65 to 8.93μg $100g^{-1}$ for raw jackfruit pasta and for cooked jackfruit pasta it was from 1.21 to 2.05μg $100g^{-1}$. The highest carotenoid content was observed for the treatment with 50% jackfruit bulb (flakes) flour and 15% cassava flour and the lowest was for the treatment with 30% jackfruit seed flour and cassava flour. Beerelly (2012) observed an increase in orange colour of sweet potato flour enriched sorghum pasta due to the increase in carotenoid content in sweet potato. Das (2014) reported an increase in β carotene content for jackfruit pulp incorporated pasta.

In the present study, crude fibre content ranged from 0.97% to 5.92% for raw jackfruit pasta and 0.11% to 0.07% for cooked jackfruit pasta. The treatment combination with 50% jackfruit bulb (flakes) flour and 15% cassava flour recorded the highest crude fibre content of 5.92% and the treatment combination with 30% jackfruit seed flour and 35% cassava flour recorded the lowest crude fibre content. Crude fibre content of pasta increased with increase in jackfruit bulb (flakes) flour concentration. Jackfruit bulb (flakes) and seed flour are rich source of fibre and Ocloo *et al.* (2010) reported a crude fibre content of 3.16% in jackfruit seed flour. Pasta prepared from jackfruit pulp recorded a crude fibre content of 1.61g $100g^{-1}$ (Das, 2014). Devi (2015) recorded a crude fibre content in the range of 3.54% to 4.50% for jackfruit pasta.

Kumari (2015) reported that crude fibre content of jackfruit noodles ranged from 4.57% to 5.42%. Addition of micronutrients in conventional pasta enhanced the fibre content of pasta from 7.61 to 22.32% (Sharma, 2017) .Fibre content of pasta increased with the addition of sprouted whole grains like wheat, maize, soybean and bengal gram and it ranged from 8.76 to 9.23% (Nataraja, 2018)

The antioxidant activity was observed highest for the treatment with 50% jackfruit seed flour and 15% cassava flour for raw (91.60%) and cooked (79.29%) jackfruit pasta. The lowest antioxidant activity was observed by the treatment with 15% jackfruit bulb (flakes) flour, 15% jackfruit seed flour and 35% cassava flour for both raw (88.26%) and cooked (51.51%) jackfruit pasta. Gupta *et al.* (2011) reported that jacalin present I the seeds of jackfruit is a rich source of antioxidant. Jackfruit bulb (flakes) and seeds are considered as an excellent source of antioxidants as reported by Shanmugapriya *et al.* (2011); Gat and Ananthanarayan (2015); Maurya and Mogra (2016) which might have contributed to the increased antioxidant activities of developed jackfruit pasta.

5.1.4. Textural characteristics of jackfruit pasta

Edwards *et al.* (1993) reported that internal structure of the cooked product decides hardiness of pasta and surface properties determines adhesiveness of pasta. Texture of the pasta is determined by gelatinization of starch and coagulation of protein (Steffe, 1996). Pasta formulation with 50% jackfruit bulb (flakes) flour and 15% cassava flour recorded the highest value for firmness and pasta with 30% jackfruit bulb (flakes) flour and 35% cassava flour recorded the highest value for toughness for raw pasta. For cooked pasta the highest value for firmness was observed for treatment with 50% jackfruit seed flour and 15% cassava flour and treatment with 30% jackfruit bulb (flakes) flour, 20% jackfruit seed flour and 15% cassava flour recorded the highest value for toughness. Brennan *et al.* (2004) in a study on enriching pasta with inulin reported a decrease in pasta firmness with addition of inulin. According to del Nobile *et al.* (2005) protein content affected hardness of cooked spaghetti. Incorporation of variable cereal brans in pasta showed increase in toughness and hardness with increase in bran concentration in the pasta dough (Padmaja *et al.*, 2015).

5.1.4. Sensory qualities of jackfruit pasta

Sensory attributes play an important role in the acceptability of pasta by the consumers. In the present study sensory scores were analyzed for appearance, taste, colour, flavour, odour, texture, elasticity, adhesiveness, mouthfeel and overall acceptability which showed significant difference among various formulations. Pasta formulation with 10% jackfruit bulb (flakes) flour, 30% jackfruit seed flour and 25% cassava flour obtained the highest mean score for colour, taste, flavour, texture, elasticity, mouth feel and overall acceptability. Similar results were obtained by Kumari (2015) in the development of jackfruit pasta from jackfruit bulb (flakes) and seed flour where pasta with higher seed flour and lower bulb (flakes) flour combination obtained the highest sensory mean score. The highest mean score for appearance (8.67) was obtained for combination with 25% jackfruit bulb (flakes) flour, 25% jackfruit seed flour and 15% cassava flour. The pasta combination with 30% bulb (flakes) flour and 35% cassava flour recorded the highest mean score for odour (7.45). This may be due to a higher amount of jackfruit bulb (flakes) flour and cassava flour used in the combinations. Lowest mean score for adhesiveness (6.52) was noticed for the treatment with 15% jackfruit bulb (flakes) flour, 15% jackfruit seed flour and 35% cassava flour and this may be due to a decrease amount of jackfruit seed flour used in the treatment combinations. Gill (2014) reported a decrease in sensory acceptance of pasta enriched with multigrain in terms of appearance, texture, flavour and acceptability compared to control durum wheat pasta. Addition of non-wheat ingredients in pasta led to decreased sensory acceptance in studies conducted by Das (2014), Devi (2015), Kumari (2015), Padmaja *et al.* (2015), Sharma (2017) and Nataraja (2018).

5.2. DEVELOPMENT OF VEGETABLE BASED FUNCTIONAL JACKFRUIT PASTA

Selected treatments from Part I of the study were taken for the development of vegetable (carrot, beet root and red amaranthus) based functional jackfruit pasta. Vegetables were incorporated as paste to the selected combinations of pasta @ 5 and 10 % and were analyzed for cooking quality, nutritional and sensory parameters.

5.2.1. Cooking quality of vegetable based functional jackfruit pasta

Cooking quality characters of vegetable based functional jackfruit pasta were analyzed for cooking loss (%), water absorption (g g^{-1}), swelling index (%) and cooking time (minutes).

Cooking loss of the developed functional jackfruit pasta marginally increased with increase in concentration of vegetable used in the combinations and it differed with the type of vegetable incorporated eventhough the difference was statistically non-significant. Cooking loss ranged from 6.84% to 12.87% with no statistical difference among the treatments. Perez and Perez (2009) reported an increased in cooking loss with addition of cassava flour and beetroot juice in conventional wheat pasta. Padalino *et al.* (2013) in a study on incorporating semolina pasta with yellow pepper flour found an increase in cooking loss due to starch gelatinization. Cooking loss of semolina pasta decreased (7.1 to 8.4g kg^{-1}) with the addition of vegetable purees like carrot, tomato, beetroot and amaranthus (Rekha *et al.,* 2013). Elderberry juice on addition to semolina pasta recorded a cooking loss of 5.98 to 8.06% (Sun-Waterhouse *et al.*, 2013). Increase in cooking loss with increase in concentration of amaranth leaf in pasta dough was observed by Cardinas-Hernandez *et al.* (2016).Pasta enriched with tomato peel showed a slight increase cooking loss ranging from 7.6 to 7.76% as compared to the control wheat pasta (Padalino *et al.,* 2017).

Water absorption of developed vegetable based functional jackfruit pasta varied with the type of vegetable incorporated and increased with increase in concentration of vegetable (Fig 4). Pasta enriched with carrot leaf meal showed an increase in water absorption with increase in leaf meal concentration in pasta (Boroski *et al.,* 2011).

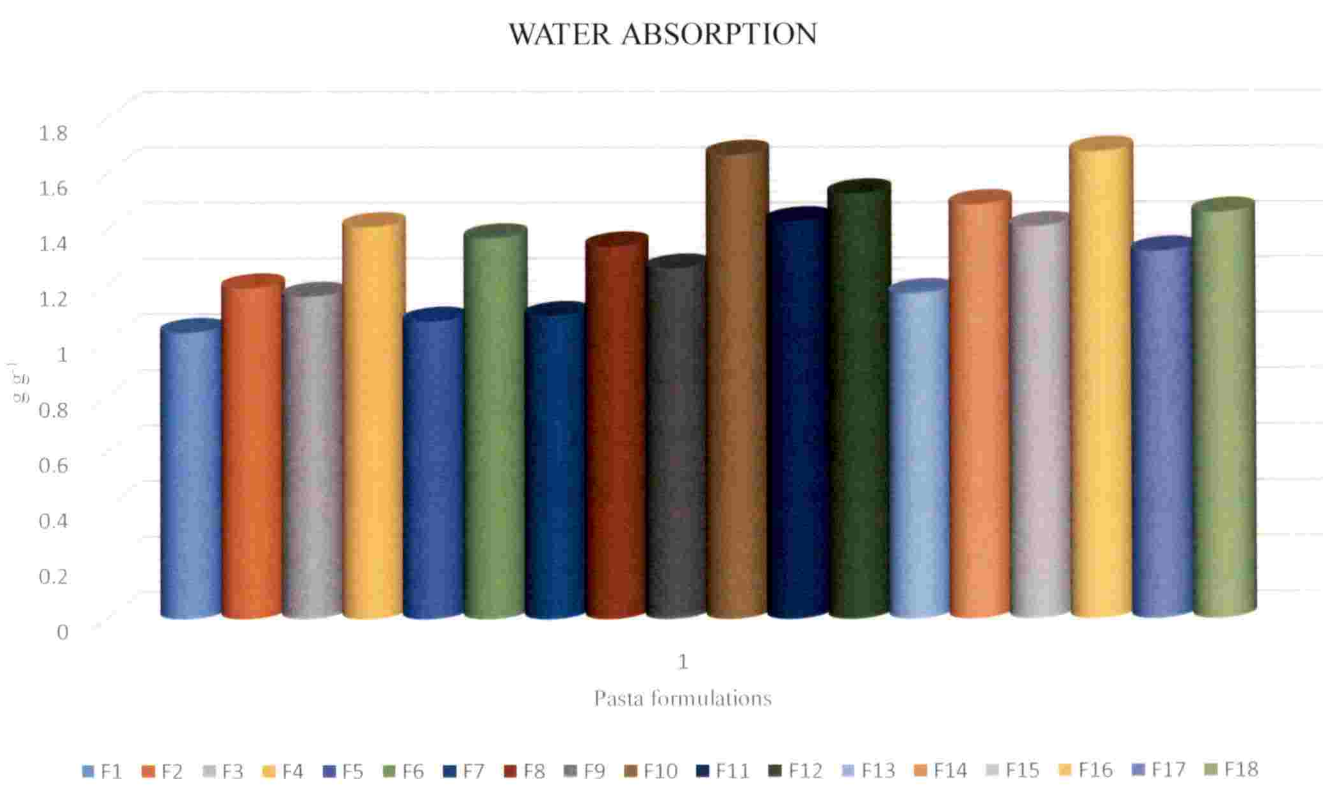

Fig 4. Water absorption (g g^{-1}) of vegetable based functional jackfruit pasta

Decrease in water absorption (131%) of spaghetti enriched with yellow pepper flour compared to the control spaghetti (141%) was observed by (Padalino *et al.*, 2013). Sun-Waterhouse *et al.* (2013) explained that the amount of water absorbed by pasta is determined by the openness in the gluten structure of pasta and increase in elderberry juice concentrate in the wheat pasta led to increase in water absorption of the developed pasta. In a study conducted by Cemin *et al.* (2014) on enriching fresh pasta with broccoli leaves and spinach leaves a water absorption of 183.9 and 182.6% was observed.

In the present study swelling index of pasta varied with the type of vegetable incorporated and increased slightly with the concentration of vegetable without statistically significant difference. Swelling index ranged from 1.06% to 3.15% with no significant difference among the treatments. In a study conducted by Ajila *et al.* (2010) on incorporating mango peel powder in macaroni observed decrease in swelling index with increase in concentration of mango peel incorporated. Swelling index of gluten free pasta increased with addition of yellow pepper flour to the pasta (Padalino *et al.*, 2013). Incorporating vegetable purees in pasta decreased the swelling index of developed pasta and it ranged from 1.24 to1.53% (Rekha *et al.,* 2013). Padalino *et al.* (2017) stated that increase in fibre content in pasta led to decreased swelling of starch and thereby decreasing the swelling index of pasta.

Similar trend was observed for cooking time also which increased with increase in concentration of vegetable incorporated in the jackfruit pasta and it ranged between 5.23 to 7.31min which showed no significant difference statistically. Borneo and Aguirre (2008) reported a cooking time of 3.1min for pasta enriched with dried amaranth leaf flour. In a study conducted by Padalino *et al.* (2013) on developing gluten free spaghetti with incorporation of vegetables, it was found that addition of yellow pepper flour decreased the optimum cooking time than the control pasta. Pasta enriched with vegetables exhibit a lesser cooking time due to the quicker reconstitution of pasta matrix by the fine vegetable matter (Rekha *et al.,* 2013). Padalino *et al.* (2017) reported decrease in cooking time with the increase in concentration of tomato peel in pasta and it ranged from 9 to 9.3 min as compared to 10.2min for control spaghetti.

5.2.2. Nutritional parameters of vegetable based functional jackfruit pasta

Nutritional parameters *viz.,* starch, total sugar, reducing sugar, protein, carotenoids, crude fibre and antioxidant activity varied with the amount of jackfruit bulb (flakes) and seed flour concentration used in the treatment combinations for the development of vegetable based functional jackfruit pasta.

Starch content of vegetable based functional jackfruit pasta ranged from 64.53% to 69.19% with no significant difference among the treatments. This may be due to lesser starch content in the incorporated vegetables. Ovando-Martinez *et al.* (2009) stated that the starch content of unripe banana flour enriched spaghetti increased with increase in level of substitution from 72.48% to 78.90%. Petitot *et al.* (2010) observed a starch content of 44.4 and 47.9g $100g^{-1}$ for pasta enriched with faba bean and split pea flour. A decrease in starch content with addition of broccoli leaves was observed by da Silva (2013).

In the present study total sugar of the vegetable based functional jackfruit pasta ranged from 6.19% to 9.20% and reducing sugar ranged from 4.77% to 6.65% with no significant difference among the treatments. Prabhashankar *et al.* (2009) reported a decrease in carbohydrate content on addition of Japanese sea weed in pasta dough and it decreased with increase in concentration of sea weed added. Pasta enriched with mango peel powder increased the carbohydrate content of pasta upto 80.70% (Ajila *et al.,* 2010). Gull *et al.* (2015) reported a slight decrease in carbohydrate content ranging from 66.57g $100g^{-1}$ to 68.89g $100g^{-1}$ on addition of millet flour and carrot pomace powder in pasta. Cardinas-Hernandez *et al.* (2016) observed a decrease in carbohydrate content with the addition of amaranthus leaf flour in pasta ranging from 72.74 to

65.85% compared to the control pasta (75.88%). Padalino *et al.* (2017) reported a decrease in carbohydrate content in pasta enriched with tomato peel ranged from 58 to 68 g $100g^{-1}$.

Protein content of vegetable based functional jackfruit pasta ranged from 12.98% to 15.06% with no significant difference among the treatments. Ajila *et al.* (2010) observed an increase in protein content of 3.6% on addition of mango peel powder on pasta. Pasta enriched with Japanese seaweed, recorded an increase in protein content of 18.92 to 21.68% with increase in sea weed concentration (Prabhashankar *et al.,* 2009). Pasta enriched with split pea and faba bean flour recorded an increased protein content of 21.4 to 29g $100g^{-1}$ (Petitot *et al.,* 2010). Giménez *et al.* (2012) reported that with the increase in addition of broad bean flour to wheat flour, the protein quality of the enriched pasta increased due to higher lysine content and 58% of protein substitution proved to be of greatest benefit. Rekha *et al.* (2013) stated that there was no difference in the protein content of pasta enriched with different vegetable purees like carrot, beetroot, tomato and amaranthus. Slinkard (2014) reported an increase in protein content in pasta fortified with chickpea and quinoa flour. Protein content of 0.70 to 7.3 g $100g^{-1}$ was observed by Gull *et al.* (2015) on enriching pasta with carrot pomace and millet flour. According to Cardinas-Hernandez *et al.* (2016) the protein content of the pasta enriched with amaranth flour and amaranth leaves were higher compared to the semolina pasta which ranged from 17.51 to 19.04% compared to 17.26% in semolina pasta. Padalino *et al.* (2017) reported that there was a decrease (10.00% to 10.35%) in protein content in tomato peel enriched spaghetti compared to control spaghetti. Minarovičová *et al.* (2018) reported a protein content of 7.72% for celery root powder enriched pasta and 10.31% for sugar beet pulp powder enriched pasta.

Carotenoid content of vegetable based functional jackfruit pasta (raw) varied from 5.87 μg $100g^{-1}$ to 10.68 μg $100g^{-1}$ (Fig 5). The highest carotenoid content of 10.68 μg $100g^{-1}$ was recorded for the treatment with 25% jackfruit bulb (flakes) flour, 25%

jackfruit seed flour, 15% cassava flour and 10% Carrot. Ajila *et al.* (2010) reported that addition of mango peel powder at 2.5, 5 and 7.5% increased the carotenoid content of pasta to 26.5, 41 and 84 μg 100g^{-1}. Rekha *et al.* (2013) reported an increase in carotenoid content with addition of vegetable purees like carrot (23mg kg^{-1}), beetroot (7 mg kg^{-1}), amaranthus (15 mg kg^{-1}) and tomato (12.3mg kg^{-1}). Padmaja *et al.* (2015) found that the total carotenoids increased with the fortification of pumpkin in cassava pasta and it ranged from1.5 to 1.8 mg 100g^{-1}. Padalino *et al.* (2017) reported that incorporation of tomato peel into spaghetti increased the carotenoid content with increase in level of substitution of tomato peel.

Fibre content of vegetable based functional jackfruit pasta ranged from 1.66% to 4.82% with no significant difference among the treatments. Petitot *et al.* (2010) reported an increased fibre content of 13.4 and 7.3 g 100g^{-1} for pasta enriched with split pea and faba bean flour. With the addition of every 10% of broad bean flour, reported an increase of fibre content in spaghetti increased by 2% (Giménez *et al.*, 2012). Spinach enriched pasta had a higher fibre content of 3.3% when compared to carrot (2.9%), tomato (2.9%) and beetroot (2.7%) enriched pasta (Rekha *et al.*, 2013). An increase in fibre content with increase in chickpea flour was observed by Slinkard (2014). Fibre content of the pasta incorporated with amaranth flour and amaranth leaves were higher (2.48 to 4.14%) as compared to the conventional semolina pasta (2.31%) (Cardinas-Hernandez *et al.*, 2016). Mishra and Bhatt (2016) reported an increase in fibre content of 2.32% on addition of ginger powder on conventional pasta which showed a fibre content of 0.48%. Lorusso *et al.* (2016) reported an increase in fibre content of 4.64g 100g^{-1} on pasta enriched with quinoa flour. Fibre content of the tomato peel enriched spaghetti found to increase from 16.80% to 22.67% compared to the control samples (Padalino *et al.*, 2017).

Antioxidant activity of vegetable based functional jackfruit pasta ranged from 93.34% to 95.21% for raw pasta and 62.85% to 71.32% for cooked pasta with no significant difference among the treatments (Fig 6). Cooking reduced the antioxidant

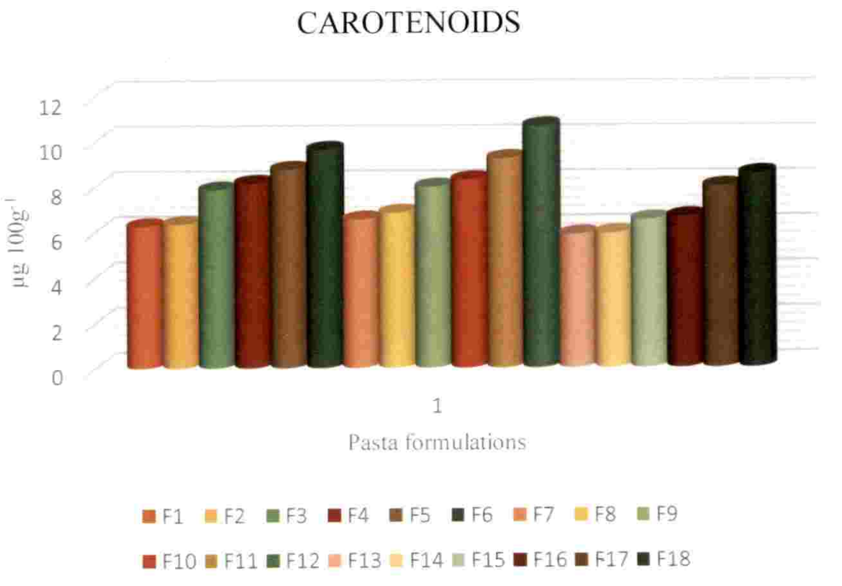

Fig 5. Carotenoids content (µg $100g^{-1}$) of raw vegetable based functional jackfruit pasta

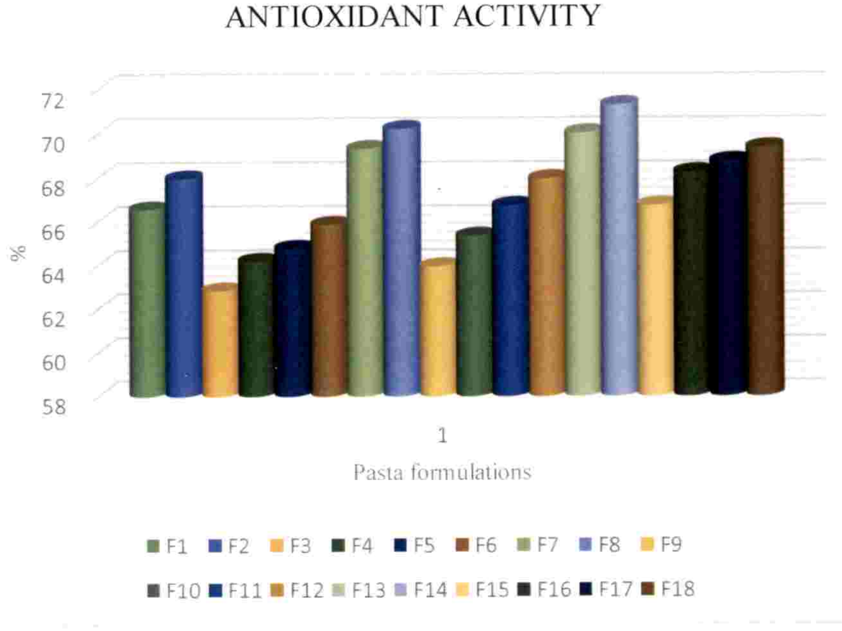

Fig 6. Antioxidant activity (%) of cooked vegetable based functional jackfruit pasta

activity of vegetable enriched jackfruit pasta. Sun-Waterhouse *et al.* (2013) reported that pasta enriched with elderberry juice concentrate showed an increase in antioxidant activity compared to the control pasta samples. The antioxidant capacity of unripe banana flour enriched pasta increased (3.31 to 6.68 μmol Trolox eq g^{-1}) with increase in level of banana flour substitution (Ovando-Martinez *et al.,* 2015). Marinelli *et al.* (2015) also reported an increase in antioxidant content with addition of grape marc in spaghetti. Cardinas-Hernandez *et al.* (2016) reported that there was an increase in total phenolic content in amaranth flour and amaranth leaf incorporated pasta compared to the conventional semolina pasta which will eventually contribute to the increase in antioxidant activity of the incorporated pasta. Antioxidant capacity of the incorporated pasta decreased during the cooking process compared to the semolina pasta. The smaller size of the amaranth starch granules are more water soluble than the wheat starch granules which produce bioactive compounds in food matrix which can be leached during the cooking process. Sęczyk *et al.* (2015) reported that addition of parsley leaves in wheat pasta increased (0.24 to 0.40 $mgTE^{-1}$ g DW) the antioxidant potential of the pasta which increased with concentration of leaf incorporated. Armellini *et al.* (2018) reported an increase in antioxidant activity of pasta enriched with saffron and reduction on cooking of pasta.

5.2.3. Textural characteristics of vegetable based functional jackfruit pasta

In the present study pasta formulation with 25% jackfruit bulb (flakes) flour, 25% jackfruit seed flour, 15% cassava flour and 10% carrot recorded the highest value for firmness and pasta with 20% jackfruit bulb (flakes) flour, 20% jackfruit seed flour, 25% cassava flour and 5% amaranthus recorded the highest value for toughness. Pasta formulation with 10% jackfruit bulb (flakes) flour, 30% jackfruit seed flour, 25% cassava flour and 10% amaranthus recorded the lowest value for firmness and toughness. Firmness of pasta enriched with broad bean flour increased with incorporation of broad bean (Giménez *et al.*, 2012). Rex *et al.* (2013) stated that firmness of pasta decreased with the addition of vegetable purees *viz.,* carrot, tomato, beetroot and amaranthus. Slinkard (2014) reported that pasta fortified with chickpea and quinoa flour showed an increased hardness and adhesiveness and decreased firmness with the increase in concentration of quinoa flour. Yadav *et al.* (2014) reported that non-starchy nature of vegetables led to firm texture of pasta. An increase in hardness for quinoa enriched pasta was observed by Lorusso *et al.* (2016). Padalino *et al.* (2017) reported that tomato peel enriched spaghetti showed poor and higher firmness compared to control pasta.

5.2.4. Sensory qualities of vegetable enriched functional jackfruit pasta

In the present study sensory scores were analyzed for appearance, taste, colour, flavour, odour, texture, elasticity, adhesiveness, mouthfeel and overall acceptability which showed significant difference among various formulations. Pasta formulations with 25% jackfruit bulb (flakes) flour, 25% jackfruit seed flour, 15% cassava flour and 10% carrot followed by pasta with 10% jackfruit bulb (flakes) flour, 30% jackfruit seed flour, 25% cassava flour and 10% amaranthus and pasta formulation with 10% jackfruit bulb (flakes) flour, 30% jackfruit seed flour, 25% cassava flour and 10% amaranthus. The results are in conformity with the findings of several researchers on pasta. Boroski *et al.* (2011) reported that sensory acceptance of pasta enriched with oregano and carrot leaf meal decreased with increase in concentration of oregano and carrot leaf meal. Rekha *et al.* (2013) in a study on enriching pasta with vegetable purees observed that appearance, mouthfeel and overall acceptability was the highest for pasta enriched with carrot puree compared to beetroot, amaranth and tomato pasta. Pasta enriched with chickpea and quinoa flour showed a decreased consumer acceptance when compared to the control pasta (Slinkard, 2014). Marinelli *et al.* (2015) observed slight decrease in overall accessibility of grape marc enriched pasta compared to control pasta. Cardinas-Hernandez. (2016) reported there was a decrease in acceptance of pasta incorporated with amaranth flour and amaranth leaf with increase in concentration. Padalino *et al.* (2017) found that there was an increase in elasticity and adhesiveness for tomato peel enriched pasta and a decrease in overall acceptability as compared to the control pasta.

5.3. STORAGE STABILITY OF VEGETABLE BASED FUNCTIONAL JACKFRUIT PASTA

The three best vegetable based functional jackfruit pasta selected were packed in polypropylene (200guage) and stored at room temperature for four months were analyzed for cooking quality, nutritional, microbial and sensory analyses at monthly interval.

Cooking quality characters *viz*., cooking loss, water absorption, swelling index and cooking time of vegetable enriched functional jackfruit pasta did not show any significant difference during the storage period. But it differed depending on the type of vegetable incorporated. Cooking loss of carrot, amaranthus and beetroot was 9.46%, 8.93% and 12.87% at the time of storage and it increased marginally to 9.88%, 9.24% and 13.17% after four months of storage without any significant difference statistically. Water absorption of carrot incorporated jackfruit pasta at the time storage was 1.53g g^{-1} followed by beetroot based functional jackfruit pasta (1.68g g^{-1}) and amaranthus based functional jackfruit pasta recorded the lowest water absorption of 1.49g g^{-1}. Swelling index of carrot based functional jackfruit pasta recorded a value of 2.06% followed by beetroot based functional jackfruit pasta with 3.15% and 2.16% for amaranthus based functional jackfruit pasta at the time of storage. Cooking time of carrot based functional jackfruit pasta was 6.21min and amaranthus incorporated functional jackfruit pasta with 7.22min at the time of storage. Beetroot based functional jackfruit pasta recorded the highest cooking time of 7.31min. Storage stability studies of macaroni enriched with wheat germ for cooking quality characteristics was studied by Ilkay-Pinarli *et al.* (2004) and stated that storage period of one year did not affected the cooking quality characteristics. In a study on pasta enriched with flaxseed flour and variable cereal brans cooking time, cooking loss, water absorption and swelling index did not showed significant difference during the storage period (Manthey *et al.,* 2008; Kaur *et al.,* 2011). Cooking quality remained constant during storage period for noodles with cocoa, wheat and mung flour and pasta with variable cereal bran (Kaur *et al.,* 2011).

Nutritional parameters *viz.,* starch, total sugar, reducing sugar, protein, fibre and antioxidant activity of vegetable enriched functional jackfruit pasta did not show any significant difference during the storage period. But it differed depending on the type of vegetable incorporated. For raw vegetable based functional jackfruit pasta, starch content of 69.19% was observed for beetroot based functional jackfruit pasta followed by amaranthus based functional jackfruit pasta with 68.71% and carrot based functional jackfruit pasta showed the lowest starch content of 67.73% at the time of storage. Total sugar content at the time of storage was 8.12%, 7.18% and 6.22% for carrot, beetroot and amaranthus based functional jackfruit pasta respectively. Reducing sugar content of beetroot based functional jackfruit pasta recorded 3.74% at the time of storage and carrot based functional jackfruit pasta with 3.48%. Amaranthus based functional jackfruit pasta recorded the lowest reducing sugar content of 2.43%. Protein content of 13.06%, 15.06% and 14.82% was observed for carrot, amaranthus and beetroot based functional jackfruit pasta respectively at the time of storage. Carotenoids content of carrot, amaranthus and beetroot based functional jackfruit pasta was 10.68 μg $100g^{-1}$, 5.92 μg $100g^{-1}$ and 6.65 μg $100g^{-1}$ at the time of storage which decreased to 9.84 μg $100g^{-1}$, 5.19 μg $100g^{-1}$ and 5.81 μg $100g^{-1}$ after four months of storage with significant difference among the treatments. Crude fibre content of carrot based functional jackfruit pasta was 3.93% at the time of storage followed by amaranthus based functional jackfruit pasta with 2.89%n and beetroot based functional jackfruit pasta with 2.18%. Antioxidant activity of amaranthus based functional jackfruit pasta was 95.21% at the time of storage and carrot based functional jackfruit pasta recorded an antioxidant activity of 93.95%. Beetroot based functional jackfruit pasta recorded the lowest antioxidant activity of 93.75%.

For cooked vegetable based functional jackfruit pasta, starch content of 49.09% was observed for beetroot based functional jackfruit pasta followed by carrot based functional jackfruit pasta with 48.95% and amaranthus based functional jackfruit pasta showed the lowest starch content of 46.07% at the time of storage. Total sugar content at the time of storage was 5.54%, 6.84% and 5.63% for carrot, beetroot and amaranthus based functional jackfruit pasta respectively. Reducing sugar content of beetroot based functional jackfruit pasta recorded 2.72% at the time of storage and carrot based functional jackfruit pasta with 2.57%. Amaranthus based functional jackfruit pasta recorded the lowest reducing sugar content of 1.55%. Protein content of 6.59%, 7.57% and 7.38% was observed for carrot, amaranthus and beetroot based functional jackfruit pasta respectively at the time of storage. Carotenoids content of carrot, amaranthus and beetroot based functional jackfruit pasta was 4.51 $\mu g\ 100g^{-1}$, 2.66 $\mu g\ 100g^{-1}$ and 2.11 $\mu g\ 100g^{-1}$ at the time of storage which decreased to 4.14 $\mu g\ 100g^{-1}$, 2.25 $\mu g\ 100g^{-1}$ and 1.74 $\mu g\ 100g^{-1}$ after four months of storage with significant difference among the treatments. Crude fibre content of carrot based functional jackfruit pasta was 1.35% at the time of storage followed by amaranthus based functional jackfruit pasta with 2.19%n and beetroot based functional jackfruit pasta with 1.62%. Antioxidant activity of amaranthus based functional jackfruit pasta was 71.32% at the time of storage and carrot based functional jackfruit pasta recorded an antioxidant activity of 67.96%. Beetroot based functional jackfruit pasta recorded the lowest antioxidant activity of 68.25%.

Decrease in carotenoid content during storage for sweet potato and soy flour added noodles was observed by Pangloli *et al.* (2000) which was in line with the present study. Ilkay-Pinarli *et al.* (2004) stated that taste panel sores of pasta enriched with wheat germ remained acceptable for a period of one year. Herken *et al.* (2007) reported slight decrease in total antioxidant activity and retention of sensory qualities of macaroni enriched with cowpea flour during storage of six months. Wani *et al.* (2011) observed a slight decrease in protein, crude fibre, carbohydrate content and overall acceptability of noodles enriched with cauliflower leaf powder during the period of three months. Yadav *et al.* (2014) reported that vegetable blended pearl millet pasta recorded acceptable sensory quality throughout the storage period of three months.

No microbial load was detected till the end of storage period for four months. Yadav *et al.* (2014) analyzed total microbial count of pearl millet pasta enriched with vegetables and found that yeast and mold count were absent throughout the storage period. Kumari (2015) reported that there was no bacterial and fungal growth observed for noodles enriched with jackfruit during the first month of storage period but an increase in fungal growth was observed during second and third months of storage period.

Summary

6. SUMMARY

The study entitled "Development of functional jackfruit pasta" was carried out at Department of Post Harvest Technology, College of Agriculture, Vellayani during the period 2017-2019 with the objective to develop functional pasta from jackfruit bulb and seed flour enriched with vegetables and to study the storage stability. The study was conducted as three continuous experiments and are summarized below.

1. Development of jackfruit pasta

2. Development of vegetable based functional jackfruit pasta

3. Storage stability studies of functional jackfruit pasta

Fully matured varikka jackfruit (90-110 days after fruit set) of good quality were taken, bulbs and seeds were separated, blanched, dried and powdered to get jackfruit bulb flour and seed flour. Cassava tubers were washed, grated and sun dried and was pulverized into fine powder using cassava grinding machine.

Jackfruit bulb flour and seed flour were used for the development of jackfruit pasta in different combinations along with cassava flour replacing a portion of refined flour contributing to 65% of total ingredients. The remaining 35% of total ingredients were kept as constant with refined flour, soy flour and starch. Pasta developed were subjected to analysis for cooking quality, nutritional and sensory parameters.

Cooking quality characters *viz.,* cooking loss, water absorption, swelling index and cooking time were analyzed for jackfruit pasta. Cooking loss of developed jackfruit pasta ranged from 14.16% to 21.97% and the lowest cooking loss (14.16%) was observed for jackfruit pasta developed with combination of jackfruit bulb flour and seed flour @ 15% and 35% cassava flour and the highest cooking loss (21.97%) was observed for treatment with 50% jackfruit seed flour and 15% cassava flour. Water absorption and swelling index of jackfruit pasta increased with increase in seed flour concentration and the highest water absorption (1.34 g g^{-1}) and swelling index (2.86%) was observed for the treatment with 50% jackfruit seed flour and 15% cassava flour. The lowest water absorption and swelling index was observed for treatment with 15% jackfruit bulb flour, 15% jackfruit seed flour and 35% cassava flour. Cooking time of developed jackfruit pasta ranged from 6.12 min to 7.44 min with no significant difference among the treatments. Nutritional parameters *viz.,* starch, total sugar, reducing sugar, protein, carotenoids, crude fibre and antioxidant activity varied with the amount of jackfruit bulb and seed flour concentration. The highest starch content was observed for the treatment combination with 10% jackfruit bulb flour, 30% jackfruit seed flour and 25% cassava flour for raw (69.38%) as well as cooked (53.28%) jackfruit pasta whereas the lowest starch content was observed for the treatment combination with 30% jackfruit bulb flour and 35% cassava flour for raw (60.10%) as well as cooked (22.52%) jackfruit pasta. Total sugar recorded the highest (7.22%) with 50% jackfruit bulb flour and 15% cassava flour and lowest total sugar (5.09%) was recorded for 15% jackfruit bulb flour and jackfruit seed flour and 35% cassava flour combination for raw jackfruit pasta. The highest reducing sugar content was noticed for the treatment combination with 50% jackfruit bulb flour and 15% cassava flour for raw (5.40%) and cooked (1.96%) jackfruit pasta and the lowest reducing sugar content was noticed for the treatment combination with 15% jackfruit bulb flour, 15% jackfruit seed flour and 35% cassava flour for raw (3.24%) as well as cooked (0.94%) jackfruit pasta. Protein content was noticed the highest with 50% jackfruit seed flour and 15% cassava flour for raw (14.99%) and cooked (7.55%) jackfruit pasta and the lowest protein content was noticed for the treatment combination 15% jackfruit bulb flour and jackfruit seed flour and 35% cassava flour for raw (10.08%) as well as cooked (4.31%) jackfruit pasta. Among the combinations, 50% jackfruit bulb flour and 15% cassava flour recorded the highest carotenoids for raw (8.93 µg 100g-1) as well as cooked (2.05 µg 100g-1) jackfruit pasta and carotenoids content was lowest for the combination with 30% jackfruit seed flour and 35% cassava flour for raw (4.65 µg 100g-1) as well as cooked (1.21 µg 100g-1) jackfruit pasta. Crude fibre content was highest for the treatment combination with 50% jackfruit seed flour and 15% cassava flour for raw (5.92%) and cooked (0.49%) jackfruit pasta and the lowest crude fibre content was recorded for the treatment combination with 50% jackfruit bulb flour and 15% cassava flour for raw (0.97%) and cooked (0.07%) jackfruit pasta . The highest antioxidant activity (79.29%) was recorded for the treatment with 50% jackfruit seed flour and 15% cassava flour and the lowest antioxidant activity (51.51%) was observed for the treatment combination with 15% jackfruit bulb flour, 15% jackfruit seed flour and 35% cassava flour for cooked jackfruit pasta. However no significant difference was noticed for raw jackfruit pasta combinations.

Sensory evaluation of developed jackfruit pasta were conducted and chi square test confirmed significant difference among the treatments for sensory attributes. Highest acceptance for all the sensory attributes were obtained for the treatment combinations T_8 [Jackfruit bulb flour (20%) + Jackfruit seed flour (20%) + cassava flour (25%)], T_9 [Jackfruit bulb flour (25%) + Jackfruit seed flour (25%) + cassava flour (15%)] and T_{10} [Jackfruit bulb flour (10%) + Jackfruit seed flour (30%) + cassava flour (25%)]. Based on the cooking quality, nutritional and sensory parameters three best treatments selected for the development of vegetable based functional jackfruit pasta were T_8 [Jackfruit bulb flour (20%) + Jackfruit seed flour (20%) + cassava flour (25%)], T_9 [Jackfruit bulb flour (25%) + Jackfruit seed flour (25%) + cassava flour (15%)] and T_{10} [Jackfruit bulb flour (10%) + Jackfruit seed flour (30%) + cassava flour (25%)].

The best three treatments selected were incorporated with three vegetables *viz.,* carrot, beetroot and red amaranthus @ 5 and 10 % for the development of vegetable based functional jackfruit pasta and were subjected to analysis for cooking quality, nutritional and sensory parameters. Cooking loss, swelling index and cooking time did not showed significant difference among the treatment combinations. Water absorption of vegetable incorporated jackfruit pasta @ 10% recorded the highest value of 1.49 g g^{-1} and 1.68g g^{-1} for the combination of 10% jackfruit bulb flour, 30% jackfruit seed flour and 25% cassava flour with 10% amaranthus and beetroot respectively while it was 1.53g g^{-1} for the combination of jackfruit bulb flour (25%) + jackfruit seed flour (25%) + cassava flour (15%) with 10% carrot. Nutritional parameters *viz.,* starch, total sugar, reducing sugar, protein, carotenoids, crude fibre and antioxidant activity for raw and cooked vegetable based functional jackfruit pasta were analyzed. For amaranthus based functional jackfruit pasta, (raw) starch, reducing sugar, protein, crude fibre and antioxidant activity were found to be non-significant. The highest total sugar content (9.20%) was observed for the treatment with 25% jackfruit bulb flour, 25% jackfruit seed flour, 15% cassava flour and 10% beetroot and the lowest (6.19%) for the treatment with 10% jackfruit bulb flour, 30% jackfruit seed flour, 25% cassava flour and 5% amaranthus. Carotenoids content was highest (6.83 μg $100g^{-1}$) for the treatment with 25% jackfruit bulb flour, 25% jackfruit seed flour, 15% cassava flour and 10% amaranthus and the lowest (5.87 μg $100g^{-1}$) for the treatment with 10% jackfruit bulb flour, 30% jackfruit seed flour, 25% cassava flour and 5% amaranthus. For cooked amaranthus based functional jackfruit pasta starch, total sugar, reducing sugar, proteins, carotenoids and crude fibre content were found to be non-significant. Antioxidant activity was observed to be the highest

(71.32%) for the treatment with 10% jackfruit bulb flour, 30% jackfruit seed flour, 25% cassava flour and 10% amaranthus and the lowest (66.58%) for 20% jackfruit bulb flour, 20% jackfruit seed, 25% cassava flour and 5% amaranthus.

Sensory evaluation of developed vegetable based functional jackfruit pasta were conducted and chi square test confirmed significant difference among the treatments for sensory attributes. Highest acceptance for all the sensory attributes for each vegetable based functional jackfruit pasta were obtained for carrot incorporated functional jackfruit pasta the combination of 25% jackfruit bulb flour, 25% jackfruit seed flour, 15% cassava flour and 10% carrot (F_{12}) recorded the highest acceptability and it was 10% jackfruit bulb flour, 30% jackfruit seed flour, 25% cassava flour and 10% amaranthus (F_{14}) for amaranthus based functional jackfruit pasta and the combination of 10% jackfruit bulb flour, 30% jackfruit seed flour, 25% cassava flour and 10% beetroot (F_{16}) recorded the highest sensory attribute for beetroot based functional jackfruit pasta. Based on the cooking quality, nutritional and sensory parameters three best treatments; one from each vegetable based functional jackfruit pasta were selected. The selected vegetable based functional jackfruit pasta were packed in 200 gauge polypropylene, and stored at room temperature. Cooking quality, nutritional and sensory parameters were analyzed at monthly interval for four months. During storage there was no significant difference observed in the starch, total sugar, reducing sugar, protein, crude fibre and antioxidant activity for raw and cooked vegetable based functional jackfruit pasta. Sensory qualities of the product decreased marginally with the advancement of storage period and carrot incorporated functional jackfruit pasta with 25% jackfruit bulb flour, 25% jackfruit seed flour, 15% cassava flour and 10% carrot (F_{12}) recorded the highest consumer acceptance followed by beetroot incorporated functional jackfruit pasta (F_{16}) with 10% jackfruit bulb flour, 30% jackfruit seed flour, 25% cassava flour and 10% beetroot and amaranthus based functional jackfruit pasta (F_{14}) with 10% jackfruit bulb flour, 30% jackfruit seed flour, 25% cassava flour and 10% amaranthus.

Development of vegetable based functional jackfruit pasta were standardized as 25% jackfruit bulb flour, 25% jackfruit seed flour, 15% cassava flour and 10% carrot for carrot based functional jackfruit pasta and the combination of jackfruit bulb flour (10%) + jackfruit seed flour (30%) + cassava flour (25%) and 10% beetroot or amaranthus for beetroot and amaranthus based functional jackfruit pasta. Storage stability studies on cooking quality, nutritional and sensory attributes revealed that there was no significant change in qualities during storage and no microbial load was found till the end of storage period for four months.

References

7. REFERENCES

Abraham, A. and Jayamuthunagai, J. 2014. An analytical study on jackfruit seed flour and its incorporation in pasta. *Res. J. Pharma. Biol. Chem. Sci.* 5(2): 1597-1610.

Ajeesh, B. R., Nimisha, C., Madala, A., Rajagopalan, A., and Giridharan, M. P. 2019. Variability in fruit characters of jackfruit types in Kasargod district of Kerala. *J. Pharmacognosy Phytochem.* 2: 541-544.

Ajila, C. M., Aalami, M., Leelavathi, K., and Rao, U. P. 2010. Mango peel powder: A potential source of antioxidant and dietary fiber in macaroni preparations. *Innovative Food Sci. Emerging Technol.* 11(1): 219-224.

Alonso, R., Grant, G., and Marzo, F. 2001. Thermal treatment improves nutritional qualityof pea seeds (*Pisum sativum* L) without reducing their hypocholesterolemic properties. *Nutr. Res.* 21(7): 1067–1077.

Alvarez-Jubete, L., Auty, M, Arendt, E. K., and Gallagher, E. 2010. Baking properties and microstructure of pseudocereal flours in gluten-free bread formulations. *Eur. Food Res. Technol.* 230: 437–445.

Amit, K. T. and Ambarish, V. 2010. Production of jackwine - A wine from ripe jackfruit. *Pharmbit.* 22(2): 154-156.

Anyobodeh, R., Spio-Kwofie, A., and Anaman, S. 2016. Preparation and production of pasta using composite cassava flour as a substitute of wheat flour. *Int. J. Novel Res. Mark. Manag. Econ.* 3(1): 97-105.

Aravind, N., Sissons, M., Egan, N., and Fellows, C. 2012. Effect of insoluble dietary fibre addition on technological, sensory, and structural properties of durum wheat spaghetti. *Food Chem.* 130(2): 299-309.

Armellini, R., Peinado, I., Pittia, P., Scampicchio, M., Heredia, A., and Andres, A. 2018. Effect of saffron (*Crocus sativus* L.) enrichment on antioxidant and sensorial properties of wheat flour pasta. *Food Chem.* 254: 55-63.

Armellini, R., Peinado, I., Pittia, P., Scampicchio, M., Heredia, A., and Andres, A. 2018. Effect of saffron (*Crocus sativus* L.) enrichment on antioxidant and sensorial properties of wheat flour pasta. *Food Chem.* 254: 55-63.

Atamanova, S. A., Brezhneva, T. A., Slivkin, A. I., Nikolaevskii, V. A., Selemenev, V. F., and Mironenko, N. V. 2005. Isolation of saponins from table beetroot and primary evaluation of their pharmacological activity. *Pharma. Chem. J.* 39(12): 650-652.

Azad, A. K. 2000. Genetic diversity of jackfruit in Bangladesh and development of propagation methods. Ph.D. thesis, University of Southampton, United Kingdom, 295p.

Bahanassey, Y., Khan. K., and Harrold, R. 1986. Fortification of spaghetti with edible legumes, physiochemical, antinutritional amino acid and mineral composition. *Cereal Chem.* 63: 210-215.

Bailey, L. H. 1949. *Manual of Cultivated Plants*. Macmillan Co. New York, 338p.

Barba de la Rosa, A. P., Gueguen, J., Paredes-Lopez, O., and Viroben, G. 1992. Fractionation procedures, electrophoretic characterization, and amino acid composition of amaranth seed proteins. *J. Agric. Food Chem.* 40(6): 931-936.

Bately, I. L. and Curtin, B. M. 2000. The effects on the pasting viscosity of starch and flour of different operating conditions for the rapid visco analyser. *Cereal Chem.* 76: 335-340.

Beerelly, S. 2012. Utilization of sweet potato (Ipomoea batatas) for the development of pasta and biscuits. B.Tech thesis, Acharya N. G. Ranga Agricultural University, 103p.

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

Boroski, M., de Aguiar, A. C., Boeing, J. S., Rotta, E. M., Wibby, C. L., Bonafé, E. G., de Souza, N. E., and Visentainer, J. V. 2011. Enhancement of pasta antioxidant activity with oregano and carrot leaf. *Food Chem.* 125(2): 696-700.

Bradford, M. M. 1976. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Anal. Biochem.* 72(1-2): 248-254.

Brennan, C. S., Kuri, V., and Tudorica, C. M. 2004. Inulin-enriched pasta: Effects on textural properties and starch degradation. *Food Chem.* 86(2): 189-193.

Cardinas - Hernandez, A., Beta, T., Pina, G. L., Tostado, E. C., Barrera, J. O. N., and Mendoza, S. 2016. Improved functional properties of pasta: Enrichment with amaranth seed flour and dried amaranth leaves. *J. Cereal Sci.* 72: 84-90.

Cemin, R. P., Rios, A. O., Thys, R. C. S., Flôres, S., and Rech, R. 2014. Use of broccoli (*Brassica oleracea italica*) leaves powder to produce fresh pasta. In: *Proceedings of 20th Congresso Brasileiro de Engenharia Quimica,* 19 a 22 de outubro de 2014. Florinopolis/SC, pp. 1-8.

Chillo, S., Laverse, J., Falcone, P. M., and del Nobile, M. A. 2007. Effect of carboxy methyl cellulose and pregelatinized corn starch on the quality of amaranthus spaghetti. *J. Food Eng.* 83(4): 492-500.

Chlopicka, J., Pasko, P., Gorinstein, S., Jedryas, A., and Zagrodzki, P. 2012. Total phenolic and total flavonoid content, antioxidant activity and sensory evaluation of pseudocereal breads. *LWT-Food Sci. Technol.* 46(2): 548-555.

Chu, Y. F., Sun, J. I. E., Wu, X., and Liu, R. H. 2002. Antioxidant and antiproliferative activities of common vegetables. *J. Agric. Food Chem.* 50(23): 6910-6916.

Cleary, L. and Brennan, C. 2006. The influence of a (1→3) (1→4)-β-glucan rich fraction from barley on the physicochemical properties and *in vitro* reducing sugars release of durum wheat pasta. *Int. J. Food Sci. Technol.* 41: 910–918.

Collins. 2006. *Essential Thesaurus* (2^{nd} Ed.). Harper Collins Publishers, 245p.

da Silva Dias, J. C. 2014. Nutritional and health benefits of carrots and their seed extracts. *Food Nutr. Sci.* 5(22): 2147-2149.

da Silva, V. E. M. 2013. Pasta highly enriched with vegetables: From microstructure to sensory and nutritional aspects. Ph.D. thesis, Wageningen University, Wageningen, 217p.

Das, K. P. 2014. Development and quality evaluation of fruit based instant snack and pasta product. Ph.D. thesis, Kerala Agricultural University, Thrissur, 228p.

Das, P. K. and Nirmala, C. 2014. Scope of incorporating fruits for the development of pasta. *Asian J. Food Sci.* 9(1): 1-5.

de Zwart, F. J., Slow, S., Payne, R. J., Lever, M., George, P. M., Gerrard, J. A., and Chambers, S. T. 2003. Glycine betaine and glycine betaine analogues in common foods. *Food Chem.* 83(2): 197-204.

Debbouz, A. and Doetkott, C. 1996. Effect of process variables on spaghetti quality. *Cereal Chem.* 73(6): 672-676.

del Nobile, M. A., Baiano, A., Conte, A., and Mocci, G. 2005. Influence of protein content on spaghetti cooking quality. *J. Cereal Sci.* 41(3): 347-356.

Devi, T. M. 2015. Development of extruded product using jackfruit bulbs and seed flours. M.Tech thesis, University of Agricultural Sciences GKVK, Bengaluru, 103p.

Dias, M. G., Camões, M. F. G., and Oliveira, L. 2009. Carotenoids in traditional Portuguese fruits and vegetables. *Food Chem.* 113(3): 808-815.

Dolly. 2016. Development of non-wheat whole grain pasta. M.Sc. thesis, Punjab Agricultural University, Ludhiana, 118p.

Edwards, N. M., Izydorczyk, M. S., Dexter, J. E., and Biliaderis, C. G. 1993. Cooked pasta texture: comparison of dynamic viscoelastic properties to instrumental assessment of firmness. *Cereal Chem.* 70: 122-122.

Fiedor, J. and Burda, K. 2014. Potential role of carotenoids as antioxidants in human health and disease. *Nutrients* 6(2): 466-488.

Fu, B. X. 2008. Asian noodles: History, classification, raw materials, and processing. *Food Res. Int.* 41: 888-902.

Gat, Y. and Ananthanarayan, L. 2015. Physicochemical, phytochemical and nutritional impact of fortified cereal-based extrudate snacks. *Nutr. Foods* 14(3): 141-149.

Gill, H. K. 2014. Development of technology for multigrain pasta. Ph.D. thesis, Punjab Agricultural University, Ludhiana, 88p.

Giménez, M. A., Drago, S. R., de Greef, D., Gonzalez, R. J., Lobo, M. O., and Samman, N. C. 2012. Rheological, functional and nutritional properties of wheat/broad bean (*Vicia faba*) flour blends for pasta formulation. *Food Chem.* 134(1): 200-206.

Gull, A., Prasad, K., and Kumar, P. 2015. Effect of millet flours and carrot pomace on cooking qualities, colour and texture of developed pasta. *Food Sci. Technol.* 63: 470-474.

Gull, A., Prasad, K., and Kumar, P. 2015. Effect of millet flours and carrot pomace on cooking qualities, colour and texture of developed pasta. *Food Sci. Technol.* 63: 470-474.

Gupta, D., Mann, S., Sood, A., and Gupta, R. K. 2011. Phytochemical, nutritional and antioxidant activity evaluation of seeds of jackfruit (*Artocarpus heterophyllus* Lam.). *Int. J. Pharma. Biosci.* 2(4): 336-345.

Guy, R. 2001. *Extrusion Cooking, Technologies and Applications*. CRC Press Inc, Boca Ration, FL. Cambridge, United Kingdom, 195p.

Harper. 2019. *Extrusion of Foods*. CRC Press, US, 220p.

Herken, E. N., İbanoğlu, Ş., Öner, M. D., Bilgiçli, N., and Güzel, S. 2007. Effect of storage on the phytic acid content, total antioxidant capacity and organoleptic properties of macaroni enriched with cowpea flour. *J. Food Eng.* 78(1): 366-372.

Jamuna, K. S., Ramesh, C. K., Srinivasa, T. R., and Raghu, K. L. 2011. In vitro antioxidant studies in some common fruits. *Int. J. Pharm. Pharm. Sci*. 3(1): 60-3.

Jastrebova, J., Witthöft, C., Grahn, A., Svensson, U., and Jägerstad, M. 2003. HPLC determination of folates in raw and processed beetroots. *Food Chem.* 80(4): 579-588.

Jin, X., Oliviero, T., van der Sman, R. G. M., Verkerk, R., Dekker, M., and van Boxtel, A. J. B. 2014. Impact of different drying trajectories on degradation of nutritional compounds in broccoli (*Brassica oleracea* var. *italica*). *Food Sci. Technol.* 59(1): 189-195.

Johns, T. and Eyzaguirre, P. B. 2007. Biofortification, biodiversity and diet: A search for complementary applications against poverty and malnutrition. *Food Policy* 32: 1-24.

Jung, K., Richter, J., Kabrodt, K., Lücke, I. M., Schellenberg, I., and Herrling, T. 2006. The antioxidative power AP- A new quantitative time dependent (2D) parameter for the determination of the antioxidant capacity and reactivity of different plants. *Spectrochimica Acta Part A: Molecular Biomolecular Spectroscopy* 63(4): 846-850.

Kapadia, G. J., Tokuda, H., Konoshima, T., and Nishino, H. 1996. Chemoprevention of lung and skin cancer by Beta vulgaris (beet) root extract. *Cancer Lett.* 100(1-2): 211-214.

Kaur, G., Sharma, S., Nagi, H. P. S., and Dar, B. N. 2012. Functional properties of pasta enriched with variable cereal brans. *J. Food Sci. Technol.* 49(4): 467-474.

Konidena, M. 2011. Formulation and evaluation of millet based pasta products by incorporating flaxseed flour. Ph.D. thesis, Acharya N G Ranga Agricultural University, Rajendranagar, Hyderabad, 104p.

Kumari, V. 2015. Development of an extruded product from raw jackfruit. M.Sc. (Home science) thesis, Kerala Agricultural University, 118p.

Leja, M., Kamińska, I., Kramer, M., Maksylewicz-Kaul, A., Kammerer, D., Carle, R., and Baranski, R. 2013. The content of phenolic compounds and radical scavenging activity varies with carrot origin and root color. *Plant Foods Hum. Nutr.* 68(2): 163-170.

Lorusso, A., Verni, A., Montemurro, M., Rossana, C., Gobbetti, M., and Rizzello, C. G. 2016. Use of fermented quinoa flour for pasta making and evaluation of the technological and nutritional features. *Food Sci. Technol.* 78: 215- 221.

Manthey, F. A., Sinha, S., Hall, W. C. E., and Hall, C. A. 2008. Effect of flaxseed flour and packaging on shelf life of refrigerated pasta. *J. Food Proc. Preser*. 32: 75-87.

Marinelli, V., Padalino, L., Nardiello, D., del Nobile, M., and Conte, A. 2015. New approach to enrich pasta with polyphenols from grape marc. *J. Chem.* 1: 8-10.

Maurya, P. and Mogra, R. 2016. Assessment of consumption practices of jackfruit (*Artocarpus heterophyllus* lam.) seeds in villages of Jalalpur block district Ambedarnagar (U.P.) India. *Remarking* 2(8): 73-75.

Meena, G. S., Dewan, A., Upadhyay, N., Barapatre, R., Kumar, N., Singh, A. K., and Rana, J. S. 2019. Fuzzy analysis of sensory attributes of gluten free pasta prepared from brown rice, amaranth, flaxseed flours and whey protein concentrates. *J. Food Sci*. 2(1): 22-37.

Minarovičová, L., Lauková, M., Kohajdova, Z., Karovičová, J., Dobrovicka, D., and Kuchtova, V. 2018. Qualitative properties of pasta enriched with celery root and sugar beet by-products. *Czech J. Food Sci.* 36(1): 66–72.

Mirhosseini, H., Rashid, N. F. A., Amid, B. T., Cheong, K. W., Kazemi, M., and Zulkurnain, M. 2015. Effect of partial replacement of corn flour with durian seed flour and pumpkin flour on cooking yield, texture properties, and sensory attributes of gluten free pasta. *LWT-Food Sci. Technol.* 63(1): 184-190.

Mishra, P., and Bhatt, D. K. 2016. A study on development of fortified pasta with ginger powder. *IOSR J. Environ. Sci. Toxicol. Technol.* 10(8): 14-18.

Mlakar, S. G., Turinek, M., Jakop, M., Bavec, M., and Bazvec, F. 2010. Grain amaranth as an alternative and perspective crop in temperate climate. *J. Geogr*. 5: 135-145.

Nataraja, B. S. 2018. Process development of pasta from sprouted and whole grains. M.Tech thesis, MPUAT, Udaipur, 95p.

Ocloo, F. C. K., Bansa, D., Boatin, R., Adom, T., and Agbemavor, W. S. 2010. Physico-chemical, functional and pasting characteristics of flour produced from jackfruits (*Artocarpus heterophyllus*) seeds. *Agric. Biol. J. N. Am.* 1(5): 903-908.

Ojure, M. A. and Quadri, J. A. 2012. Quality evaluation of noodles produced from unripe plantain flour using xanthan gum. *Int. J. Recent Res. Appl. Stud.* 13(3): 740-752.

Oliviero, T., and Fogliano, V. 2015. Food design strategies to increase vegetable intake: The case of vegetable enriched pasta. *Trends Food Sci. Technol.* 51: 58-64.

Ovando-Martinez, M., Sayago-Ayerdi, S., Agama-Acevedo, E., Goni, I., and Bello-Perez, L. A. 2009. Unripe banana flour as an ingredient to increase the undigestable carbohydrates of pasta. *Food Chem.* 113: 121-126.

Padalino, L., Conte, A., Lecce, L., Likyova, D., Sicari, V., Pellicanò, T. M., Poiana, M., and del Nobile, M. A. 2017. Functional pasta with tomato by-product as a source of antioxidant compounds and dietary fibre. *Czech J. Food Sci.* 35: 48–56.

Padalino, L., Mastromatteo, M., Lecce, L., Cozzolino, F., and del Nobile, M. A. 2013. Manufacture and characterization of gluten-free spaghetti enriched with vegetable flour. *J. Cereal Sci.* 57(3): 333-342.

Padmaja, G., Menon, R., Krishnan, J. G., and Sajeev, M. S. 2015. *Pasta and Noodles from Tuber Crops as Novel Health Foods.* ICAR- Central Tuber Crops Research Institute, Sreekariyam, Thiruvanathapuram, 204p.

Pangloli, P., Collins, J. L., and Penfield, M. P. 2000. Storage conditions affect quality of noodles with added soy flour and sweet potato. *Int. J. Food Sci. Technol.* 35(2): 235-242.

Patkai, G. Y., Barta, J., and Varsanyi, I. 1997. Decomposition of anticarcinogen factors of the beetroot during juice and nectar production. *Cancer Lett.* 1(114): 105-106.

Payumo, E. H., Briones, P. P., Banzon, E. A., and Torres, M. L. 1969. The preparation of coco noodles. *J. Nutr.* 22: 216-224.

Pérez, E. and Pérez, L. 2009. Effect of the addition of cassava flour and beetroot juice on the quality of fettuccine. *Afr. J. Food Sci.* 3(11): 352-360.

Petitot, M., Boyer, L., Minier, C., and Micard, V. 2010. Fortification of pasta with split pea and faba bean flours: Pasta processing and quality evaluation. *Food Res. Int.* 43(2): 634-641.

Pinarli, İ., İbanoğlu, Ş., and Öner, M. D. 2004. Effect of storage on the selected properties of macaroni enriched with wheat germ. *J. Food Eng.* 64(2): 249-256.

Plahar, W. A., Okezie, B. O., and Gyato, C. K. 2003. Development of a high protein weaning food by extrusion cooking using peanuts, maize and soyabeans. *Plant Foods Hum. Nutr.* 58: 1-12.

Prabhasankar, P., Ganesan, P., Bhaskar, N., Hirose, A., Stephen, N., Gowda, L. R., Hosokawa, M., and Miyashita, K. 2009. Edible Japanese seaweed, wakame (*Undaria pinnatifida*) as an ingredient in pasta: Chemical, functional and structural evaluation. *Food Chem.* 115(2): 501-508.

Ranasinghe, R. A. S. N., Maduwanthi, S. D. T., and Marapana, R. A. U. J. 2019. Nutritional and health benefits of jackfruit (*Artocarpus heterophyllus Lam.*): A review. *Int. J. Food Sci.* 1: 25-37.

Ranganna, S. 1986. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*. Tata McGraw-Hill Education, 145p.

Reddy, M. K., Alexander-Lindo, R. L., and Nair, M. G. 2005. Relative inhibition of lipid peroxidation, cyclooxygenase enzymes, and human tumor cell proliferation by natural food colors. *J. Agric. Food Chem.* 53(23): 9268-9273.

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.

Riaz, M. N., Faqir, M. A., and Khan, M. I. 2007. Latest trends in food processing using extrusion technology. *Pak. J. Food Sci.* 17(1): 53-138

Sadasivam, S. and Manikkam, A. 1992. *Biochemical Methods of Agricultural Sciences.* Wiley eastern Ltd, New Delhi, 8p.

Saini, R. K., Nile, S. H., and Park, S. W. 2015. Carotenoids from fruits and vegetables: Chemistry, analysis, occurrence, bioavailability and biological activities. Food Res. Int. 76: 735-750.

Sȩczyk, L., S´wieca, M., Gawlik-Dziki, U., Luty, M., and Czyz, J. 2015. Effect of fortification with parsley (*Petroselinum crispum* Mill.) leaves on the nutraceutical and nutritional quality of wheat pasta. *Food Chem.* 190: 419–428.

Shamrez, A., Shukla, R. N., and Mishra, A. 2013. Study on drying and quality characteristics of tray and microwave dried guava slices. *Int. J. Sci. Eng. Technol.* 3(4): 2348-4098.

Shanmugapriya, K., Saravana, P. S., Payal, H., Mohammed, P. S., and Binnie, W. 2011. Antioxidant activity, total phenolic and flavonoid contents of *Artocarpus heterophyllus* and *Manilkara zapota* seeds and its reduction potential. *Int. J. Pharmacy Pharma. Sci.* 3: 256-260.

Sharma, K. D., Karki, S., Thakur, N. S., and Attri, S. 2012. Chemical composition, functional properties and processing of carrot- A review. *J. Food Sci. Technol.* 49(1): 22-32.

Sharma, N. 2017. Development of micronutrient fortified pasta. Ph.D. thesis, Punjab Agricultural University, Ludhiana, 111p.

Sharma, O. P. and Bhat, T. K. 2009. DPPH antioxidant assay revisited. *Food Chem.* 113: 1202-1205.

Simmons, M. 1988. *365 Ways to Cook Pasta*. Harper & Row, 265p.

Singh, B. and Hathan, B. S. 2014. Chemical composition, functional properties and processing of beetroot-a review. *Int. J. Sci. Eng. Res.* 5(1): 679-684.

Singh, S., Gamlath, S., and Wakeling, L. 2007. Nutritional aspects of food extrusion. *Int. J. Food Sci. Technol.* 42(8): 916-929.

Sissons, M. J. 2004. Pasta. In: Wrigley, C., Corke, H., and Walker, C. (eds), *Encyclopaedia of Grain Science*. Elsevier, Australia, pp. 409-418.

Slinkard, M. 2014. Fortification of pasta with chickpea and quinoa flours. M.Sc. thesis, University of Missouri, 96p.

Sravanthi, B. 2012. Utilization of sweet potato (*Ipomoea batatas*) for the development of pasta and biscuits. Ph.D. thesis, Acharya N G Ranga Agricultural University, Rajendranagar, Hyderabad, 103p.

Steffe, J. F. 1996. *Rheological Methods in Food Process Engineering*. Freeman press, 245p.

Strack, D., Vogt, T., and Schliemann, W. 2003. Recent advances in betalain research. *Phytochem.* 62(3): 247-269.

Sun-Waterhouse, D., Jin, D., and Geoffrey, I. N. 2013. Effect of adding elderberry concentrate on the quality attributes, polyphenol contents and antioxidant activity of three fibre enriched pastas. *Food Res. Int.* 54: 781-789.

Tan, H. Z., Li, Z. G., and Tan, B. 2008. Starch noodles: History, classification, materials, processing, structure, nutrition, quality evaluating and improving. *Food Res. Int.* 42: 551-576.

Topwal, T. 2019. A review on amaranth: Nutraceutical and virtual plant for providing food security and nutrients. *CTA Sci. Agric.* 3(1): 81-84.

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

Uusiku, N. P., Oelofse, A., Duodu, K. G., Bester, M. J., and Faber, M. 2010. Nutritional value of leafy vegetables of sub-Saharan Africa and their potential contribution to human health: A review. *J. Food Composition Anal.* 23(6): 499-509.

Váli, L., Stefanovits-Bányai, É., Szentmihályi, K., Fébel, H., Sárdi, É., Lugasi, A., Kocsis, I., and Blázovics, A. 2007. Liver-protecting effects of table beet (*Beta vulgaris* var. *rubra*) during ischemia-reperfusion. *Nutr.* 23(2): 172-178.

Vasanthan, T., Jiang, G., and Yeung, J. 2002. Dietary fiber profile of barley flour as affected by extrusion cooking. *Food Chem.* 77: 35-40.

Venskutonis, P. R. and Kraujalis, P. 2013. Nutritional components of amaranth seeds and vegetables: A review on composition, properties, and uses. *Comprehensive Rev. Food Sci. Food Saf.* 12(4): 381-412.

Waghmare, R., Memon, N., Gat, Y., Gandhi, S., Kumar, V., and Panghal, A. 2019. Jackfruit seed: An accompaniment to functional foods. *Brazilian J. Food Technol.* 22: 118-129.

Wani, T. A., Sood, M., and Kaul, R. K. 2011. Nutritional and sensory properties of roasted wheat noodles supplemented with cauliflower leaf powder. *Ann. Food Sci. Technol.* 12(2): 102-107.

Yadav, D. N., Sharma, M., Chikara, N., Anand, T., and Bansal, S. 2014. Quality characteristics of vegetable-blended wheat–pearl millet composite pasta. *Agric. Res.* 3(3): 263-270.

Zaini, R., Clench, M. R., and Le Maitre, C.L. 2011. Bioactive chemicals from carrot (*Daucus carota*) juice extracts for the treatment of leukemia. *J. Med. Food* 14(11): 1303-1312.

Appendix

APPENDIX - I

COLLEGE OF AGRICULTURE, VELLAYANI

Department of Post Harvest Technology

Title: Development of functional jackfruit pasta.

Score card for assessing the organoleptic qualities of functional jackfruit pasta

Sample: Functional jackfruit pasta

Instructions: You are given 13 functional jackfruit pasta. Evaluate them and give scores for each criteria

Criteria	Scores												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Appearance													
Taste													
Colour													
Flavour													
Odour													
Texture (Hard/Firm/Soft)													
Elasticity													
Adhesiveness													
Mouth feel													
Overall acceptability													

<u>Score</u>

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

Date :

Name :

Signature:

DEVELOPMENT OF FUNCTIONAL JACKFRUIT PASTA

By

SWATHI. B. S
(2017-12-004)

ABSTRACT

of the thesis submitted in partial fulfilment of the requirements for the degree of

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Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF POST HARVEST TECHNOLOGY
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2019

ABSTRACT

The present study entitled "Development of functional jackfruit pasta" was carried out at Department of Post Harvest Technology, College of Agriculture, Vellayani during the period 2017-2019 with the objective to develop functional pasta from jackfruit bulb and seed flour enriched with vegetables and to study the storage stability.

Jackfruit bulb and seed flour were used for the development of jackfruit pasta in different combinations along with cassava flour replacing a portion of refined flour contributing to 65% of total ingredients. The remaining 35% of total ingredients were kept as constant with refined flour, soy flour and starch. Jackfruit pasta developed were subjected to analysis for cooking quality, nutritional, textural and sensory parameters.

Cooking quality characters *viz.* cooking loss, water absorption, swelling index and cooking time were analyzed for jackfruit pasta and cooking loss ranged from 14.16% to 21.97%. The lowest cooking loss (14.16%) was recorded for jackfruit pasta developed with 15% jackfruit bulb flour, 15% jackfruit seed flour and 35% cassava flour. Water absorption and swelling index of jackfruit pasta increased with increase in seed flour concentration and the highest water absorption (1.34 g g^{-1}) and swelling index (2.86%) was observed for 50% jackfruit seed flour and 15% cassava flour combination. Cooking time of developed jackfruit pasta ranged from 6.12 min to 7.14 min with no significant difference among the treatments. Nutritional parameters *viz.* starch, total sugar, reducing sugar, protein, carotenoids, crude fibre and antioxidant activity were analyzed for raw as well as cooked jackfruit pasta which varied with jackfruit bulb and seed flour concentration. Starch and protein content of jackfruit pasta increased with increase in seed flour and cassava flour concentration and total sugar, reducing sugar and carotenoids increased with bulb flour concentration.

Sensory evaluation of developed jackfruit pasta exhibited significant difference in consumer acceptance for the treatment combinations. Based on cooking quality, nutritional, textural and sensory parameters the three best treatments *viz.* jackfruit bulb flour (10%) + jackfruit seed flour (30%) + cassava flour (25%), jackfruit bulb flour (25%) + jackfruit seed flour (25%) + cassava flour (15%) and jackfruit bulb flour (20%) + jackfruit seed flour (20%) + cassava flour (25%) were selected for further studies.

The best three jackfruit pasta combinations selected were incorporated with three vegetables *viz.* carrot, beetroot and red amaranthus @ 5 and 10 % and the developed functional jackfruit pasta were subjected to cooking quality, nutritional, textural and sensory analyses. Cooking loss, swelling index and cooking time did not show significant difference among the combinations. Water absorption of vegetable incorporated jackfruit pasta @ 10% recorded the highest value of 1.49 g g^{-1} and 1.68g g^{-1} for the combination of 10% jackfruit bulb flour, 30% jackfruit seed flour and 25% cassava flour with 10% amaranthus and beetroot respectively while it was 1.53g g^{-1} for the combination of jackfruit bulb flour (25%) + jackfruit seed flour (25%) + cassava flour (15%) with 10% carrot. Carrot incorporated functional jackfruit pasta with 25% jackfruit bulb and seed flour, 15% cassava flour and 10% carrot recorded the highest consumer acceptance followed by beetroot and amaranthus based functional jackfruit pasta with 10% jackfruit bulb flour, 30% jackfruit seed flour, 25% cassava flour and 10% respective vegetables.

The selected vegetable based functional jackfruit pasta were stored at room temperature and storage stability studies on cooking quality, nutritional and sensory attributes revealed that there was no significant change in qualities during storage and no microbial load was found till the end of storage period of four months.

In the present study, combinations for development of vegetable based functional jackfruit pasta were standardized as 25% jackfruit bulb flour, 25% jackfruit seed flour, 15% cassava flour and 10% carrot for carrot based functional jackfruit pasta and the combination of jackfruit bulb flour (10%) + jackfruit seed flour (30%) + cassava flour (25%) and 10% beetroot or amaranthus for beetroot and amaranthus based functional jackfruit pasta. Storage stability studies on cooking quality, nutritional and sensory attributes revealed that there was no significant change in qualities during storage and no microbial load was found till the end of storage period of four months.