PROCESS OPTIMISATION AND QUALITY EVALUATION OF JACKFRUIT (*KOOZHA* TYPE) BASED VERMICELLI

By

AJISHA K. H.
(2015-16-003)

THESIS

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DECLARATION

I, hereby declare that the thesis entitled "**Process optimisation and quality evaluation of jackfruit (*Koozha* type) based vermicelli**" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed during the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Certified that the thesis entitled **"Process optimisation and quality evaluation of jackfruit (*Koozha* type) based vermicelli"** is a bonafide record of research work done independently by **Ms. Ajisha K. H.** under my guidance and supervision and that it has not been previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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INTRODUCTION

1. INTRODUCTION

"The jacks.... are such large and interesting fruits and trees so well behaved that it is difficult to explain the general lack of knowledge concerning them".

- O.W. Barret

Jackfruit (*Artocarpus heterophyllus* Lam.), belongs to the family 'Moraceae' and is a native of India. It bears the largest fruits among edible fruits. The fruit finds mention in the seminal ancient treatise *Hortus Malabaricus*. Jackfruit is an integral crop component of our homestead farming. Even though it enjoyed the status of a heavenly fruit in ancient periods, it has lost its status and is one of the most under exploited fruits in the state today. Kerala contributes 551.47 million tons in total production (NHB, 2015) but greater per cent of its production is wasted because of the lack of processing units and marketing. Jackfruit having firm flesh is called *varikka* and soft textured, fibrous and melting bulbs are referred to as *koozha* which is usually wasted.

Jackfruit is a miracle fruit rich in carbohydrates, proteins, vitamins and minerals like potassium, calcium and iron. Along with nutrients it contains appreciable amount of isoflavones, phytonutrients and anti-oxidants and their health benefits are wide-ranging from anticancer, antihypertensive, antiaging, antimicrobial and antiulcer. The flesh of the jackfruit is starchy and fibrous, and is an excellent source of dietary fibre. Jackfruit seeds make up around 10- 15 per cent of the total fruit weight and have high carbohydrate and protein content, dietary fibre, vitamins, minerals and phytonutrients. Jackfruit seeds can be relished as a nutritious nut, but is usually discarded as a waste.

In the present scenario, India is facing the problems of hidden hunger, nutrient deficiencies and poverty. India is the second largest producer of fruits and

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vegetables. The consumption of underutilised fruit crops can provide nutrition to the poor by meeting the nutrient requirements of vulnerable groups. It is also an established fact that seasonal, locally available and cheap fruits and vegetables can keep the population healthy and nutritionally secure rather than costly off-season ones. Promising varieties with enhanced production of quality fruits, suitable for value addition and product diversification would transform the status of jackfruit from the "neglected" category to an export-oriented crop. Utilization of the wonder fruit will strengthen the self employment opportunities and economic security.

An accelerated pace of modern life having greater awareness about health and preference for instant food items, have made vermicelli very popular and an item of mass consumption in the category of extruded product. The market potential of jackfruit can be promoted if the fruits are made available to the consumer in a ready to eat or ready to cook form throughout the year. Moreover it has become necessary to open new avenues for its better utilisation, as traditional uses have already become stabilised. There lies a great opportunity for non-traditional uses of jackfruit in the form of convenience foods like vermicelli.

Hence, the present study entitled "Process optimisation and quality evaluation of jackfruit (*koozha* type) based vermicelli" was undertaken with the following objectives

1. To standardise jackfruit based vermicelli using raw jackfruit flour, whole wheat flour, rice flour and jackfruit seed flour
2. To evaluate its acceptability, nutritional and shelf life qualities
3. To develop an acceptable instant *payasam* mix with the standardised vermicelli

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The literature of the present study entitled "Process optimisation and quality evaluation of jackfruit based (*Koozha* type) vermicelli" is presented as the following headings:-

2.1 Nutritional and health benefits of jackfruit

2.2 Value added products from raw jackfruit

2.3 Neutraceutical properties of jackfruit seed and value addition

2.4 Fruit based extruded products

1. Nutritional and health benefits of jackfruit

Jackfruit (*Artocarpus heterophyllus Lam.*) a member of the family Moraceae is a fairly large sized tree and bears the largest fruit among the edible fruits. It is a popular fruit consumed in the tropics. It is widely grown in India, Bangladesh, South East Asia and West Africa (Chowdhury *et al.,* 2012). In our country, the trees are found distributed in southern states like Kerala, Tamil Nadu, Karnataka, Goa, coastal Maharashtra and other states like, Assam, Bihar, Tripura, Uttar Pradesh and foothills of Himalayas.

The name jackfruit, originated from Malayalam name "*Chakka*". Among the fruit crops seen in Kerala, jackfruit has a prominent position, which comes to 89702 hectares as reported in Farm Guide (2014). However the fruit is perishable and cannot be stored for long time because of its inherent compositional and textural characteristics. Every year considerable amounts of jackfruit are wasted due to lack of processing units and marketing.

Ahmed *et al.* (1986) classified jackfruit into two general types: (1) *koozha,* the fruits of which have small, fibrous, soft, mushy, but very sweet carpels and (2) *varikka,* more important commercially, with crisp carpels of high quality. The fruits of *koozha* variety are consumed mainly in the raw stage and if allowed to ripen, do not taste as good as the *varikka* variety, and hence wasted more than *varikka.* The market potential of jackfruit can be promoted if the fruits are made available to the consumer in a ready to eat or ready to cook form throughout the year. Moreover it has become necessary to open new avenues for its better utilization, as traditional uses have already become stabilised.

Jackfruit can act as source of complete nutrition to the consumers. Jackfruit is an underutilised fruit, which provides about 2 MJ of energy per kg weight of ripe perianth (Ahmed *et al.,* 1986). Jackfruit seeds make up around 10- 15 per cent of the total fruit weight. Jackfruit seed is used occasionally as a minor supplement in culinary preparations, but greater portion is wasted. Jackfruit seed is considered as cheap non-conventional protein source, so it can be used for the prevention of malnutrition in developing countries like India (Chowdhury *et al.*, 2012). Table 1 depicts the nutritional profile of raw jackfruit (APAARI, 2012).

Table 1. Nutritional composition of jackfruit

Nutrients	Amount ($100g^{-1}$)
Moisture (%)	76.20
Energy (Kcal)	88
Protein (g)	1.90
Fat (g)	0.10
Fibre (g)	1.10

Carbohydrates (g)	19.80
Potassium (mg)	107.00
Calcium (mg)	20.00
Phosporous (mg)	41.00
Iron (mg)	0.56
β Carotene (μg)	61
Thiamine (mg)	0.03
Riboflavin (mg)	0.13
Niacin (mg)	0.40
Vitamin C (mg)	7.00

The jackfruit consists of soft, easily digestible bulbs with simple sugars (fructose and sucrose) which when eaten, replenishes energy and revitalizes the body instantly. Jackfruit contains 14 per cent of total sugars which consists of 3.63 per cent alpha glucose, 2.33 per cent beta glucose, 1.74 per cent fructose and 6.90 per cent sucrose (Valavi *et al.*, 2011). Baliga *et al.* (2011) compared the nutritional value of jackfruit with other tropical fruits like orange, banana, mango, pineapple, papaya and ber and concluded that jackfruit had more nutrients (fibre, vitamin C and potassium) compared to other fruits. Jackfruit pulp and seeds quantitatively contains more protein, calcium, iron and thiamine and are a good source for these essential nutrients.

Jackfruit is also a good source of antioxidants and provide about 13.7 mg of vitamin C. Consumption of foods rich in vitamin C helps the body to develop resistance against infectious agents and scavenge harmful free radicals. It is one of the rare fruits, rich in B-complex group of vitamins such as pyridoxine, niacin,

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riboflavin, and folic acid. Fresh fruit is a good source of potassium, magnesium, manganese, and iron. Potassium is an important component of cell and body fluids that helps to control heart rate and blood pressure (Baliga and Bhat, 2001).

Raw jackfruit is composed of nutritional and health promoting substances, especially minerals, antioxidant compounds, vitamins, folates, phytochemical components, dietary fibres and has relatively low calories (Murcia, 2009). According to Tejpal and Amrita (2016) jackfruit is a health boon to mankind due to its multifaceted medicinal properties like anti-asthmatic activity, antioxidant, antibacterial, antifungal, anticancer, antimalarial, antidiarrhoel, antiarthritic, antiviral, antitubercular, antiatherosclerotic and wound healing effect. The consumption of jackfruit helps to fight against wrinkles and helps in getting a glowing complexion and flawless skin.

Jackfruit is a rich source of magnesium, it helps in the calcium absorption, strengthen the bone and prevent bone related disorders such as osteoporosis. The iron present in jackfruit helps to maintain healthy blood circulation and prevent anaemia (Devi *et al*, 2004). Chandrika *et al.* (2005) identified the carotenoids present in jackfruit, namely β carotene, α carotene, β zeacarotene, α zeacarotene, di carboxylic carotenoids and crocitin. Carotenoids present in jackfruit, fight against certain diseases, especially cardiovascular diseases and age related macular degeneration. Lignans, isoflavones, and saponins, the main phytonutrients seen in jackfruit have the ability to inhibit the formation of cancer cells in the body, lower blood pressure, fight against stomach ulcers and slow down the degeneration of cells, that makes the skin look young and fresh (Soobrattee *et al.*, 2005).

The phenylflavones present in jackfruit act against lipid peroxidation and have strong antioxidant properties. Jackfruit also contains numerous chemical

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constituents like artocarpin, isoartocarpin, cycloartocarpin, artocarpanone, artocarpetin, cynomacurin, dihydromorin, cyloartocarpin, morin, oxydihydroartocaepesin and cycloartinone (Rao *et al.*, 1973). The study conducted by Wei *et al.* (2005) showed that flavonoids present in jackfruit have anti-inflamatory effect by inhibiting the release of inflammatory mediators from the mast cells, neutrophils and macrophages.

Jackfruit contains 63 per cent neutral lipid, 21 per cent glycolipids and 16 per cent phospholipids. Fat content of raw jackfruit ($0.3g/100g^{-1}$) is high compared to ripe jackfruit ($0.1/100g^{-1}$). The neutral lipids present in raw jackfruits are glycerides, free fatty acids, hydrocarbons with free sterols, sterol esters, linoleic acid and palmitic acids. These lipids are considered as good for health (Valavi *et al.*, 2011). According to Hettiaratchi *et al.* (2011) jackfruit is considered as low glycaemic fruit, due to the collective contributions of dietary fibre, slow availability of glucose and presence of resistant starch granules.

Fresh fruit has small amounts of vitamin-A and flavonoid pigments such as carotene-ß, xanthin, lutein and cryproxanthin-ß. Together, these compounds play a vital role in antioxidant and vision functions. Vitamin A is also required for maintaining integrity of mucous membranes and skin. The fibre content helps to protect the colon mucous membrane by decreasing exposure time as well as binding to cancer causing chemicals in the colon. The high fibre content in the jackfruit helps to prevent constipation, maintain smooth bowel movement and offers protection to the mucus membrane by removing carcinogenic substances from colon (APAARI, 2012).

According to Rates (2001) *Artocarpus heterophyllus Lam.* is the one of the plant, traditionally used in Indian and Malay folklore medicine to treat gastric ulcers.

Jackfruit is considered as casein free and gluten free food. Jackfruit exhibits analgesic and immunomodulating properties. It is used for the preparation of traditional medicine (Prakash *et al.*, 2013).

Chandra and Bharati (2016) conducted a study to estimate the anti-oxidant activity and *in vitro* starch digestibility of raw jackfruit. The anti-oxidant activity and *in vitro* starch digestibility was observed to be 98.13 per cent and 14.79 per cent respectively. The glycaemic index was found to be very low (39.72), grouping the fruit as low glycemic food. The study concluded that raw jackfruit having good antidiabetic property and can be used as diabetic and pre-diabetic foods.

2.2 Value added products from jackfruit

The jackfruit is considered as a miracle fruit in processing sector. The ripe jackfruit bulbs have delicious taste, captivating aroma, attractive colour and excellent quality, which make it suitable for processing and value addition. Jam, jelly, squash, syrup, wine, ready to serve beverages, candies and nectars are the products usually prepared from ripe fruit. The unripe fruits are used in vegetable curries and pickles (Prakash *et al.,* 2009).

Devi *et al.* (2014) stated that jackfruit has got great potential for value addition and more than 100 items can be prepared from jackfruit right from immature stage to well ripened stage. Each item has its own virtues in terms of taste, preference, keeping quality etc.

2.2.1 Jackfruit chips

Jackfruit chips are a popular group of food item that adds variety to 'salty snacks'. Molla *et al.* (2008) prepared jackfruit chips and packed them in three

packaging materials viz., metalex foil pouch, high density polyethylene and polypropylene pouches for two months, and found that the chips packed in metalex foil pouch secured the highest sensory score followed by high density polyethylene pouch and polypropylene pouch obtained the lowest score. The maximum moisture content observed was 4.49 per cent which was not favourable for microbial growth.

Dehydrated jackfruit chips have one year shelf life. It can be reconstituted with water and used for the preparation of curries during off season. The quality and yield of chips depends upon flake thickness, bulb length, TSS, reducing sugars and starch content. Jagadeesh *et al.* (2007) prepared chips with 34 variety of jackfruit. Based on overall acceptabilty SRS-26, SRS-3, UKY-5 and SRS-4 types are suitable for making dehydrated chips. The chips treated with ascorbic acid posses maximum mean score for colour, texture and overall acceptability. Jackfruit chips have great demand and fetch good prices in domestic market and abroad especially gulf countries and as per GOK (2015) around 8443Kg of jackfruit chips are exported from Kerala to other countries.

Sudheer *et al.* (2016) developed two varieties of chips (vaccum fried jackfruit chips and vaccum dried chips) in a study conducted in KCAET, Tavanur. Jackfruit bulbs were kept in refrigerator until the intra cellular water become solidified, and fried in low temperature. Vaccum fried jackfruit chips show less oil absorption capacity and long shelf life. Raw and ripe jackfruit bulbs can be processed by vaccum drying. The prepared product, have one year shelf life without affecting the colour of fresh bulbs.

Munishamanna *et al.* (2016) developed the vaccum fried raw jackfruit chips and evaluated its sensory and nutritional qualities. The prepared chips was highly acceptable in terms of colour (4.21/5), texture (4.30/5), crispiness (4.58/5), taste

(4.67/5) and overall acceptability (4.75/5) and it contain 8.86% protein, 3.69% fat, 2.39% fibre, 80.91% carbohydrate and 392.29 Kcal energy.

2.2.2 Minimally processed jackfruit

Bhatia *et al.* (1956) reported that thermally processed canned jackfruit can be stored under ambient condition (24 to 30^0 C) without affecting the colour, taste and flavour. However, the product when stored at 37°C for 19 weeks depicted deteriorative changes. Lal *et al.* (1960) standardised a method for canning raw jackfruit bulbs in brine solution containing 0.5-0.75% citric acid. Jackfruit bulbs both raw and ripe could be successfully canned for subsequent use in vegetable curries and also for table purpose (Berry and Kalra, 1987).

Praveena (2015) standardised the procedure for the production of good quality, safe and affordably priced, tender *koozha* type jackfruit, in ready to cook form. The jackfruit blanched with 0.3 per cent citric acid solution for three minutes got high sensory scores. After thermal processing (121^0C for 15 minutes) samples were packed in a retort pouches with addition of preservatives. This product was safe for consumption up to 90 days.

Prathibha *et al.* (2016) investigated the effect of pre-treatments on quality and shelf life of jackfruit bulbs under refrigerated storage. The raw jackfruit bulbs were pretreated by dipping in calcium chloride (0.5- 1%) along with different combinations of ascorbic acid (0.25%), aloe vera gel (10%) and potassium meta bisulphite at 0.1% for 5 minutes. The sample pretreated with calcium chloride with ascorbic acid (0.25%) was found to be the best method and with a maximum shelf life upto 24 days.

Minimally processed ready to cook tender jackfruit pretreated with citric acid and 15 minutes dipping time, packed in polythene bags could be stored for 4 weeks under refrigerated temperature and for 2 weeks in ambient temperature (27-29^{0}C) without affecting the sensory qualities and nutritional composition (Munishamanna *et al.*, 2016).

2.2.3 Raw jackfruit flour

Jackfruit flour can be an alternative intermediary product, which can be utilised for value addition to blend with other flours like wheat, rice etc. and stored without affecting the nutritional and sensory qualities of the final product. The flour prepared from jackfruit can be used as thickening and binding agent in food products (Ocloo *et al.*, 2010).

Kumar *et al.* (2012) evaluated jackfruit flour by applying both oven drying and freeze drying methods. Freeze drying is found to be more acceptable in terms of sensory parameters and higher nutrient content of vitamin A and vitamin C. The vitamin A and C content in oven dried flour was 150.45 IU and 2.15mg 100g^{-1}respectively and in freeze dried powder it was 250.68 IU and 5.92mg 100 g^{-1} respectively. The flour is used for the preparation of breakfast foods (*chapathies*, patties, *dosa* etc), bakery products (bread, biscuits, cakes), and extruded products (pasta, noodles etc).

Kumari (2015) prepared flour from raw jackfruit and stored them in laminated and HDPE (High Density Poly Ethylene) cover for a period of three months. Bulbs was subjected to different treatments for preparation of flour and standardised for optimum width, blanching, immersion in different media, drying and milling. The sample kept in laminated and HDPE cover exhibited an increase in moisture content

by 0.89 and 0.75 per cent respectively. The prepared flours were safe from microbes and insects during the storage periods.

Jeevan *et al.* (2016) developed drum dried flour from mature jackfruit. This drying method helps to reduce the nutrient loss due to high temperature short time treatment. The drum dried jackfruit powder was suitable for the preparation of instant soup mix, snacks, bakery products, baby foods and extruded food like pasta.

2.2.4. Weaning food

Satter *et al.* (2014) developed weaning food by incorporating 41 per cent of jackfruit bulbs with wheat flour, soy flour and milk powder. 100g of the product provides 16.55g of protein, 1.18g of fibre, 450 mg of calcium and 4.26 mg of zinc. The formulated weaning foods were inexpensive and nutritious and have the potential to reduce protein energy malnutrition.

Escala and Bestil (2014) prepared jackfruit based supplementary food for infants. The product was prepared by raw jackfruit including the skin, pith and rugs, chopped into smaller pieces and then dried (contain about 10-14% moisture) milled and stored. The prepared product was highly acceptable by sensory attributes.

2.2.5. Baked products

Ozioma (2010) developed bread and cookies from raw jackfruit. Substitution of wheat flour with 20% jackfruit bulb flour was highly acceptable for sensory parameters. The prepared bread and cookies contain 13 and 10.4 per cent protein, 1.40 and 1.07 per cent fibre, and 43 per cent and 53 per cent carbohydrate. The vitamin A and C content was 48.35mg and 12mg in bread and 28.37mg and 11.68mg in cookies.

Feili *et al.* (2013) developed jackfruit based high fibre bread by utilizing jackfruit rind flour with wheat flour in various combinations (5:95, 10:90 and 15: 85).

Bread substituted with 5 per cent jackfruit flour had the highest mean score for overall acceptance.

Hosamani *et al.* (2016) conducted a study to investigate the effect of partial replacement of wheat flour by different levels of carrot powder (10 and 20%) jackfruit powder (25 and 50%) and anola powder (10, and 20%) on the color, nutritional and sensory characteristics of the sweet biscuits. The result revealed that biscuits prepared from refined wheat flour incorporated with 25% of jackfruit powder had higher acceptance for sensory characteristics during initial (4.58 out of 5) and throughout the storage period (4.16 out of 5) than the other blends.

2.2.6. Ready to eat jackfruit foods

John *et al.* (1993) prepared ready to eat raw jack fruit curry, pretreated in boiling water for 30 minutes and packed in laminated pouches. The prepared product was stored at 3 different conditions (room temperature (28^0C), refrigerated low temperature (4^0C) and frozen state (-18^0C). Longer shelf life was observed in frozen state (1year), followed by refrigerated low temperatue (270 days) and room temperature (120 days). The raw jackfruit curry was safe for consumption due to the low microbial load and had acceptable sensory qualities throughout the storage periods.

Lakshmana *et al.* (2013) prepared ready to eat tender jackfruit curry processed by using steam air retort with an overriding pressure of 15 lbs. After 45 minutes processing, curry was packed in multilayer laminated retort pouches. During storage period, the protein and fibre content increased whereas fat and carbohydrate were decreased. The product was acceptable and stable up to 12 months under ambient condition with good texture and sensory characteristics.

Hettiaratchi *et al.* (2011) developed jackfruit meal with jackfruit flesh (400g), jackfruit seeds (50g), coconut scrapings (25g) and onion (10g). The meal contributes 50 per cent of carbohydrate, 6.8 per cent of protein and 5.2 per cent of resistant starch. Jackfruit meal is considered as a low glycaemic food. This could be due to the collective contributions of dietary fibre, slowly available glucose, intact starch granules and influence of different sources of carbohydrates. Raw jackfruit *biriyani*, *idly* and jackfruit dumplings are food products prepared from tender and half matured jackfruits. These products are highly acceptable both nutritionaly and organolepticaly (APAARI, 2012).

2.2.7. Pickle

Mondal *et al.* (2013) prepared both green and sweet pickle with jackfruit bulbs and compared its nutritional qualities. The study concluded that the vitamin C and carotenoid content was high in green jackfruit pickle (3.4mg/100g^{-1} and 22.78mg/100g^{-1}) compared to sweet pickle (2.20 mg/100g^{-1} and 15.69 mg/100g^{-1}). The quality factors such as colour, taste, flavour and texture of the two pickles remain unchanged even after 12 months of storage.

A study was conducted to develop shelf stable jackfruit pith pickle and evaluate its physico-chemical, microbial and organoleptic characteristics. The ingredients used for the preparation of pickle were raw jackfruit pith, vinegar, salt, oil, spices and condiments. The ingredients used were optimised with regard to pH, saltiness, taste and flavour. The product was found acceptable and microbiologically safe under ambient conditions up to 6 months of storage period (Divakar *et al.*, 2012).

2.2.8. Instant mixes

Liji (2014) standardised ready to cook *avial, koottu* and *olath* mix by using jackfruit and seeds in the ratio of 60: 40 with other ingredients. The nutritional composition showed that *Avial* mix contains high amount of carbohydrate

(38.37g/100g^{-1}), protein (13.32g/100g^{-1}), fibre (8.37g/100g^{-1}). *Koottu* mix contains low fat (0.52g/100g^{-1}) and high βcarotene (0.46 %) content. The prepared mixes had three months of shelf life without bacterial growth. Cost of the product indicated that *avial* mix was most expensive followed by *olath* and *koottu* mixes.

Das and Nirmala (2014) prepared instant snack mix from *koozha* jackfruit incorporated with papaya, banana and other ingredients (rice flour, green gram, horse gram flour and coconut). The developed snack contains 66.96g/100g^{-1} of carbohydrate, 10.83g/100g^{-1} of protein, and 4.94 g/100g^{-1}of fat. Polyphenols, fibre and total mineral content of developed snack were 1.27mg/100g^{-1}, 2.9g/100g^{-1}, and 2.28mg/100g^{-1} respectively. The prepared instant snack have a shelf life of three months.

Shahanas *et al.* (2017) developed raw jackfruit flour based instant pudding mix and evaluated its sensory attributes with control (100 per cent corn flour). Based on organoleptic evaluation instant pudding mix prepared with 40 per cent raw jackfruit flour and 60 per cent corn flour was highly acceptable than control with the score of 8.97 for overall acceptability.

Remya *et al.* (2017) prepared instant shake mix with pregelatinised jackfruit flour, skimmed milk powder and sugar. Based on sensory evaluation, the shake mix prepared with 50 per cent of raw jackfruit flour was found to be the most acceptable with a mean score of 8.7. The prepared product contained 86.74g 100g^{-1}of carbohydrate, 7.28g 100g^{-} of protein, 3.20g 100g^{-1} of fat and 0.18g 100g^{-1} of fibre.

2.2.9. Jackfruit *pappad*

Jackfruit bulbs which are neither fully mature nor completely raw can be used for the preparation of *pappads*. Bhatia *et al.* (1956) prepared jackfruit flour incorporated *pappad* and he found that jackfruit based *pappads* had a shelf life of 6 months at room temperature (24- 30^{0}C).

Pandey (2004) conducted a study to prepare a good quality *pappad* from raw jackfruit flour and black gram dal flours. The jackfruit incorporated *pappad* was highly acceptable for sensory parameters like taste, flavour and texture. The prepared product was very crispy after frying.

Jagadeesh *et al.* (2009) conducted a study to know the suitability of 19 varieties of jackfruit for pappad making. The jackfruit types SRS-3 and SRS-15 recorded high starch and dry matter in their bulbs and were associated with higher pappad yield. Moisture content in pappads of different varieties varied widely from 6.43 (SRS-32) to 14.66% (SRS-19). The selections UKY-14, SRS-6, SRS-12, SRS-15, SRS-16, SRS-17 and SRS-19 conformed to the Bureau of Indian Standards for moisture content. Pappads made from different selections exhibited a wide variation for oil uptake and expansion on frying. The colour and appearance of prepared pappads appeared to be excellent.

Kalpana *et al.* (2016) prepared pappad from 5 different varieties of jackfruit (HV_1, tane varikka, muttom varikka, swarna halasu and NSP) with rice flour and black gram flour. The results revealed that jackfruit pappad prepared from HV_1 and swarna halsu was highly acceptable in terms of colour (4/5 and 3.78/5), crispiness (4.24/5 and 4/5), taste (4.96/5 and 3.95/5) and overall acceptability (4.89/5 and 3.95/5).

2.2.10. Extruded products

According to Das and Nirmala (2014), pasta prepared by incorporating underutilised fruits like jackfruit (300g) with green gram flour (100g), wheat flour (500g) and tapioca starch (100g) showed a good acceptable score with improved nutritional value and reduced cost. The prepared pasta packed in laminated pouches have a shelf life of three months. The cost of the developed products was Rs. 240/ kg.

Kumari and Divakar (2016) developed raw jackfruit based noodles by mixing refined flour, bulb flour and seed flour in the ratio of 50:10:40. The prepared product was found to be highly acceptable for appearance (4.59/5), colour (4.77/5), texture (4.89/5), taste (4.87/5) and overall acceptability (4.78/5). The prepared product have good nutritional and shelf life qualities. The cost of the developed product was Rs.108/1400g.

2.3 Neutraceutical properties of jackfruit seed

Jackfruit seed is enclosed in a white outer layer encircling a thin brown spermoderm, which covers the fleshy white cotyledon. Jackfruit cotyledons are fairly rich in starch and protein. The jackfruit seeds can be relished as a nutritious nut. It contain high amount of carbohydrate, protein and fibre (Kumar *et al.*, 1988). Jackfruit seed contain thousands of phyto nutrients that may help to prevent cancer and provide other health benefits (Ko *et al.*, 1998). Jackfruit seed is considered as an abundant source of starch, 100g of cooked jackfruit seed contributes 77 per cent of starch (Tulyathan *et al.*, 2002).

Omale and Friday (2010) reported that Jackfruit seed contains lignin, isoflavones, saponins, phytonutrients, and their health benefits are wide-ranging from anticancer to antihypertensive, anti-aging, antioxidant and antiulcer. Jackfruit seeds have the capability to treat infectious diseases by preventing the growth and multiplication of food borne pathogen.

Jackfruit seeds have the ability to inhibit growth of *Fusarium moniliforme* and *Saccharomyces cerevisiae* (Trindade *et al.,* 2006). The ethanolic and methanolic extracts of the jackfruit seed powder were observed to be effective on multidrug resistant methicillin resistant *Staphylococcus aureus* (Karthy *et al.,* 2009). Nano particle present in jackfruit seeds inhibits the growth of *E. coli* and *B. megaterium* microbes.

Jackfruit seeds are composed of resistant starch, which resist digestion in the small intestine of healthy individual and are available for fermentation in large intestine (Englyst *et al.*, 1992). The bacteria produce short chain fatty acids from the resistant starch as a result of fermentation present in large intestine. This decreases the pH in large intestine which is favourable for the growth of beneficial bacteria.

Jackfruit seeds contain two lectins namely jacalin and artocarpin. Jacalin has been proved to be useful for the detection of the immune status of patients infected with human immunodeficiency virus 1 (Samaddar, 2002). The abundance of source material for the production of jacalin, its ease of purification, yield and stability has made it an attractive cost effective lectin. It has found applications in diverse areas such as the isolation of human plasma glycoproteins (IgA1, C1inhibitor, hemopexin, 2-HSG), the investigation of IgA- nephropathy, the analysis of O-linked glycoproteins and the detection of tumours. Jacalin, is a tetrameric two-chain lectin (MW 65 kDa) combining a heavy α-chain of 133 amino acid resides with a light β-chain of 20-21 amino acid residues. Even in its sialylated form, it is highly specific for the α-o- glycoside of the disaccharide Thomsen-Friedenreich antigen (Galbeta 1-3Ga 1 NAc) (Haq, 2006).

Jackfruit seed has aphrodisiac activity (Ratnasooriya and Jayakody, 2002). Theivasanthi and Alagar (2011) studied the antibacterial effect of nano sized particles

of jackfruit seed against *E. coli* and revealed the efficacy of jackfruit seed nanoparticles as an antibacterial agent. Jackfruit seeds are capable in treating infectious diseases and preventing food borne diseases.

Jackfruit seed is an important ingredient in antidote preparation for heavy drinkers to overcome the effect of alcohol (Butool and Butool, 2013). Azeez *et al.* (2015) reported that the essential amino acids, fatty acids and trace amount of sugars present in jackfruit seeds make it a cheap source of dietary nutrients and health snack for overweight people. Jackfruit seed is considered as fat free food, it is suitable for the patients having life style diseases like diabetes, cardiovascular diseases etc.

2.3.1. Value added products from jackfruit seed

The jackfruit seeds are the main produce of a plant containing large number of nutrients. Carbohydrate, protein and fibre are the major constituents of seeds and these nutrients interact with each other during product development and play an important role in determining the final quality of the food products. As jackfruit seeds are bland in taste with no unique flavour, there is potential opportunity for utilizing the seed in the form of flour for value addition in the industrial sector (Rajarajeshwari and Jamuna, 1999).

The incorporation of jackfruit seed flour was found to reduce the fat absorption, especially in deep fried food products to a remarkable extent (Rajarajeshwari and Jamuna, 1999). The jack seed flour packed in polyethylene pouches can be stored at ambient temperature without deterioration for a period of six months without affecting the sensory parameters. The moisture content of seed flour gradually increased during storage (Airani, 2007).

The sensory evaluation of *chapathies* made with 50 per cent seed flour and wheat flour was more acceptable than 75 per cent incorporation (Munishamanna *et al.*, 2010). The study conducted by Chowdury *et al.* (2012) reveal that jackfruit seeds

with wheat flour (15%) blends could be used as a protein supplement or functional ingredient in bakery and confectionary items.

Jackfruit seed flour can be used for preparing cereal/pulse based fried preparations like *vada*, *pazhampori*, *baji* and *puri* by replacing 50% of flour of cereals/pulses. The products were found highly acceptable in sensory attributes (APAARI, 2012). Sulthana *et al.* (2014) reported that the shelf life of jackfruit seed enriched *chapaties* was 3 to 4 days at ambient and 30 days at refrigerated temperature (6^0 C).

2.3.1.1 Starch

Starch is an important product in food industry. It gives nutrients and also functional properties like textural qualities, mouth feel, thickening and jelling properties to the foods. Pandey (2004) extracted starch from both *varikka* and *koozha* varieties. The amylose content in *varikka* starch was found to be 32.36 per cent, and 22.53 per cent in *koozha* starch. The yield of *varikka* and *koozha* starch was 6.9 per cent and 6.1 per cent respectively. The extraction cost was found to be economical (Rs. 55/100g).

Jackfruit seed starch is suitable as a thickener and stabilizer in chilli sauce due to its low serum separation and high viscosity during storage compared with control (chilli sauce without jackfruit starch) and has better sensory score in terms of color, mouth feel, homogeneity and overall quality (Rengsutthi and Charoenrein, 2011).

Physical and chemical modifications can be employed to obtain modified jackfruit starches with improved gelatinization temperature, water solubility, viscosity, swelling ability, water uptake and resistance to enzymatic degradation.

Modified jackfruit starches could find application in the food and pharmaceutical industries (Kittipongpatana and Kittipongpatana, 2011).

2.3.1.2 Bakery products

Tananuwong *et al.* (2002) evaluated the possibility of substitution of jackfruit seed flour in bread preparation. By increasing level of replacement, the water absorption capacity increased and bread dough peak time and dough stability time were reduced. The specific baking volume of the bread was reduced by 51 per cent at 5 per cent replacement with jack seed flour. Study revealed that, less than 5 per cent of wheat flour can be replaced with jack seed flour in the bread preparation. According to Butool and Butool (2013) 20 per cent incorporation of jack fruit seed flour was found to increase the crude fibre content from 1.95g/100g^{-1} to 2.78g/100g^{-1} and decrease the fat content from 1.4g/100g^{-1} to 1.22g/100g^{-1}of the bread.

Pandey (2004) standardised the procedure for obtaining good quality flour which could be utilised for the preparation of bakery and confectionary products. Seed flour biscuit was crispy with good taste and flavour and remained shelf stable for two months. Incorporation of the jack fruit seed flour increased the ash and crude fibre in formulated biscuits. The high ash content could be indicative of more mineral content of the seed flour.

Naik (2007) incorporated 10 to 50 per cent jackfruit seed flour in 50:50 blend of wheat flour (maida and full wheat flour) for the preparation of cookies. The products at 20 and 30 per cent incorporation were acceptable with good sensory profile, while 50 per cent incorporation, had a hard texture.

Hasan (2010) prepared biscuits with 50% wheat flour and 50% jackfruit seed flour and secured the highest score (8.30) for overall acceptability and excellent

nutritive value (carbohydrate-75.72%, ash-1.52%, protein-6.03%, fat- 12.24% and moisture content-4.50%) compared to the biscuit prepared from wheat flour alone.

Arpit and John (2015) used jackfruit seed flour and wheat flour in the formulation of low calorie cake in the ratio of 95:5 (T_1), 90:10 (T_2), 85:15 (T_3) and 100% wheat flour served as control (T_0). Based on organoleptic evaluation and nutritive value, 10 per cent of jackfruit seed incorporated bread got highest score.

2.3.1.3 Extruded products

Abraham and Jayamuthunagai (2014) observed that the firmness of pasta increased with the addition of jackfruit seed flour. Ten per cent jackfruit seed flour substituted pasta showed greater consumer acceptability, in relation to flavour, mouth feel, appearance, colour and overall quality. Nandkule *et al.* (2015) enriched noodles with 5 % jackfruit seed flour and soy flour packed in LDPE and stored at room temperature. The storage studies were conducted at an interval of 0-60 days. The prepared noodles was highly acceptable during entire storage period.

Kumari and Divakar (2016) developed nutrient dense noodles by the incorporation of raw jackfruit bulb flour, raw jackfruit seed flour and refined wheat flour in various proportions (90:30:30, 50:25:25, 50:30:20, 50:40:10, 50:10:40, 50:20:30). The jackfruit bulb and seed flour added noodles, contained more protein, fibre and minerals and less energy and carbohydrate as compared to control (100 per cent refined wheat flour). The noodles developed with addition of jackfruit bulb and seed flour had desirable organoleptic properties. Based on organoleptic evaluation treatment T_5, (50% refined wheat flour, 10% jackfruit seed flour and 40% raw jackfruit bulb flour) and T_6 (50 refined wheat flour, 20 jackfruit seed flour and 30% jackfruit bulb flour) were found to be highly acceptable compared to other treatments.

2.3.1.4 Cereal bar

Torres *et al.* (2010) formulated cereal bar from jenipapo and jackfruit seed with oat bran and rice. Incorporation of jenipapo (5%) and jackfruit seed (15%) produced cereal bars with the highest score for sensorial attributes. The fiber content of prepared cereal bar was 25.5 per cent but the calories decreased by 14 per cent when compared with commercial cereal bar.

Santos *et al.* (2011) prepared fibre enriched cereal bar by using dehydrated jackfruit seeds. The results showed that 40 per cent incorporation of jackfruit seed was highly acceptable in sensory attributes and it contains 11.35g $100g^{-1}$of carbohydrate, 1.15g $100g^{-1}$ of protein, 1.35g $100g^{-1}$ of fibre and 1.95g $100g^{-1}$ of fat.

2.3.1.5 Health drink mix

Pandey (2004) formulated malted health drink mix and spiced health drink mix from jackfruit seed and stored them in laminated pouches for a period of six months. The protein, fat and energy content had no change during storage but minerals such as calcium and magnesium slightly decreased. The overall acceptability of mixes was found to be 4.20/5 in malted health drink mix and 4.10/5 in spiced health drink mix, which indicates good acceptability of the products.

Aneena and James (2015) developed "JKS health drink mix" for from jackfruit seed flour (50%), soyabean flour (10%), milk powder (10%) and sugar. The prepared health drink mix contains 274 Kcal energy, 38g carbohydrate, 15g protein, 5mg iron and 137mg calcium. Based on organoleptic evaluation the health drink mix was highly acceptable in terms of flavour, taste, texture and overall acceptability (9/9). The prepared products can be stored in laminated pouches for four months.

2.4 Fruit based extruded products

Changing lifestyles, greater awareness about health and preference for instant food items have made vermicelli very popular and an item of mass consumption. Vermicelli is a popular extruded product, round in section (2.08 to 2.14 mm in diameter) which is translucent after cooking. Traditionally, vermicelli is made from refined wheat flour. Many studies on extruded products with different formulations are available, yet the studies with incorporation of fruits and vegetables are limited.

Development of newer products from underexploited fruits by the application of modern technology is essential to boost the processing sector and these products can attract wider spectrum of consumer market. Value added products prepared from underutilised fruits would play a significant role not only for the domestic market but also for export (Srivastava and Sanjeev, 2002).

Kumar *et al.* (2010) optimised extruded product from carrot pomace, rice flour and pulse powder at various levels. The sensory evaluation results indicated that carrot pomace could be incorporated into ready-to-eat extruded products upto the level of 8.25%, was highly acceptable and could be considered a source of dietary fibre and vitamins in ready to eat snacks.

Potter *et al.* (2013) prepared extruded snack from apple, banana, and strawberry along with other ingredients (wheat flour, corn starch, potato starch and milk powder). Incorporation of 11 per cent fruits powder was more acceptable in terms of appearance and taste. Strawberry based products contain high amount of carbohydrate, protein and fibre (71.78g $100g^{-1}$, 9.72g $100g^{-1}$ and 5.56g $100g^{-1}$ respectively) compared to other fruits. The formulated three types of extrudates, are low in calorie, unsaturated fat and sodium content. The study concluded that, the

process of extrusion substantially increased the levels of fibre and antioxidants in the fruit powder formulations.

Indra and Kowsalya (2014) prepared papaya vermicelli and tomato pasta. Based on organoleptic evaluation, vermicelli incorporated with 5 per cent of papaya was found to be more acceptable than other combinations. Hand extruded vermicelli was more nutritious than machine extruded vermicelli. It contained 15.20g $100g^{-1}$ of protein, 2.15g $100g^{-1}$ of fibre, 120 mg $100g^{-1}$of calcium and 4 mg $100g^{-1}$ of iron. Pasta made from 10 per cent incorporated tomato give 11.75g $100g^{-1}$ of protein, 324.85µg $100g^{-1}$of β-carotene, 122 mg $100g^{-1}$of calcium and 355 mg $100g^{-1}$ of phosphorus.

Makila *et al.* (2014) utilised the residue of blackcurrant juice for the preparation of extruded products. The ingredients are blackcurrant press residues (30%), cereal materials (40%) and potato starch (30%) and small amount of sugar and salt. The prepared products showed higher expansion, lower hardness and density, and higher contents of fructose, glucose and fruit acids which are positively correlated to sensory parameters such as texture, appearance and flavor.

Selani *et al.* (2014) incorporated pineapple pomace in extruded products to enhance the fibre content. The pomace had low fat (0.61%) and high dietary fibre (45.22%), showing its potential for fibre enrichment of some extruded snacks, which are nutritionally inferior. The addition of 10.5 per cent of pineapple pomace was acceptable in terms of physical qualities and sensory parameters. Results also showed low microbiological counts, water activity and pH, and low risk of physicochemical deterioration.

Mirhosseini *et al.* (2015) investigated the effect of partial replacement of corn flour with durian seed flour and pumpkin flour (25% and 50%) on the characteristics of gluten-free pasta. The prepared pasta have high mineral content, soft texture and better cooking yield. The gluten free pasta containing 50% durian seed flour had

maximum score for overall acceptability among all formulated samples. The addition of 25% pumpkin flour to the formulation led to improvement in the color, texture properties and sensory attributes of gluten free pasta.

Oduro *et al.* (2016) developed nutrient dense pasta from bread fruit flour with whole wheat flour in five treatments (10:90, 20:80, 30:70, 40:60 and 50:50). The bread fruit flour added pasta contained more fibre, carbohydrate and minerals as compared to wheat flour added pasta. Based on organoleptic evaluation, 30 per cent incorporation of bread fruit pasta was found to be highly acceptable compared to other treatment.

Thurkal (2017) standardised macaroni by incorporating 10% and 20% of bael fruit powder. Among these two treatments, macaroni incorporated with 10% bael fruit powder was highly acceptable and almost similar to control (refined flour) in terms of colour (8.30), appearance (7.30), texture (7.40), but got a higher score for taste (7.70).

Sarah *et al.* (2017) prepared vermicelli from banana flour (BF) along with wheat flour (WF) in four treatments (T_1-100% wheat flour, T_2-75:25, T_3-50:50, T_4-25:75). Increased level of fortification of unripe banana flour with wheat flour showed an increase in carbohydrate, ash and fiber and decrease in fat and protein content. Based on organoleptic evaluation and nutritive value, treatment T_3, which is 50 per cent wheat and banana flour incorporated vermicelli, was highly acceptable. It has 68.78g $100g^{-1}$ of carbohydrate, 10.84g $100g^{-1}$ of protein, and 5.52g $100g^{-1}$ of ash.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study entitled "Process optimisation and quality evaluation of jackfruit (*koozha* type) based vermicelli" was proposed to develop vermicelli with raw jackfruit flour, jackfruit seed flour, whole wheat flour and rice flour and to evaluate its acceptability, nutritional and shelf life qualities. The study also aims to develop an acceptable instant payasam mix with standardised vermicelli. The materials and methods adopted in the study are given under the following headings.

3.1 Collection of raw materials

3.2 Preparation of flours from raw jackfruit bulb and seed

3.3 Process standardisation of jackfruit based vermicelli

3.4 Organoleptic evaluation of prepared vermicelli and *payasam*

3.4.1 Selection of judges

3.4.2 Preparation of score card

3.4.3 Selection of most acceptable vermicelli

3.5 Quality evaluation of the selected jackfruit based vermicelli

3.5.1 Organoleptic qualities

3.5.2 Chemical and nutritional qualities

3.5.3 Microbial enumeration

3.5.4 Insect infestation

3.6 Standardisation of instant *payasam* mix

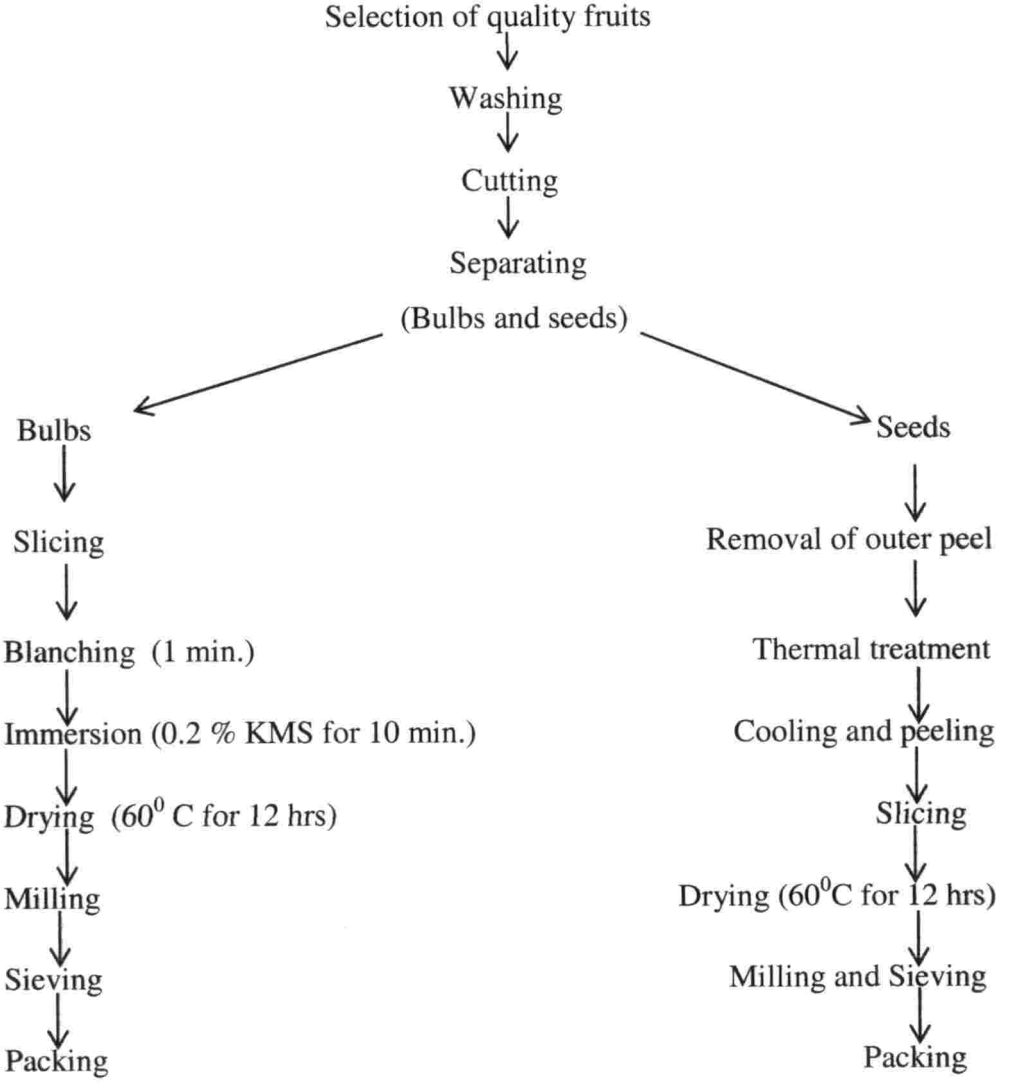
3.7 Statistical analysis

3.8 Cost of production

3.1 Collection of raw materials

Raw jackfruit (*koozha* type) and seeds was collected from the households. Raw jackfruit flour (Kumari, 2015) and jackfruit seed flour (Pandey, 2004) were prepared as per the standard procedures. Whole wheat flour, rice flour, milk, sugar, cardamom, raisins and cashew nuts were purchased from the local market.

Flow diagram for the preparation of raw jackfruit bulb and seed flour



3.2 Preparation of raw jackfruit bulb and seed flour

The raw jackfruits were washed and separated into bulbs and seeds. The bulbs were sliced into 2.5×1 cm and then blanched in boiling water for one minute. The blanched slices were cooled and immersed in 0.2 per cent KMS solution for 10 minutes. The immersed slices were then dried in a cabinet drier at 60^0C for 12 hours. The dried chips were milled into flour and sieved through 0.5 mm mesh to get uniform flour.

Jackfruit seeds were cleaned and the white arils were peeled off manualy. It was then washed thoroughly in running water and subjected to thermal treatment (pressure cooked for 20 minutes) to inactivate anti-nutritional factors. Spermoderm layer was removed by rubbing the seeds between hands. The sliced seeds were dried (60^0C for 12 hours) and powdered.

3.3 Process standardisation of jackfruit based vermicelli

Vermicelli was prepared using the standard procedure by Ranganna *et al.* (2014). The flours were mixed thoroughly and the dough was prepared with 30 per cent water in a dough mixer. The dough was kept for proofing for 30 minutes at room temperature. The prepared dough was extruded through manual extruder. The extruded vermicelli was dried in a cabinet drier at 55^0C to 65^0C for 4 to 6 hours. Preliminary trials were conducted to standardise the quantity of water required for the preparation of vermicelli.

For the development of jackfruit based vermicelli, 21 treatments were tried using different combination of raw jackfruit flour at the level of 40 to 70 per cent with 30 to 60 per cent of whole wheat flour and rice flour and jackfruit seed flour was done only up to 40 per cent. Refined wheat flour vermicelli served as the control. From these treatments (Table2) the highly acceptable combination of jackfruit flour each with whole wheat flour, rice flour and jackfruit seed flour (both roasted and unroasted) vermicelli were selected for further shelf life studies.

Table 2. Treatments for the standardisation of jackfruit based vermicelli

Treatments	Combinations
T_o	Control (100% Refined wheat flour)
T_1	70% RJF + 30% WWF
T_2	60% RJF + 40% WWF
T_3	50% RJF + 50% WWF
T_4	40% RJF + 60% WWF
T_5	70% RJF + 30% RF
T_6	60% RJF + 40% RF
T_7	50% RJF + 50% RF
T_8	40% RJF + 60% RF
T_9	70% RJF + 30% JSF
T_{10}	60% RJF + 40% JSF
T_{11}	70% Roasted RJF + roasted 30% WWF
T_{12}	60% Roasted RJF + roasted 40% WWF
T_{13}	50% Roasted RJF + roasted 50% WWF
T_{14}	40% Roasted RJF + roasted 60% WWF
T_{15}	70% Roasted RJF + roasted 30% RF
T_{16}	60% Roasted RJF + roasted 40% RF
T_{17}	50% Roasted RJF + roasted 50% RF
T_{18}	40% Roasted RJF + roasted 60% RF
T_{19}	70% Roasted RJF + roasted 30% JSF
T_{20}	60% Roasted RJF + roasted 40% JSF

(RJF- raw jackfruit flour, WWF- whole wheat flour, RF-rice flour, JSF- jackfruit seed flour)

3.4 Organoleptic evaluation of prepared jackfruit vermicelli and *payasam*

Organoleptic evaluation of jackfruit vermicelli and *payasam* prepared with the vermicelli was conducted preparing score card with nine point hedonic scale by a panel of fifteen judges.

3.4.1. Selection of judges

Panel of fifteen judges between age group of 18 to 35 years are selected by conducting a series of organoleptic evaluation using a simple triangle test at laboratory level as suggested by Jellinek (1985).

3.4.2. Preparation of score cards

The organoleptic score cards with six sensory attributes like appearance, colour, flavour, texture, taste and overall acceptability were prepared based on the nine point hedonic scale and is given in Appendix I.

3.4.2 Selection of acceptable vermicelli

From these prepared vermicelli, one highly acceptable combination of vermicelli, each with whole wheat flour, rice flour and jackfruit seed flour (both roasted and unroasted) were selected for further studies. Thus a total of six best combinations viz. raw jackfruit flour (RJF) + whole wheat flour (WWF), raw jackfruit flour (RJF) + rice flour (RF), raw jackfruit flour (RJF) + jackfruit seed flour (JSF), roasted RJF + roasted WWF, roasted RJF + roasted RF, and roasted RJF + roasted JSF along with control (refined wheat flour vermicelli) was taken for further shelf life studies.

3.5 Quality evaluation of jackfruit based vermicelli

The selected 6 treatments of vermicelli and control were packed in 250 gauge polyethylene pouches and kept in ambient conditions for a period of four months. Quality evaluation was done initially and during the 2^{nd} and 4^{th} month of the storage period.

3.5.1. Organoleptic qualities

Organoleptic qualities like appearance, colour, flavor, texture, taste and overall acceptability of vermicelli and *payasam* was done during storage periods.

3.5.2. Chemical and nutritional qualities

3.5.2.1. Moisture

Moisture content of selected vermicelli was estimated by the method of A.O.A.C (1980). To determine moisture content of the sample a known weight of the sample is dried in a hot air oven at 60^0C to 70^0C, cooled in a desicator and weighed. The process of heating and cooling was repeated till constant weight was achieved. The moisture content of the sample was calculated from the loss in weight during drying.

3.5.2.2. Energy

The energy content of vermicelli was computed according to Gopalan *et al.* (1989) and expressed as kilocalories (kcal). The energy present in sample was calculated as per the formula given below.

Energy = (4 ×Protein) + (4 ×Total carbohydrates) + (9 ×Fat)

3.5.2.3. Total carbohydrate

The total carbohydrate content of products was estimated by the method suggested by Sadasivam and Manickam (1997). A dried sample of 100mg sample

was hydrolysed with 5ml of 2.5N HCl for 3 hours by boiling in a water bath and cooled to room temperature. The residue was neutralized with sodium carbonate until effervescence ceases. The volume was made up to 100ml and centrifuged. An aliquot 0.2ml from the supernatant was pipetted out and made up to 1ml and then 4ml of anthrone reagent was added. Heated for 8 minutes in a boiling water bath, cooled rapidly and the intensity of green to dark colour was read at 630nm (OD). A standard graph was prepared using standard glucose by applying the serial dilutions. From the standard graph, the amount of total carbohydrate present in the sample was estimated and expressed in gram per 100g of sample.

3.5.2.4. Protein

The protein content of vermicelli was estimated using Lowry's method given by Sadasivam and Manickam (1997). A sample of 500mg was extracted using 5 to 10 ml of buffer (Tris buffer GR – tris hydroxymethyl amino methane) and centrifuged. An aliquot 0.1ml from the supernatant was taken in a test tube, 5ml alkaline copper solution were mixed well and allowed to stand for 10 minutes. Folin-Ciocalteau reagent of 0.5 ml was added and incubated at room temperature in the dark for 30 minutes and the developed blue colour was read at 660nm (OD). A standard graph was prepared using alkaline copper solution and Folin-Ciocalteau reagent by applying serial dilutions. From the standard graph, the amount of total protein present in sample was estimated and expressed in gram per 100g of sample.

3.5.2.5. Total fat

The fat content of the vermicelli was estimated using the method given by Sadasivam and Manickam (1997). Five gram of sample was taken in a thimble and plugged with cotton. The material was extracted with petroleum ether for six hours without interruption by gentle heating in a soxhlet apparatus. Extraction flask was

then cooled and ether was removed by heating and the weight was taken. The fat content was expressed in gram per 100g of the sample.

3.5.2.6. Crude fibre

The crude fibre content was estimated using the method given by Sadasivam and Manickam (1997). Powdered vermicelli sample of two grams was boiled with 200 ml of 1.25 per cent sulphuric acid for 30 minutes. It was then filtered using muslin cloth and washed with boiling water. The residue was again boiled with 200 ml of 1.25 per cent of sodium hydroxide for 30 minutes. Repeat the filtration through muslin cloth and residue was washed with 25 ml of boiling 1.25 per cent of sulphuric acid, three 50 ml portion of water and 25 ml of alcohol. The obtained residue was taken in an ashing dish (W_1) and dried at 130^0C for 2 hours. Cool the dish in a desiccator which was reweighed and noted as W_2. The residue was again ignited in muffle furnace at 600^0C for 30 minutes, cooled in a desiccator and reweighed (W_3).

3.5.2.7. Starch

Starch present in the vermicelli was estimated calorimetrically at 630nm as per the standard protocol of Sadavisam and Manikam (1997).

The vermicelli samples of 0.5g were weighed. The sample was treated with 80% ethanol to remove the sugars. The residue was washed again and again to remove the sugars completely. The obtained residues were dried and then add 5ml of water and 6.5ml of 52% perchloric acid and extracted in cold water for 20 minutes. Centrifuge the sample for the collection of supernatant. The sample was then reextracted with fresh percholoric acid. From the sample, supernatant were collected and made up to 100ml. Pipette out 0.2ml supernatant of and made upto 1ml with water. Then add 4ml of the anthrone reagent to it, which is heated for 8minutes, cooled and read at 630nm.

3.5.2.8. TSS

Total soluble solids of the vermicelli were accessed by the Erma hand refractometer which will be expressed as degree brix (°brix) as per Ranganna (1997).

3.5.2.9. Reducing sugars

Twenty five gram of vermicelli was grinded with 100ml of distilled water and transferred to a conical flask. It was neutralised with 1N sodium hydroxide in the presence of phenolphthalein. For the clarification of the neutralised mixture, 2ml of lead acetate was added followed by addition of 2ml of potassium oxalate to neutralise the excess amount of lead acetate. It was then allowed to stand for 10 minutes for the settlement of precipitate. Filter the solution through Whatman's No.1 filter paper which was made upto 250ml. Aliquot of the solution was titrated against a boiling mixture of fehlings solution A and B using methylene blue as indicator until the appearance of brick red colour (Ranganna, 1997). The reducing sugars present in vermicelli were computed using the formula as follows.

$$\text{Reducing sugar (\%)} = \frac{\text{Fehling's factor X dilution X 100}}{\text{Titre value X weight of the sample}}$$

3.5.2.10. Total sugar

From the clarified solution used for the estimation of reducing sugar, 50 ml was taken and boiled gently after adding 5g citric acid and 50ml of water. This solution was neutralized with sodium hydroxide (1N) with few drops of phenolphthalein indicator until colourless solution. An aliquot of this solution were titrated against standard Fehling's solution A and B by adding methylene blue indicator (Ranganna, 1997). The totalsugars present in vermicelli were computed using the formula as follows.

$$\text{Total sugars (\%)} = \frac{\text{Fehling's factor X 250 X dilution}}{\text{Titre value X 50 X weight of the sample}} \times 100$$

3.5.2.11. Calcium

Calcium content present in vermicelli is estimated using method suggested by Perkin – Elmer (1982). One gram of the vermicelli was pre-digested using 10 ml of 9:4 ratio of nitric and percholoric acid. The prepared diacid extract of the vermicelli sample was used for estimation of calcium in Atomic Absorption Spectrophotometer. The amount of calcium content present in sample can be expressed as mg per 100g.

3.5.2.12. Iron

Iron content present in selected vermicelli is estimated using method suggested by Perkin – Elmer (1982). One gram of the vermicelli was pre-digested using 10 ml of 9:4 ratio of nitric and percholoric acid. The prepared diacid extract of the vermicelli sample was used for estimation of iron in Atomic Absorption Spectrophotometer. Iron content present in the sample can be expressed as mg per 100g.

3.5.2.13. Sodium and Potassium

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

3.5.3. Microbial enumeration

The microbial population present in the vermicelli sample were estimated using serial dilution plate count method as suggested by Agarwal and Hasija (1986). The microbial analysis were carried out in vermicelli initially and during the second and fourth month of storage.

3.5.3.1. Preparation of samples and media for microbial enumeration

The sample was prepared by mixing 90ml of distilled water with 10g of vermicelli and shaken well using a shaker to obtain suspension. The serial dilutions were carried out in the prepared water blank. To 9ml of water blank transfer one ml of the prepared suspension with a dilution of 10^{-2}. This is then diluted to 10^{-3} followed by 10^{-4}, 10^{-5} and 10^{-6} using serial dilution techniques. Bacteria, fungi and yeast count were accessed using Nutrient Agar (NA), Potato Dextrose Agar (PDA) and Sabouraud's Dextrose Agar (SDA) media respectively and results were given as cfu/g.

3.5.3.2. Enumeration of bacterial colony

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

3.5.3.3. Enumeration of Fungal colony

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

3.5.3.4. Enumeration of Yeast colony

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

3.5.4 Insect infestation

Insect infestation of vermicelli were observed and recorded initially and during the second and fourth month of storage. Insect infestations were assessed by visual examination.

3.6. Standardisation of instant *payasam* mix

From the selected jackfruit based vermicelli instant *payasam* mix was standardised with 200 g vermicelli with 2 proportions of milk and 3 proportions of sugar (Table 3) based on organoleptic qualities. In all treatments 10g toasted cashew nuts and raisins, and 5g crushed cardamom was added.

Table 3. Treatments for the standardisation of instant *payasam* mix

Treatments	Milk (litre)	Sugar (g)
T_1	1 L	100g
T_2	1 L	125g
T_3	1 L	150g
T_4	1.5 L	100g
T_5	1.5 L	125g
T_6	1.5 L	150g

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3.7. Statistical analysis

The data were recorded and analysed as completely randomised design (CRD). Based on organoleptic evaluation, the best treatment was selected using Kendall's Coefficient of Concordance (W).The nutritional qualities of the jackfruit based vermicelli and control were compared using Duncan's Multiple Rank Test (DMRT) and relative change.

3.8. Cost of production of the most acceptable vermicelli and instant *payasam* mix

The cost of production of the most acceptable combinations of jackfruit vermicelli and *payasam* mix were computed based on the market price of procured ingredients used for preparation of products along with labour charge, fuel charge, electricity charge and packaging cost. The cost was calculated for 1Kg of the product and compared with similar products available in the market.

RESULTS

4. RESULTS

Results of the study entitled "Process optimisation and quality evaluation of jackfruit (*koozha* type) based vermicelli" are presented under the following headings:

4.1. Standardisation of jackfruit based vermicelli

4.2. Quality evaluation of selected jackfruit based vermicelli

4.2.1. Organoleptic qualities

4.2.2. Nutritional qualities

4.2.3. Microbial enumeration

4.2.4. Insect infestation

4.3. Standardisation of instant *payasam* mix

4.3.1. Cooking time for instant *payasam*

4.3.2. Organoleptic qualities of instant *payasam*

4.4. Cost of production for selected jackfruit based vermicelli and *payasam* mix

4.1. Standardisation of jackfruit based vermicelli

Jackfruit based vermicelli were prepared using raw jackfruit flour, whole wheat flour, rice flour and jackfruit seed flour (both roasted and unroasted) at different levels. The refined wheat flour vermicelli served as control. Organoleptic evaluation of jackfruit based vermicelli were carried out by the panel of fifteen judges based on six sensory attributes like appearance, colour, flavour, texture, taste and overall acceptability using a 9 point hedonic scale. These obtained mean scores for the jackfruit based vermicelli were ranked statistically using Kendall's coefficient of concordance. The details are as follows

4.1.1. Organoleptic evaluation of jackfruit based vermicelli incorporated with whole wheat flour

Jackfruit based vermicelli incorporated with whole wheat flour were prepared in various proportions and compared with control (refined wheat flour) vermicelli. Based on organoleptic qualities, the mean score and the mean rank scores obtained for different sensory attributes of vermicelli prepared with raw jackfruit flour in combination with wheat flour are presented in Table 4. The prepared jackfruit based vermicelli incorporated with whole wheat flour is shown in Plate 1.

The mean score for the appearance of jackfruit based vermicelli (T_1 to T_4) ranges from 7.62 to 8.2 (2.43 to 3.40). For colour and flavour, the mean score varied from 7.73 to 8.08 (2.73 to 3.10) and 8.13 to 8.34 (2.63 to 2.90). Mean score for taste and texture varied from 7.75 to 7.91 (2.57 to 3.00) and 7.8 to 7.86 (2.70 to 2.90). Mean score for overall acceptability ranges from 7.66 to 7.86 (2.67 to 2.83). The control vermicelli had the mean score of 8.44, 8.44, 8.82, 8.4, 8.35 and 8.37 for appearance, colour, flavour, texture, taste and overall acceptability.

Among jackfruit based vermicelli, the highest mean score for different quality attributes were noticed in vermicelli prepared with 70 per cent raw jackfruit flour and 30 per cent whole wheat flour (T_1), but it was found to be lower than refined wheat flour vermicelli (T_0). The lowest mean score for different quality attributes was noticed for vermicelli prepared using 40 per cent raw jackfruit flour and 60 per cent whole wheat flour (T_4).

Significant agreement (Kendalls value) among judges was observed for the different sensory parameters of vermicelli prepared using raw jackfruit flour in combination with whole wheat flour.

Table 4. Mean scores for organoleptic evaluation of vermicelli prepared with jackfruit flour and whole wheat flour

Treatments	Sensory parameters					
	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
T_0 (control)	8.44 (3.60)	8.44 (3.83)	8.82 (4.07)	8.4 (3.90)	8.35 (3.70)	8.37 (3.90)
T_1 (70% RJF: 30% WWF)	8.2 (3.40)	8.08 (3.10)	8.34 (2.90)	7.86 (2.90)	7.91 (3.00)	7.86 (2.83)
T_2 (60% RJF: 40% WWF)	7.97 (3.03)	7.88 (2.60)	8.24 (2.80)	7.8 (2.83)	7.88 (2.73)	7.84 (2.80)
T_3 (50% RJF: 50% WWF)	7.84 (2.53)	7.8 (2.73)	8.28 (2.60)	7.82 (2.67)	7.86 (3.00)	7.68 (2.80)
T_4 (40% RJF: 60% WWF)	7.62 (2.43)	7.73 (2.73)	8.13 (2.63)	7.8 (2.70)	7.75 (2.57)	7.66 (2.67)
Kendalls W	.117**	.109**	.207**	.120**	.083**	.111**

(RJF - Raw jackfruit flour, WWF- Whole wheat flour)
Value in parentheses is mean rank score based on Kendall's W
**Significance at 1 % level

4.1.1.1. Organoleptic evaluation of *payasam* prepared with jackfruit flour and whole wheat flour vermicelli

The mean score and the mean rank scores obtained for different sensory attributes of *payasam* prepared with jackfruit flour and whole wheat flour vermicelli are presented in Table 5. The prepared jackfruit based *payasam* incorporated with whole wheat flour is shown in Plate 1.

Among different treatments tried for the preparations of jackfruit based *payasam*, the highest mean score and mean rank score for appearance (8.64 and

3.83), colour (8.64 and 4.17), flavour (8.6 and 4.00), taste (8.48 and 3.43), texture (8.51 and 3.60) and overall acceptability (8.68 and 3.87) was recorded for T_1 (70 per cent jackfruit flour and 30 per cent whole wheat flour). The lowest mean score for quality attributes were noticed in *payasam* prepared with 40 per cent raw jackfruit flour and 60 per cent whole wheat flour (T_4).

Significant agreement (Kendall's value) among judges was observed for the evaluation of different quality attributes of *payasam* prepared using raw jackfruit and whole wheat flour based vermicelli.

Table 5. Mean scores for organoleptic evaluation of *payasam* prepared with jackfruit flour and whole wheat flour vermicelli

Treatments	Sensory parameters					
	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
T_0 (control)	8.51 (3.53)	8.51 (3.53)	8.48 (3.77)	8.62 (3.80)	8.71 (4.40)	8.75 (4.07)
T_1(70% RJF: 30% WWF)	8.64 (3.83)	8.64 (4.17)	8.6 (4.00)	8.51 (3.60)	8.48 (3.43)	8.68 (3.87)
T_2(60% RJF: 40% WWF)	8.35 (2.80)	8.17 (2.53)	8.04 (1.97)	8.17 (2.73)	8.04 (2.47)	8.22 (2.40)
T_3(50% RJF: 50% WWF)	8.06 (2.17)	8.02 (2.30)	8.33 (2.80)	8.06 (2.57)	8.02 (2.40)	8.08 (1.93)
T_4(40% RJF: 60% WWF)	8.24 (2.67)	7.95 (2.47)	8.2 (2.47)	8.02 (2.30)	8.08 (2.30)	8.31 (2.73)
Kendalls W	.199**	.289**	.320**	.199**	.374**	.405**

(RJF - Raw jackfruit flour, WWF- Whole wheat flour)
Value in parentheses is mean rank score based on Kendall's W
**Significance at 1 % level

4.1.2. Organoleptic evaluation of jackfruit based vermicelli incorporated with rice flour

The score obtained for organoleptic attributes of raw jackfruit and rice flour based vermicelli in comparison with control are presented in Table 6. The prepared jackfruit based vermicelli incorporated with rice flour is shown in Plate 2.

The highest mean score and mean rank score for different quality attributes was observed in vermicelli prepared with 60 per cent raw jackfruit flour and 40 per cent rice flour (T_2). The mean score and mean rank score for appearance and colour of T_2 vermicelli was 8.28 (3.70) and 8.17 (3.20) respectively. For flavour and taste the mean score were found to be 8.31 (3.19) and 8.24 (2.90). The mean score for texture was 8.6 (3.03) and for overall acceptability was 8.30 (3.73). Lowest mean score for all sensory attributes was observed for T_4.

Compared to control (T_0), mean score and mean rank for sensory parameters of vermicelli (T_2) was low. The prepared vermicelli obtained a significant agreement among judges for all sensory parameters.

Table 6. Mean scores for organoleptic evaluation of vermicelli prepared with jackfruit flour and rice flour

Treatments	Sensory parameters					
	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
T_0 (control)	8.42 (3.67)	8.44 (3.93)	8.38 (3.93)	8.75 (3.90)	8.37 (3.77)	8.33 (3.93)
T_1 (70% RJF: 30% RF)	7.84 (2.67)	7.95 (2.60)	7.73 (2.70)	8.57 (2.97)	8.11 (2.80)	7.8 (2.73)
T_2 (60% RJF: 40% RF)	8.28 (3.70)	8.17 (3.20)	8.31 (3.19)	8.6 (3.03)	8.24 (2.90)	8.30 (3.73)
T_3 (50% RJF: 50% RF)	7.82 (2.53)	7.77 (2.57)	7.71 (2.67)	8.53 (2.63)	7.95 (2.90)	7.64 (2.83)
T_4 (40% RJF: 60% RF)	7.64 (2.43)	7.75 (2.70)	7.71 (2.73)	8.46 (2.47)	7.53 (2.63)	7.6 (2.73)
Kendalls W	.178**	.149**	.165**	.142**	.087**	.121**

(RJF - Raw jackfruit flour, RF- Rice flour)
Value in parentheses is mean rank score based on Kendall's W
**Significance at 1 % level

4.1.2.1. Organoleptic evaluation of *payasam* prepared with jackfruit flour and rice flour vermicelli

Jackfruit based *payasam* prepared from raw jackfruit and rice flour vermicelli shown in Plate 2. The sensory score of the prepared *payasam* were tabulated and presented in Table 7.

The result revealed that, T_2 (60 per cent jackfruit flour and 40 per cent rice flour) had a maximum score in all quality parameters like appearance (8.75 and 4.23), colour (8.73 and 4.30), flavour (8.64 and 4.10), texture (8.37 and 3.73), taste (8.4 and

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3.40) and overall acceptability (8.82 and 4.30). The sensory parameters like colour, texture and overall acceptability of T_2 was high compared to control.

The minimum mean score and mean rank score of 7.84 (1.57) for appearance, 7.93 (1.70) for colour, and 7.84 (1.80) for overall acceptability was observed in treatment T_3. In T_4 minimum mean score and mean rank score obtained for taste was 8.06 and 2.33 and texture 8.08 and 2.57 respectively, whereas T_1 had minimum score of 8.84 and 1.87 for flavour.

The Kendall's value observed a significant agreement among judges for the quality attributes of *payasam* prepared using raw jackfruit and rice flour based vermicelli.

Table 7. Mean scores for organoleptic evaluation of *payasam* prepared with jackfruit flour and rice flour vermicelli

Treatments	Sensory parameters					
	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
T_0 (control)	8.82 (4.53)	8.71 (4.30)	8.75 (4.10)	8.77 (3.90)	8.53 (4.43)	8.71 (4.40)
T_1 (70% RJF :30% RF)	8.13 (2.43)	8.08 (2.27)	8.04 (1.87)	8.26 (2.73)	8.33 (2.43)	7.97 (2.30)
T_2 (60% RJF :40% RF)	8.75 (4.23)	8.73 (4.30)	8.64 (4.10)	8.37 (3.73)	8.4 (3.40)	8.82 (4.30)
T_3 (50% RJF :50% RF)	7.84 (1.57)	7.93 (1.70)	8.22 (2.57)	8.24 (2.07)	8.26 (2.40)	7.84 (1.80)
T_4 (40% RJF :60% RF)	8.15 (2.23)	8.08 (2.43)	8.2 (2.37)	8.08 (2.57)	8.06 (2.33)	7.97 (2.20)
Kendalls W	.762**	.679**	.465**	.380**	.279**	.720**

(RJF - Raw jackfruit flour, RF- Rice flour)
Value in parentheses is mean rank score based on Kendall's W
**Significance at 1 % level

Plate 1. Raw jackfruit flour and whole wheat flour based vermicelli and *payasam*

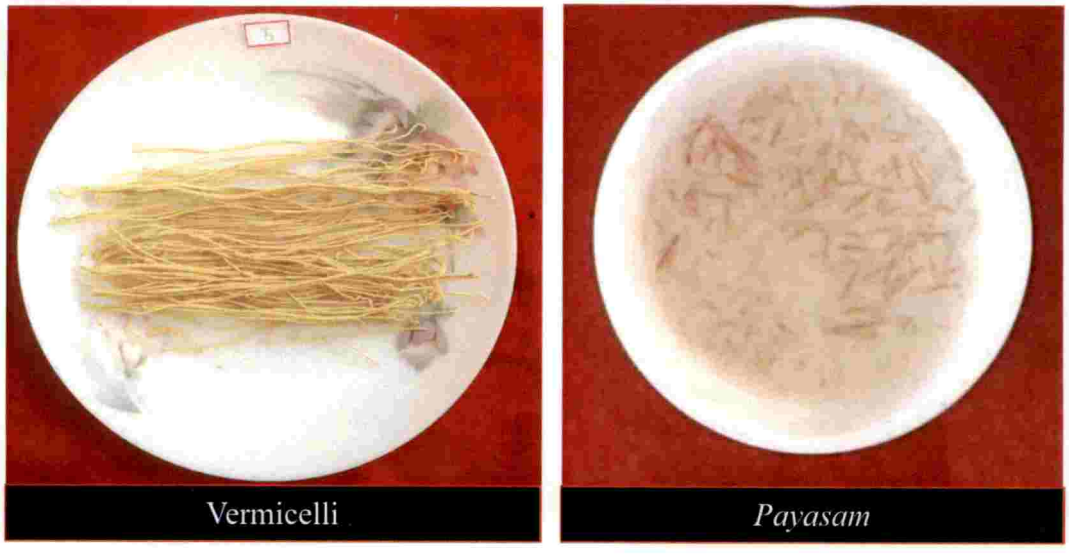

Plate 2. Raw jackfruit flour and rice flour based vermicelli and *payasam*

4.1.3. Organoleptic evaluation of jackfruit based vermicelli incorporated with jackfruit seed flour

The mean score and the mean rank scores obtained for different sensory attributes of vermicelli and *payasam* prepared with raw jackfruit flour in combination with jackfruit seed flour are presented in Table 8 and 9. The prepared vermicelli and *payasam* are shown in plate 3.

Vermicelli prepared with 70 per cent jackfruit flour and 30 per cent jackfruit seed flour (T_1) had better mean score and mean rank score for appearance (8.4 and 2.17), colour (8.35 and 2.30), flavour (8.33 and 2.07), taste (8.2 and 1.90), texture (8.26 and 2.00), and overall acceptability (8.31 and 2.33) than T_2 (vermicelli prepared with 60 per cent jackfruit flour and 40 per cent jackfruit seed flour). Mean score and mean rank score for different quality attributes of T_2 was 8.22 (1.87) for appearance, 8.31 (1.17) for colour, 8.26 (1.87) for flavour, 8.04 (1.60) for taste, 8.22 (1.70) for texture, and 8.02 (1.43) for overall acceptability. Compared to control (T_0), mean score for all sensory parameters of jackfruit based vermicelli was lower, except for appearance.

Based on Kendall's (W) value, significant agreement among judges was noted among different quality attributes of vermicelli prepared using jackfruit flour in combination with jackfruit seed flour.

Table 8. Mean scores for organoleptic evaluation of vermicelli prepared with jackfruit flour and jackfruit seed flour

Treatments	Sensory parameters					
	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
T_0 (control)	8.37 (1.97)	8.44 (2.20)	8.33 (2.07)	8.42 (2.30)	8.46 (2.50)	8.4 (2.33)
T_1(70% RJF: 30% JSF)	8.4 (2.17)	8.35 (2.30)	8.33 (2.07)	8.26 (2.00)	8.2 (1.90)	8.31 (2.33)
T_2(60% RJF: 40% JSF)	8.22 (1.87)	8.31 (1.17)	8.26 (1.87)	8.22 (1.70)	8.04 (1.60)	8.02 (1.43)
Kendalls W	.029**	.064**	.020**	.275**	.123**	.275

(RJF - Raw jackfruit flour, JSF- Jackfruit seed flour)
Value in parentheses is mean rank score based on Kendall's W
**Significance at 1 % level

4.1.3.1 Organoleptic evaluation of *payasam* prepared with jackfruit flour and jackfruit seed flour vermicelli

From Table 9, it is clear that higher mean score for sensory parameters of jackfruit based *payasam* were observed in T_1 (70 per cent jackfruit and 30 per cent jackfruit seed vermicelli) compared to T_2 (60 per cent jackfruit flour and 40 per cent jackfruit seed flour vermicelli). Treatment T_1 had high mean score and mean rank score for appearance (8.35 and 2.07), colour (8.37 and 1.87), flavour (8.31 and 2.20), taste (8.4 and 2.27), texture (8.33 and 1.90) and overall acceptability (8.4 and 2.07). The mean score for different quality attributes of jackfruit based *payasam* were lower than control (T_0).

Significant agreement (Kendall's value) among judges was observed for the different quality attributes of *payasam* prepared using raw jackfruit flour and jackfruit seed flour vermicelli.

Table 9. Mean scores for organoleptic evaluation of *payasam* prepared with jackfruit flour and jackfruit seed flour vermicelli

Treatments	Sensory parameters					
	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
T_0 (control)	8.62 (2.43)	8.62 (2.70)	8.46 (2.33)	8.6 (2.43)	8.57 (2.50)	8.71 (2.57)
T_1(70% RJF: 30% JSF)	8.35 (2.07)	8.37 (1.87)	8.31 (2.20)	8.33 (1.90)	8.4 (2.27)	8.4 (2.07)
T_2(60% RJF: 40% JSF)	8.00 (1.50)	8.22 (1.43)	8.11 (1.47)	8.22 (1.67)	8.02 (1.23)	8.12 (1.37)
Kendalls W	.340**	.488**	.267**	.185**	.593**	.484**

(RJF - Raw jackfruit flour, JSF- Jackfruit seed flour)
Value in parentheses is mean rank score based on Kendall's W
**Significance at 1 % level

4.1.4. Organoleptic evaluation of vermicelli prepared with roasted jackfruit flour and roasted whole wheat flour

The mean score obtained for organoleptic attributes of roasted jackfruit flour and roasted whole wheat flour based vermicelli and *payasam* in comparison with control are presented in the table 10. The prepared vermicelli and *payasam* are shown in Plate 4.

As observed in the Table 10, mean score for appearance and colour of roasted jackfruit flour based vermicelli ranged from 7.71 to 8.35 (2.47 to 3.47) and 7.84 to 8.26 (2.67 to 3.30) respectively. For flavour the mean score was 8.24 to 8.35 (2.77 to

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2.97). For taste and texture the mean score varied from 7.77 to 8.02 (2.50 to 3.03) and 7.8 to 7.88 (2.77 to 3.00) respectively. The mean score for overall acceptability ranged from 7.8 to 7.95 (2.70 to 3.00).

The highest and lowest mean scores for different quality attributes were noticed for T_1 (70 per cent roasted jackfruit flour with 30 per cent roasted whole wheat flour) and T_4 (40 per cent roasted jackfruit flour and 60 per cent roasted whole wheat flour) respectively. Compared to control (T_0), mean score for different quality attributes of jackfruit based vermicelli was low.

Based on Kendall's (W) value, significant agreement among judges was noted in the evaluation of different quality attributes of vermicelli prepared using roasted jackfruit flour in combination with roasted whole wheat flour.

Table 10. Mean scores for organoleptic evaluation of vermicelli prepared with roasted jackfruit flour and wheat flour

Treatments	Sensory parameters					
	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
T_0 (control)	8.4 (3.37)	8.44 (3.73)	8.84 (3.87)	8.44 (3.80)	8.4 (3.77)	8.37 (3.77)
T_1 (70% RJF: 30% WWF)	8.35 (3.47)	8.26 (3.30)	8.35 (2.97)	7.88 (3.00)	8.02 (3.03)	7.95 (3.00)
T_2 (60% RJF: 40% WWF)	8.06 (2.97)	7.93 (2.53)	8.31 (2.70)	7.84 (2.89)	7.91 (2.83)	7.93 (2.90)
T_3 (50% RJF: 50% WWF)	7.97 (2.73)	7.91 (2.77)	8.33 (2.70)	7.8 (2.77)	7.88 (2.87)	7.86 (2.63)
T_4 (40% RJF: 60% WWF)	7.71 (2.47)	7.84 (2.67)	8.24 (2.77)	7.82 (2.60)	7.77 (2.50)	7.8 (2.70)
Kendalls W	.076**	.114**	.123**	.099**	.101**	.095**

(RJF - Raw jackfruit flour, WWF- Whole wheat flour)
Value in parentheses is mean rank score based on Kendall's W
**Significance at 1 % level

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4.1.4.1 Organoleptic evaluation of *payasam* prepared with roasted jackfruit flour and roasted whole wheat flour vermicelli

Table 11 reveals that jackfruit based *payasam* with 70 per cent incorporation of roasted jackfruit flour vermicelli and 30 per cent roasted whole wheat flour vermicelli (T_1) had a higher mean score and mean rank score for the quality attributes namely appearance (8.79 and 4.07), colour (8.74 and 4.03), flavour (8.66 and 4.10), taste (8.66 and 3.97), texture (8.55 and 3.90) and overall acceptability (8.73 and 3.97). The lowest mean score of 8.42, 8.08, 8.35, 8.2, 8.26 and 8.26 for appearance, colour, flavour, taste, texture and overall acceptability was found in T_4.

Payasam with 70 per cent incorporation of roasted jackfruit flour vermicelli and 30 per cent roasted whole wheat flour vermicelli (T_1) had better mean score and mean rank score than control (T_0). Significant agreement (Kendall's value) among judges was observed for the different quality attributes of *payasam* prepared using roasted jackfruit and roasted wheat flour vermicelli.

Table 11. Mean scores for organoleptic evaluation of *payasam* prepared with roasted jackfruit flour and roasted wheat flour vermicelli

Treatments	Sensory parameters					
	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
T_0 (control)	8.53 (2.93)	8.68 (3.67)	8.33 (2.70)	8.46 (3.73)	8.35 (3.67)	8.51 (3.30)
T_1 (70% RJF: 30% WWF)	8.79 (4.07)	8.74 (4.03)	8.66 (4.10)	8.55 (3.90)	8.66 (3.97)	8.73 (3.97)
T_2 (60% RJF: 40% WWF)	8.46 (2.83)	8.28 (2.70)	8.46 (2.70)	8.31 (3.10)	8.35 (2.87)	8.53 (3.00)
T_3 (50% RJF: 50% WWF)	8.59 (2.93)	8.24 (2.57)	8.44 (2.87)	8.48 (2.50)	8.33 (2.63)	8.35 (2.47)
T_4 (40% RJF: 60% WWF)	8.42 (2.23)	8.08 (2.03)	8.35 (2.63)	8.26 (1.77)	8.2 (1.87)	8.26 (2.27)
Kendall's W	.207**	.324**	.179**	.388**	.358**	.210**

(RJF - Raw jackfruit flour, WWF- Whole wheat flour)
Value in parentheses is mean rank score based on Kendall's W
**Significance at 1 % level

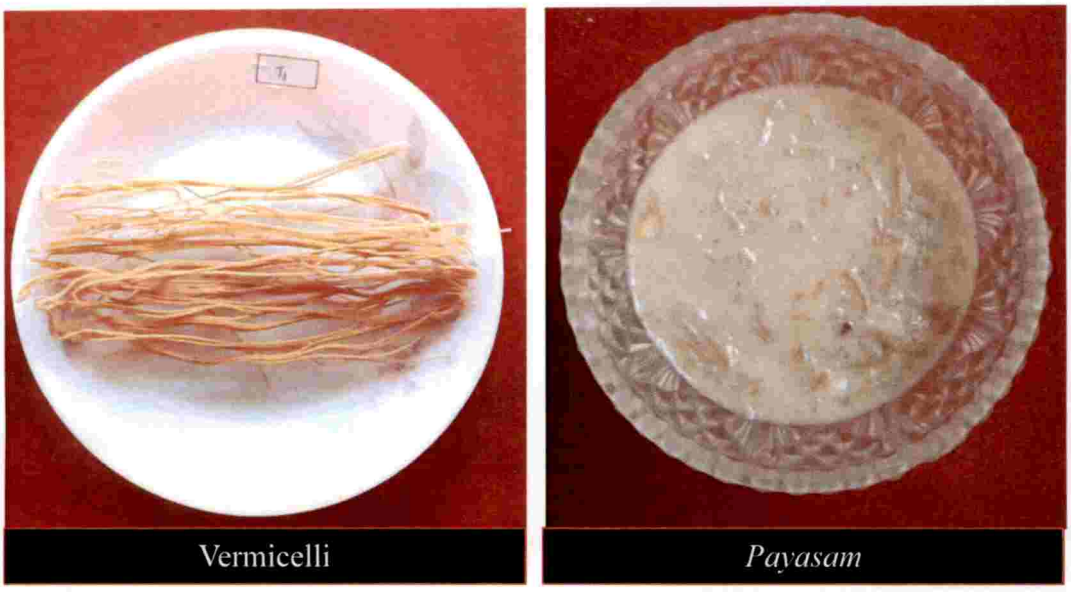

Plate 3. Raw jackfruit flour and jackfruit seed flour based vermicelli and *payasam*

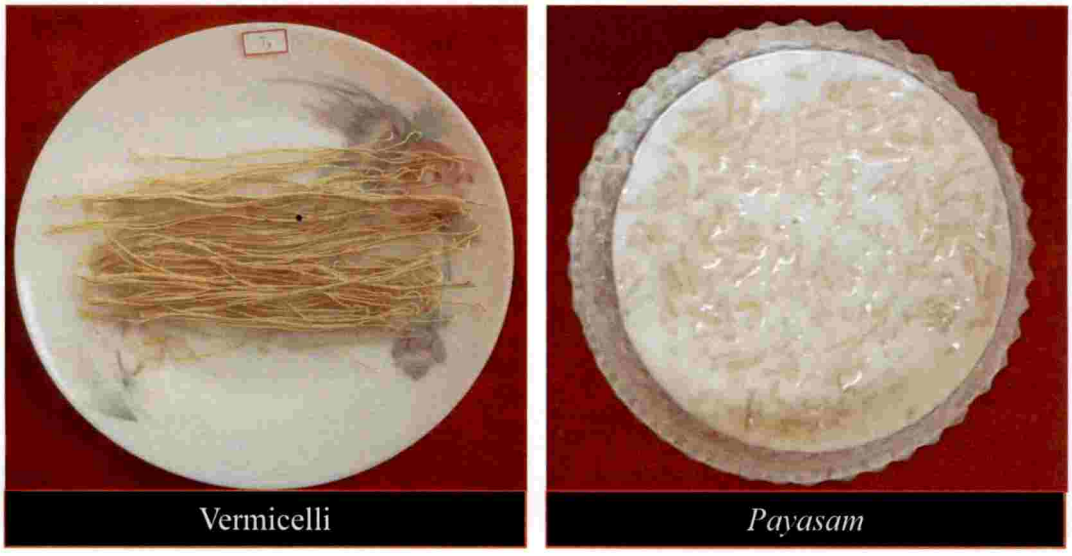

Plate 4. Roasted jackfruit flour and roasted whole wheat flour based vermicelli and *payasam*

4.1.5. Organoleptic evaluation of vermicelli prepared with roasted jackfruit flour and roasted rice flour

The mean score obtained for organoleptic attributes of roasted jackfruit flour and roasted whole wheat flour based vermicelli in comparison with control are presented in the table 12. The prepared vermicelli is represented in plate 5.

From the various treatments tried for the preparation of roasted jackfruit based vermicelli, the highest mean score for different quality attributes were noticed for T_2 (60 per cent roasted jackfruit flour with 40 per cent roasted rice flour) than other treatments. The mean score and mean rank score for T_2 was 8.48 (3.67), 8.24 (3.27), 8.36 (3.16), 8.48 (2.97), 8.36 (2.93) and 8.54 (3.86) for appearance, colour, flavour, texture, taste and overall acceptability respectively.

Compared to control (T_0) mean score for quality attributes of jackfruit based vermicelli was low except for appearance. Based on Kendall's value, there is significant agreement among judges for different quality attributes of vermicelli prepared using roasted jackfruit flour in combination with roasted rice flour.

Table 12. Mean scores for organoleptic evaluation of vermicelli prepared with roasted jackfruit flour and roasted rice flour

Treatments	Sensory parameters					
	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
T_0 (control)	8.4 (3.30)	8.48 (3.73)	8.28 (3.93)	8.55 (3.83)	8.66 (3.73)	8.58 (3.90)
T_1 (70% RJF: 30% RF)	8.00 (2.87)	8.02 (2.67)	7.75 (2.57)	8.31 (2.83)	8.35 (2.90)	7.84 (2.73)
T_2 (60% RJF: 40% RF)	8.48 (3.67)	8.24 (3.27)	8.36 (3.16)	8.48 (2.97)	8.36 (2.93)	8.54 (3.86)
T_3 (50% RJF: 50% RF)	7.97 (2.70)	7.88 (2.57)	7.75 (2.73)	8.46 (2.93)	8.33 (2.83)	7.77 (2.73)
T_4 (40% RJF: 60% RF)	7.68 (2.47)	7.86 (2.77)	7.66 (2.80)	8.26 (2.43)	8.2 (2.60)	7.68 (2.73)
Kendall's W	.102	.111	.146	.114	.090	.122

(RJF - Raw jackfruit flour, RF - Rice flour)
Value in parentheses is mean rank score based on Kendall's W
**Significance at 1 % level

4.1.5.1 Organoleptic evaluation of *payasam* prepared with roasted jackfruit flour and roasted rice flour vermicelli

The *payasam* prepared with roasted jackfruit flour and roasted rice flour vermicelli is presented in Plate 5. The organoleptic evaluation for the prepared vermicelli compared with control is depicted in Table 13.

Among the different treatments of roasted jackfruit based *payasam*, the highest mean score of 8.82 (3.97), 8.79 (4.17), 8.66 (4.13), 8.71 (4.03), 8.57 (3.80) and 8.73 (4.43) for appearance, colour, flavour, taste, texture and overall acceptability

was observed in T_2 (*payasam* prepared with 60 per cent roasted jackfruit flour with 40 per cent roasted rice flour vermicelli), whereas the lowest score was found in T_4 (*payasam* prepared with 40 per cent roasted jackfruit flour with 60 per cent roasted rice flour vermicelli).

The highest mean score and mean rank score for different sensory parameters was observed in jackfruit based vermicelli than control. Significant agreement (Kendall's value) among judges was observed for the different quality attributes of *payasam* prepared using roasted jackfruit and roasted rice flour vermicelli.

Table 13. Mean scores for organoleptic evaluation of *payasam* prepared with roasted jackfruit flour and roasted rice flour vermicelli

Treatments	Sensory parameters					
	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
T_0 (control)	8.53 (2.80)	8.73 (3.73)	8.33 (2.73)	8.57 (3.87)	8.68 (3.73)	8.4 (3.23)
T_1 (70% RJF: 30% RF)	8.46 (2.73)	8.28 (2.43)	8.35 (2.73)	8.35 (2.80)	8.37 (2.70)	8.4 (2.97)
T_2 (60% RJF: 40% RF)	8.82 (3.97)	8.79 (4.17)	8.66 (4.13)	8.57 (3.80)	8.71 (4.03)	8.73 (4.43)
T_3 (50% RJF: 50% RF)	8.28 (3.60)	8.33 (2.73)	8.39 (2.69)	8.33 (2.80)	8.28 (2.60)	8.28 (2.70)
T_4 (40% RJF: 60% RF)	8.24 (1.90)	8.11 (1.93)	8.33 (2.70)	8.11 (1.73)	8.13 (1.93)	8.06 (1.67)
Kendalls W	.324**	.427**	.189**	.383**	.381**	.468**

(RJF - Raw jackfruit flour, RF - Rice flour)
Value in parentheses is mean rank score based on Kendall's W
**Significance at 1 % level

4.1.6. Organoleptic evaluation of vermicelli prepared with roasted jackfruit flour and roasted jackfruit seed flour

The vermicelli prepared with roasted jackfruit flour and roasted jackfruit seed flour is exhibited in Plate 6. The organoleptic evaluation for the prepared vermicelli compared with control is presented in Table 14.

As observed in table 14, vermicelli prepared with 70 per cent roasted jackfruit flour and 30 per cent roasted jackfruit seed flour (T_1) had high mean score and mean rank score for appearance (8.53 and 2.07), colour (8.51 and 2.07), flavour (8.48 and 2.07), taste (8.4 and 2.03), texture (8.42 and 2.3) and overall acceptability (8.55 and 2.20) than T_2 (vermicelli prepared with 60 per cent jackfruit flour and 40 per cent jackfruit seed flour).

Compared to control (T_0), jackfruit seed flour incorporated vermicelli had high mean score and mean rank score for appearance and flavour. Based on Kendall's (W) value, significant agreement among judges was noted for the different quality attributes of vermicelli prepared using roasted jackfruit flour in combination with roasted jackfruit seed flour.

Table 14. Mean scores for organoleptic evaluation of vermicelli prepared with roasted jackfruit flour and jackfruit seed flour

Treatments	Sensory parameters					
	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
T_0 (control)	8.46 (1.97)	8.53 (2.13)	8.35 (2.00)	8.6 (2.37)	8.57 (2.37)	8.4 (1.97)
T_1 (70% RJF: 30% JSF)	8.53 (2.07)	8.51 (2.07)	8.48 (2.07)	8.42 (2.3)	8.4 (2.03)	8.55 (2.20)
T_2 (60% RJF: 40% JSF)	8.35 (1.97)	8.48 (180)	8.33 (1.93)	8.32 (1.70)	8.2 (1.60)	8.35 (1.83)
Kendalls W	.004**	.043**	.006**	.177**	.181**	.275**

(RJF - Roasted jackfruit flour, JSF- Roasted jackfruit seed flour)
Value in parentheses is mean rank score based on Kendall's W
**Significance at 1 % level

4.1.6.1 Organoleptic evaluation of *payasam* prepared with roasted jackfruit flour and roasted jackfruit seed flour vermicelli

The *payasam* prepared with roasted jackfruit flour and roasted jackfruit seed flour was given in Plate 6. The organoleptic evaluation for the prepared *payasam* compared with control is presented in Table 15.

The organoleptic evaluation shows that, *payasam* prepared with 70 per cent roasted jackfruit flour and 30 per cent roasted jackfruit seed flour (T_1) had high mean scores than *payasam* prepared with 60 per cent roasted jackfruit flour and 40 per cent roasted jackfruit seed flour (T_2) for all the sensory attributes namely appearance (8.44), colour (8.44), flavor (8.51), taste (8.6), texture (8.42) and overall acceptability (8.57). The mean score for different quality attributes of jackfruit based *payasam* were found to be lower than control. Significant agreement (Kendall's value) among

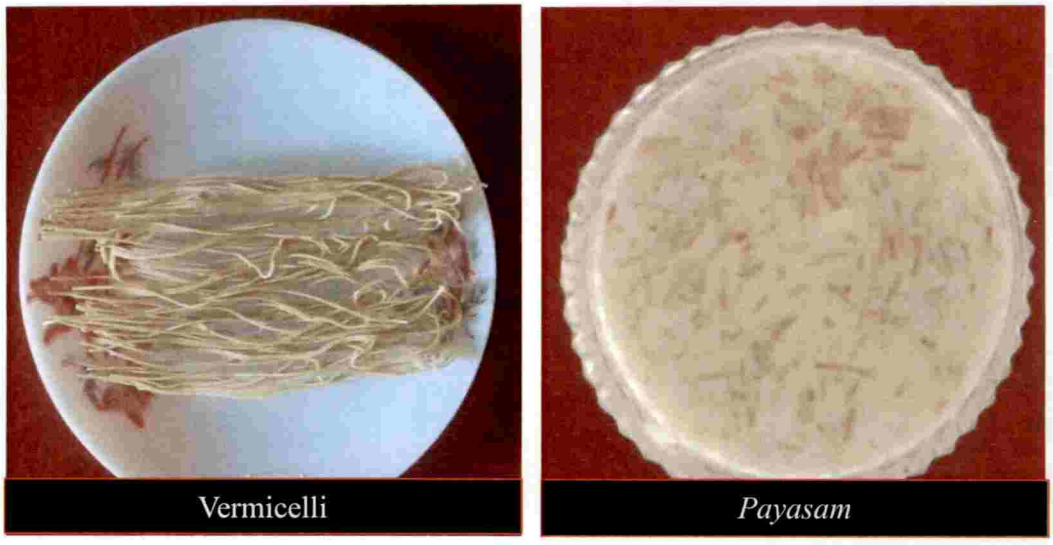

Plate 5. Roasted jackfruit flour and roasted rice flour based vermicelli and *payasam*

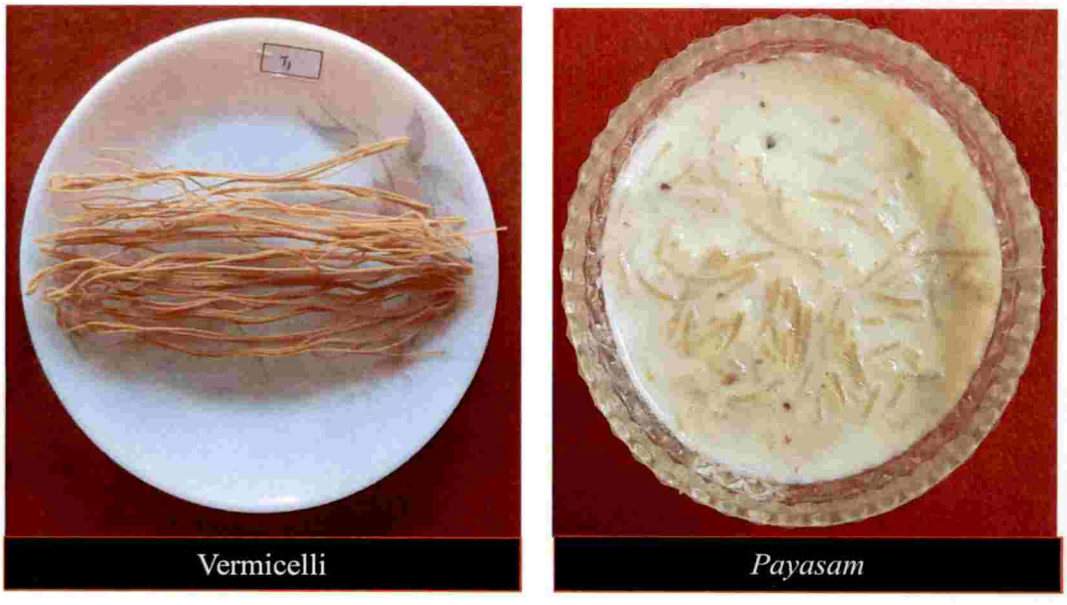

Plate 6. Roasted jackfruit flour and roasted jackfruit seed flour based vermicelli and *payasam*

judges was observed for different quality attributes of *payasam* prepared using raw jackfruit flour and jackfruit seed flour vermicelli.

Table 15. Mean scores for organoleptic evaluation of *payasam* prepared with roasted jackfruit flour and jackfruit seed flour vermicelli

Treatments	Sensory parameters					
	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
T_0 (control)	8.66 (2.20)	8.62 (2.47)	8.62 (2.23)	8.6 (2.40)	8.66 (2.33)	8.71 (2.33)
T_1 (70% RJF: 30% JSF)	8.44 (2.07)	8.44 (1.93)	8.51 (2.20)	8.42 (2.07)	8.6 (2.30)	8.57 (2.13)
T_2 (60% RJF: 40% JSF)	8.28 (1.50)	8.4 (1.60)	8.28 (1.57)	8.17 (1.53)	8.15 (1.37)	8.26 (1.53)
Kendalls W	.124**	.225**	.166**	.244**	.401**	.254**

(RJF - Roasted jackfruit flour, RF- Roasted rice flour)
Value in parentheses is mean rank score based on Kendall's W
**Significance at 1 % level

4.1.7. Comparison of vermicelli and *payasam* prepared from roasted and unroasted jackfruit flour

The vermicelli and *payasam* prepared with roasted and unroasted raw jackfruit flour, whole wheat flour, rice flour and jackfruit seed flour were compared statistically using Mann-Whitney U test and presented in Table 16 and 17.

As depicted in table 16, the mean rank score for colour (15.50), flavour (17), texture (16.25), taste (15.45) and overall acceptability (16.63) of roasted RJF+WWF vermicelli was found to be higher than unroasted jackfruit based vermicelli. There is

a significant difference between roasted and unroasted vermicelli (except for appearance).

The vermicelli prepared with roasted RJF+ RF obtained high mean rank score of 17, 14.75, 14.25, 17.75, 17 and 16 for the sensory attributes like appearance, colour, flavour, texture, taste and overall acceptability. As per Mann-Whitney test, the colour and flavour of roasted and unroasted vermicelli was not significant.

On comparing the roasted and unroasted RJF+JSF vermicelli, the highest mean rank score for appearance, colour, flavour, texture, taste and overall acceptability (7.83, 7.50, 8.75, 8.33, 8.75 and 9) was recorded in roasted jackfruit flour based vermicelli. No significant difference was observed in appearance and colour of the roasted and unroasted jackfruit and seed flour based vermicelli. From this table it is evident that roasting of flours improves the sensory attributes (appearance, colour, flavour, texture, taste and overall acceptability) of prepared jackfruit based vermicelli.

Table 16. Comparison of mean rank score of roasted and unroasted vermicelli

Parameters	RJF+WWF			RJF+RF			RJF+JSF		
	Unroasted	Roasted	U	Unroasted	Roasted	U	Unroasted	Roasted	U
Appearance	10.63	14.38	49.5^{NS}	8	17	18*	5.17	7.83	10^{NS}
Colour	9.50	15.50	36*	10.25	14.75	45^{NS}	5.50	7.50	12^{NS}
Flavour	8	17	18*	10.75	14.25	51^{NS}	4.25	8.75	4.5*
Texture	8.75	16.25	18*	7.25	17.75	9*	4.67	8.33	7*
Taste	9.55	15.45	34*	8	17	18*	4.25	8.75	4.5*
Overall acceptability	8.38	16.63	22.5*	9	16	30*	4	9	3*

Table 17. Comparison of mean rank score of roasted and unroasted vermicelli *payasam*

Parameters	RJF+WWF			RJF+RF			RJF+JSF		
	Unroasted	Roasted	U	Unroasted	Roasted	U	Unroasted	Roasted	U
Appearance	8.92	16.08	29*	9.83	15.17	40*	4.68	8.32	6.5*
Colour	10.33	14.67	46^{NS}	9	16	30*	4.67	8.33	7*
Flavour	10.42	14.58	47^{NS}	9.25	15.75	33*	6.25	6.75	16.5^{NS}
Texture	9.50	15.50	36*	9.83	15.17	40*	4.50	8.50	6*
Taste	8.75	16.25	27*	9.50	15.50	36*	4	8	9*
Overall acceptability	9.50	15.50	36*	9.33	15.65	34*	4.75	8.25	7.5*

RJF-raw jackfruit flour, WWF- whole wheat flour, RF- Rice flour, JSF- Jackfruit seed flour, U-Mann-Whitney U,

NS-not significant*Significant at 5% level

As observed in Table 17, *payasam* prepared with roasted RJF+ WWF, obtained high mean rank score of 16.08, 14.67, 14.58, 15.50, 16.25 and 15.50 for appearance, colour, flavour, texture, taste and overall acceptability. In case of colour and flavour, no significant difference was found in *payasam* prepared with roasted and unroasted flour.

The mean rank score for appearance (15.17), colour (16), flavour (15.75), texture (15.17), taste (15.50) and overall acceptability (15.65) of roasted RJF+ roasted RF *payasam* found to be higher than unroasted jackfruit based *payasam*. There is a significant difference between quality attributes of roasted and unroasted *payasam*.

On comparing the roasted and unroasted RJF+JSF *payasam*, the highest mean score for appearance, colour, flavour, texture, taste and overall acceptability (8.32, 8.33, 6.75, 8.50, 8 and 8.25) was recorded in roasted jackfruit flour based *payasam*. As per Mann-Whitney test, there is a significant difference between roasted and unroasted jackfruit based *payasam* except for appearance. The present study concluded that roasting of flours increases the quality attributes of jackfruit based *payasam*.

4.1.8. Selection of most acceptable jackfruit based vermicelli

The most acceptable jackfruit based vermicelli from 6 combinations was selected based on the organoleptic scores obtained for different quality attributes. The selected vermicelli along with control was stored for a period of 4 months for further studies. The selected vermicelli from each sets are presented in Table 18 (Plate 7).

Table 18. Selected combinations of jackfruit based vermicelli

Treatments	Combination
RJF+WWF	70% RJF:30% WWF
RJF+RF	60% RJF:40% RF
RJF+JSF	70% RJF:30% JSF
Roasted RJF+ roasted WWF	70% RJF:30% WWF
Roasted RJF+ roasted RF	60% RJF:40% RF
Roasted RJF+ roasted JSF	70% RJF:30% JSF

(RJF- Raw jackfruit flour, WWF- Whole wheat flour, RF- rice flour, JSF jackfruit seed flour)

4.2. Quality evaluation of selected jackfruit based vermicelli

The selected six combinations of jackfruit based vermicelli along with control (refined wheat flour vermicelli) were packed in polyethylene pouches of 250 gauge and kept in ambient condition for a period of four months. The quality evaluation of the stored vermicelli was assessed initially and during the second and fourth month.

4.2.1. Organoleptic qualities

The organoleptic evaluation of the selected jackfruit based vermicelli and control was assessed initially and during the second and fourth month of storage. The mean score for the organoleptic evaluation of selected vermicelli and *payasam* prepared is presented in Table 19 and 20.

4.2.1.1. Organoleptic evaluation of selected vermicelli on storage

The mean score for appearance of jackfruit based vermicelli initially varied from 8.20 (RJF+WWF) to 8.53 (roasted RJF + roasted JSF) which gradually decreased in second and fourth month of storage with a range of 8.18 (RJF+WWF) to

Plate 7. Selected vermicelli for storage

8.50 (roasted RJF + roasted JSF) and 8.15 (RJF+WWF) to 8.45 (roasted RJF + roasted JSF). The control (refined wheat flour vermicelli) initially had a score of 8.54 which decreased to 8.49 at the end of storage. In case of appearance, control had a higher score than jackfruit based vermicelli.

The colour of the jackfruit based vermicelli was observed to vary from 8.08 (RJF+WWF) to 8.51 (roasted RJF + roasted JSF) initially. During second and fourth month of storage vermicelli prepared with roasted RJF + roasted JSF was found to have high mean score of 8.50 and 8.47 whereas lowest mean score of 8.07 and 8.04 was seen in RJF+WWF based vermicelli.

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Table 19. Mean score for organoleptic evaluation of selected vermicelli during storage

Treatments	Appearance			Colour			Flavour		
	Initial	2nd month	4th month	Initial	2nd month	4th month	Initial	2nd month	4th month
Control	8.54	8.52	8.49	8.54	8.54	8.53	8.82	8.80	8.77
RJF + WWF	8.20	8.18	8.15	8.08	8.07	8.04	8.34	8.33	8.30
RJF + RF	8.28	8.25	8.20	8.17	8.15	8.12	8.30	8.27	8.24
RJF + JSF	8.40	8.36	8.31	8.35	8.33	8.28	8.33	8.30	8.25
Roasted RJF + Roasted WWF	8.35	8.33	8.28	8.26	8.25	8.20	8.35	8.34	8.32
Roasted RJF + Roasted RF	8.48	8.46	8.42	8.24	8.22	8.19	8.36	8.35	8.32
Roasted RJF +Roasted JSF	8.53	8.50	8.45	8.51	8.50	8.47	8.48	8.46	8.42

Treatments	Texture			Taste			Overall acceptability		
	Initial	2nd month	4th month	Initial	2nd month	4th month	Initial	2nd month	4th month
Control	8.5	8.45	8.41	8.45	8.41	8.38	8.57	8.54	8.49
RJF + WWF	7.86	7.83	7.79	7.91	7.88	7.85	7.86	7.83	7.78
RJF + RF	8.60	8.56	8.48	8.24	8.21	8.17	7.82	7.80	7.77
RJF + JSF	8.26	8.21	8.15	8.20	8.16	8.13	8.31	8.27	8.24
Roasted RJF + Roasted WWF	7.88	7.85	7.81	8.20	8.18	8.15	8.53	8.51	8.48
Roasted RJF + Roasted RF	8.48	8.43	8.38	8.36	8.32	8.28	8.52	8.50	8.46
Roasted RJF +Roasted JSF	8.42	8.39	8.32	8.40	8.36	8.31	8.55	8.53	8.49

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour

Table 20. Mean score for organoleptic evaluation of selected vermicelli based *payasam* during storage

Treatments	Appearance			Colour			Flavour		
	Initial	2nd month	4th month	Initial	2nd month	4th month	Initial	2nd month	4th month
Control	8.81	8.78	8.71	8.51	8.48	8.43	8.78	8.75	8.70
RJF + WWF	8.64	8.61	8.58	8.64	8.61	8.58	8.60	8.57	8.53
RJF + RF	8.75	8.72	8.69	8.73	8.69	8.65	8.62	8.56	8.54
RJF + JSF	8.35	8.31	8.27	8.37	8.36	8.32	8.31	8.30	8.27
Roasted RJF + Roasted WWF	8.79	8.75	8.71	8.74	8.71	8.68	8.66	8.62	8.60
Roasted RJF + Roasted RF	8.82	8.79	8.74	8.79	8.76	8.74	8.66	8.63	8.61
Roasted RJF +Roasted JSF	8.44	8.41	8.39	8.44	8.41	8.37	8.51	8.48	8.45

Treatments	Texture			Taste			Overall acceptability		
	Initial	2nd month	4th month	Initial	2nd month	4th month	Initial	2nd month	4th month
Control	8.62	8.59	8.53	8.72	8.69	8.63	8.85	8.81	8.77
RJF + WWF	8.51	8.48	8.44	8.48	8.43	8.38	8.68	8.64	8.60
RJF + RF	8.37	8.33	8.28	8.40	8.36	8.31	8.72	8.66	8.61
RJF + JSF	8.33	8.29	8.25	8.40	8.35	8.29	8.40	8.36	8.29
Roasted RJF + Roasted WWF	8.55	8.51	8.45	8.66	8.62	8.57	8.73	8.67	8.62
Roasted RJF + Roasted RF	8.57	8.53	8.48	8.71	8.67	8.63	8.57	8.55	8.50
Roasted RJF +Roasted JSF	8.42	8.38	8.33	8.60	8.56	8.51	8.57	8.55	8.49

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour

The highest mean score for flavour of jackfruit based vermicelli initially was 8.48 in roasted RJF + roasted JSF vermicelli and lowest in RJF + RF vermicelli of 8.30. During second and fourth month of storage vermicelli prepared with roasted RJF + roasted JSF was highest with the mean score of 8.46 and 8.42 whereas lowest in RJF + RF vermicelli of 8.27 and 8.24.

The texture and taste of jackfruit based vermicelli varied from 7.86 to 8.60 and 7.91 to 8.40 (initially), 7.83 to 8.56 and 7.88 to 8.36 (second month), 7.79 to 8.48 and 7.85 to 8.31(fourth month). The vermicelli prepared with RJF + RF had highest mean score for texture whereas in case of taste the highest value was observed in roasted RJF + roasted JSF vermicelli.

The overall acceptability was high in roasted RJF + roasted JSF vermicelli (8.55, 8.53 and 8.49) and lowest in RJF+RF vermicelli (8.52, 8.50 and 8.46) during initial, second and fourth month of storage. The result of the study show that control vermicelli had a high mean score than jackfruit based vermicelli for all the sensory parameters. During storage the mean score gradually decreased but maintained an acceptable level throughout storage.

4.2.1.2. Organoleptic evaluation of *payasam* prepared from selected vermicelli on storage

The sensory evaluation of *payasam* prepared with jackfruit vermicelli and control was carried out initially and during the second and fourth month of storage. Initially mean score for organoleptic evaluation of *payasam* varied from 8.35 to 8.82 (appearance), 8.37 to 8.79 (colour), 8.31 to 8.66 (flavour), 8.33 to 8.57 (texture), 8.40 to 8.71 (taste) and 8.40 to 8.73 (overall acceptability). Among the jackfruit vermicelli *payasam,* roasted RJF + roasted RF was found have a highest mean score of 8.82 for appearance, 8.79 for colour, 8.66 for flavour, 8.57 for texture, 8.71 for taste and 8.73

for overall acceptability which was lower than control except for appearance and colour.

The mean score for organoleptic evaluation decreased with further months of storage. During second month, the mean score for appearance, colour, flavour, texture, taste and overall acceptability for *payasam* prepared from selected vermicelli varied from 8.31 to 8.79, 8.36 to 8.76, 8.30 to 8.63, 8.29 to 8.53, 8.35 to 8.67 and 8.36 to 8.68, where a highest mean score was observed in roasted RJF + roasted RF vermicelli *payasam* and lowest in RJF + JSF vermicelli *payasam*. The mean score for control was highest for flavour (8.75), texture (8.59), taste (8.69) and overall acceptability (8.81), whereas appearance (8.78), colour (8.48) was lower than roasted RJF + roasted RF vermicelli *payasam.*

During fourth month of storage the *payasam* prepared with roasted RJF + roasted RF vermicelli was found to have highest mean score for appearance (8.74), colour (8.74), flavour (8.61), texture (8.48), taste (8.63) and overall acceptability (8.63) followed by roasted RJF + roasted WWF vermicelli *payasam* of 8.71(appearance), 8.68 (colour), 8.60 (flavour), 8.45 (texture), 8.57 (taste) and 8.62 (overall acceptability). Jackfruit vermicelli *payasam* (roasted RJF + roasted RF) was found to have highest score for appearance and colour than control.

4.2.2. Nutritional qualities

The nutritional qualities of selected combinations of jackfruit based vermicelli in comparison with control were evaluated initially and during the second and fourth month of storage. The details are as follows.

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4.2.2.1. Moisture

The moisture content of six combinations of jackfruit based vermicelli and control are presented in Table 21.

Initially among all the treatments, moisture content was found to be high in control vermicelli (7.75%) and lowest in vermicelli prepared with roasted jackfruit flour and roasted whole wheat flour (7.15%). During second and fourth month moisture content was found to be highest in control, which was 7.78% and 7.82% respectively and lowest in vermicelli prepared with roasted jackfruit flour and roasted whole wheat flour of 7.18% and 7.22% respectively. During second and fourth month moisture content of vermicelli prepared from RJF + WWF (7.58% and 7.61%) was on par with vermicelli prepared RJF + RF (7.61% and 7.65%), and vermicelli prepared from roasted RJF + roasted WWF (7.18% and 7.22%) was on par with roasted RJF + roasted RF (7.21% and 7.25%) and roasted RJF + roasted JSF (7.23% and 7.28%). The relative change was observed to more in vermicelli prepared with roasted jackfruit flour and roasted jackfruit seed flour (0.69%) during second and fourth month of storage. The effect of changes in moisture was observed to have a significant difference between control and jackfruit (both roasted and unroasted flours) based vermicelli.

Table 21. Moisture content of the selected jackfruit based vermicelli and control on storage

Treatments	Moisture (%)		
	Initial	2nd month	4th month
Control	7.75[a]	7.78[a] (0.38)	7.82[a] (0.51)
RJF + WWF	7.53[ab]	7.58[b] (0.66)	7.61[b] (0.39)
RJF + RF	7.57[a]	7.61[b] (0.52)	7.65[b] (0.52)
RJF + JSF	7.62[a]	7.64[ab] (0.26)	7.67[b] (0.39)
Roasted RJF + Roasted WWF	7.15[c]	7.18[c] (0.41)	7.22[c] (0.55)
Roasted RJF + Roasted RF	7.17[bc]	7.21[c] (0.551)	7.25[c] (0.554)
Roasted RJF +Roasted JSF	7.18[c]	7.23[c] (0.69)	7.28[c] (0.69)
C.D (0.05)	0.266*	0.156*	0.123*
Significance	S	S	S

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour

Figure in parenthesis indicates per cent relative change over the previous month

Values with same alphabet for different treatments represented in each column form a homogenous group

4.2.2.2. Energy

The energy content in selected jackfruit based vermicelli was compared with control as detailed in Table 22.

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Table 22. Energy content of the selected jackfruit based vermicelli and control on storage

Treatments	Energy		
	Initial	2nd month	4th month
Control	321.2[a]	319.89[a] (0.40)	317.08[a] (0.87)
RJF + WWF	267.02[d]	266.42[d] (0.22)	262.54[de] (1.45)
RJF + RF	274.32[cd]	273.59[d] (3.90)	269.23[e] (1.65)
RJF + JSF	280.52[c]	270.74[c] (3.48)	266.46[cd] (1.58)
Roasted RJF + Roasted WWF	275.32[cd]	267.03[e] (6.64)	262.93[f] (1.59)
Roasted RJF + Roasted RF	280.28[b]	277.33[b] (3.08)	276.07[b] (1.89)
Roasted RJF +Roasted JSF	282.64[bc]	279.27[c] (3.31)	277.63[c] (1.70)
C.D (0.05)	8.360*	4.238*	5.434*
Significance	S	S	S

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour

Figure in parenthesis indicates per cent relative change over the previous month

Values with same alphabet for different treatments represented in each column form a homogenous group

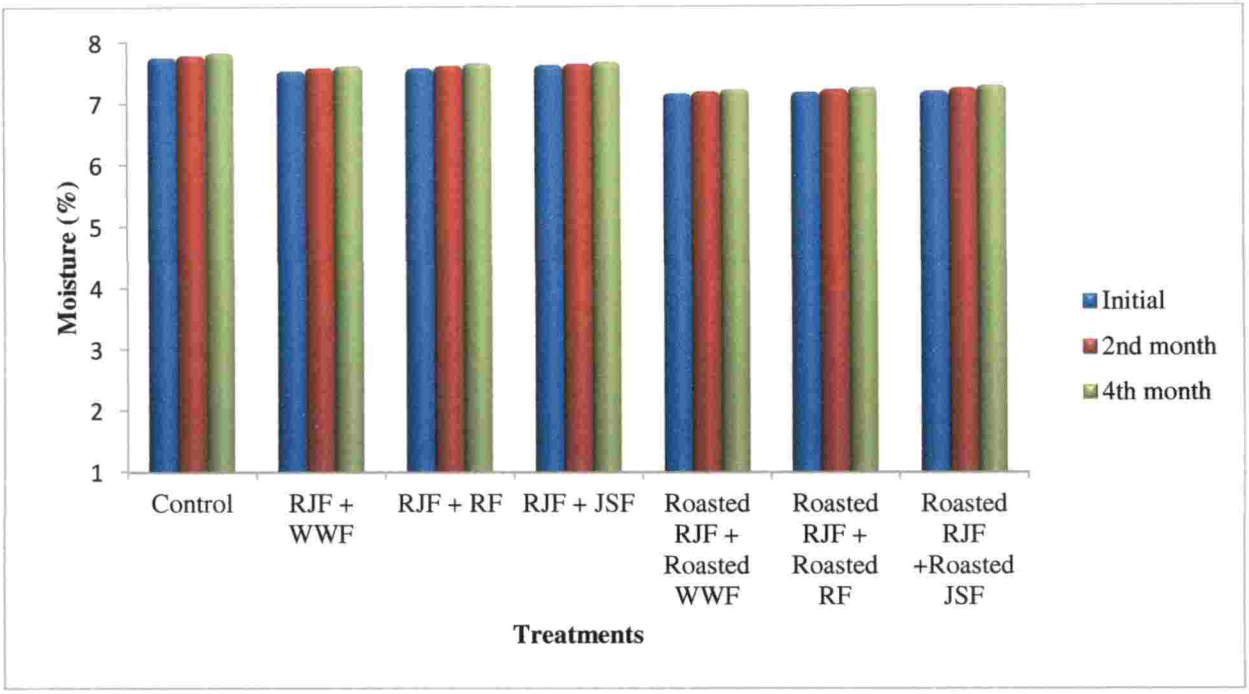

Fig. 1 Moisture content of the selected jackfruit based vermicelli and control on storage

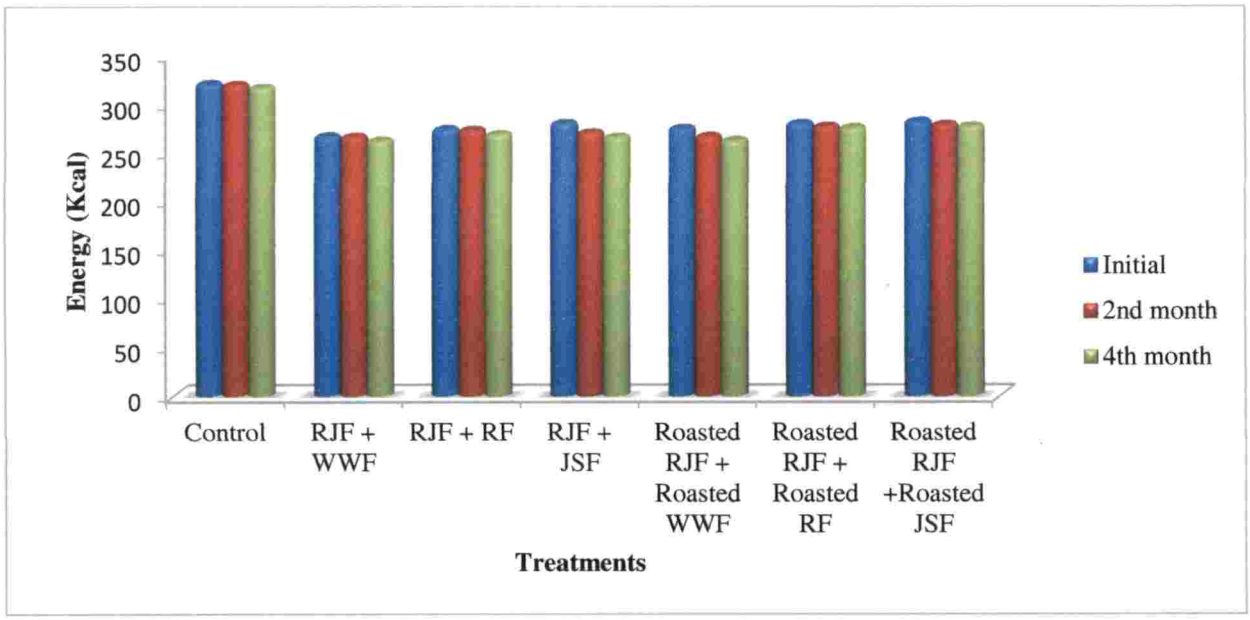

Fig. 2 Energy content of the selected jackfruit based vermicelli and control on storage

The energy content of the prepared vermicelli was found to vary from 267.02 to 321.2 Kcal initially. The energy value observed a decreasing trend from initial to the fourth month of storage. On 4th month of storage energy content of jackfruit based vermicelli found to be least of 262.54 (RJF + WWF) to 277.63Kcal (Roasted RJF + Roasted JSF). The highest and lowest value was observed in control and vermicelli prepared from RJF + WWF throughout the storage. As per DMRT, there was a significant variation between control and jackfruit based vermicelli. The highest relative change of 6.64 was observed in vermicelli from roasted RJF + roasted WWF on second month of storage. From the table it is evident that vermicelli prepared from roasted flour exhibits high calorific value than vermicelli prepared from raw flour.

4.2.2.3. Carbohydrate

The carbohydrate content of six combinations of jackfruit based vermicelli and control is presented in Table 23.

The initial carbohydrate content of jackfruit based vermicelli prepared with different combinations was 61.45g 100 g^{-1}, 62.29g 100 g^{-1}, 63.03g 100 g^{-1}, 61.94g 100 g^{-1}, 62.79g 100 g^{-1} and 63.73g 100 g^{-1} which gradually decreased to 59.18g 100 g^{-1}, 61.02g 100 g^{-1}, 61.15g 100 g^{-1}, 59.71g 100 g^{-1}, 61.90g 100 g^{-1} and 62.13g 100 g^{-1} during the 4th month of storage. The carbohydrate content of control vermicelli was higher than jackfruit based vermicelli throughout the storage. The relative change was observed to more in treatment, roasted RJF + roasted WWF (2.36) and RJF + WWF (2.15) during second and fourth month of storage. Table 21 revealed the carbohydrate content was more in vermicelli prepared from roasted jackfruit flour than unroasted flours.

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Table 23. Carbohydrate content of selected jackfruit based vermicelli and control on storage

Treatments	Carbohydrate (g 100g $^{-1}$)		
	Initial	2nd month	4th month
Control	78.10^{a}	77.85^{a} (0.31)	77.21^{a} (0.83)
RJF + WWF	61.45^{d}	60.49^{d} (1.56)	59.18^{c} (2.15)
RJF + RF	62.29^{cd}	61.18^{cd} (1.77)	61.02^{b} (0.27)
RJF + JSF	63.03^{bc}	62.43^{bc} (0.95)	61.15^{b} (2.05)
Roasted RJF + Roasted WWF	61.94^{cd}	60.48^{d} (2.36)	59.71^{c} (1.2)
Roasted RJF + Roasted RF	62.79^{bc}	62.06^{bcd} (1.15)	61.90^{b} (0.25)
Roasted RJF +Roasted JSF	63.73^{b}	63.49^{b} (0.43)	62.13^{b} (2.14)
C.D (0.05)	1.240*	1.805*	1.304*
Significance	S	S	S

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour

Figure in parenthesis indicates per cent relative change over the previous month

Values with same alphabet for different treatments represented in each column form a homogenous group

4.2.2.4. Protein

The protein content in selected jackfruit based vermicelli was compared with control as detailed in Table 24.

Among all treatments, protein was found to be highest of 3.78g 100g $^{-1}$ in raw jackfruit and jackfruit seed flour vermicelli followed by roasted jackfruit and roasted jackfruit seed flour vermicelli (3.42g 100g $^{-1}$) and least value of 1.30g 100g $^{-1}$ was observed in control. During second and fourth month, protein content of jackfruit vermicelli decreased to a range of 2.06 g 100g^{-1} to 3.69g 100g^{-1} and 2.02g 100g^{-1} to

3.66g 100 g^{-1} respectively. Vermicelli prepared with RJF + WWF and roasted RJF + roasted WWF, RJF + RF and roasted RJF + roasted RF was on par initially and during the second and fourth month of storage. The study also revealed that the protein content was slightly decreased in vermicelli prepared from roasted jackfruit flour compared with raw jackfruit flour vermicelli. There was a significant difference in the protein content among all the treatments during initial, second and fourth month on storage with C.D value of 0.347, 0.121 and 0.107.

Table 24. Protein content of the selected jackfruit based vermicelli and control on storage

Treatments	Protein (g $100g^{-1}$)		
	Initial	2nd month	4th month
Control	1.30^{e}	1.27^{e} (1.79)	1.25^{f} (2.08)
RJF + WWF	2.74^{c}	2.73^{c} (0.36)	2.69^{c} (1.46)
RJF + RF	2.24^{d}	2.07^{d} (7.29)	2.02^{d} (5.9)
RJF + JSF	3.78^{a}	3.69^{a} (2.38)	3.66^{a} (0.81)
Roasted RJF + Roasted WWF	2.70^{c}	2.64^{c} (2.2)	2.61^{c} (1.13)
Roasted RJF + Roasted RF	2.08^{d}	2.06^{d} (0.96)	2.02^{e} (1.94)
Roasted RJF +Roasted JSF	3.42^{b}	3.34^{b} (2.33)	3.28^{b} (1.79)
C.D (0.05)	0.347*	0.121*	0.107*
Significance	S	S	S

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour

Figure in parenthesis indicates per cent relative change over the previous month

Values with same alphabet for different treatments represented in each column form a homogenous group

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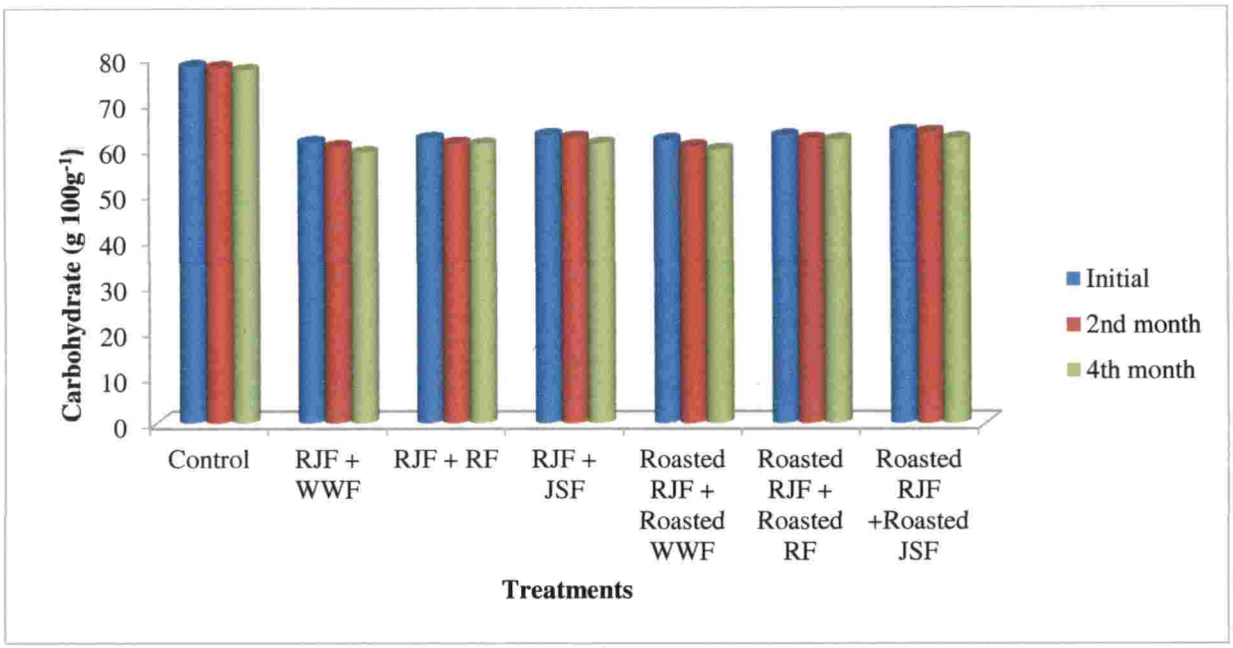

Fig. 3 Carbohydrate content of selected jackfruit based vermicelli and control on storage

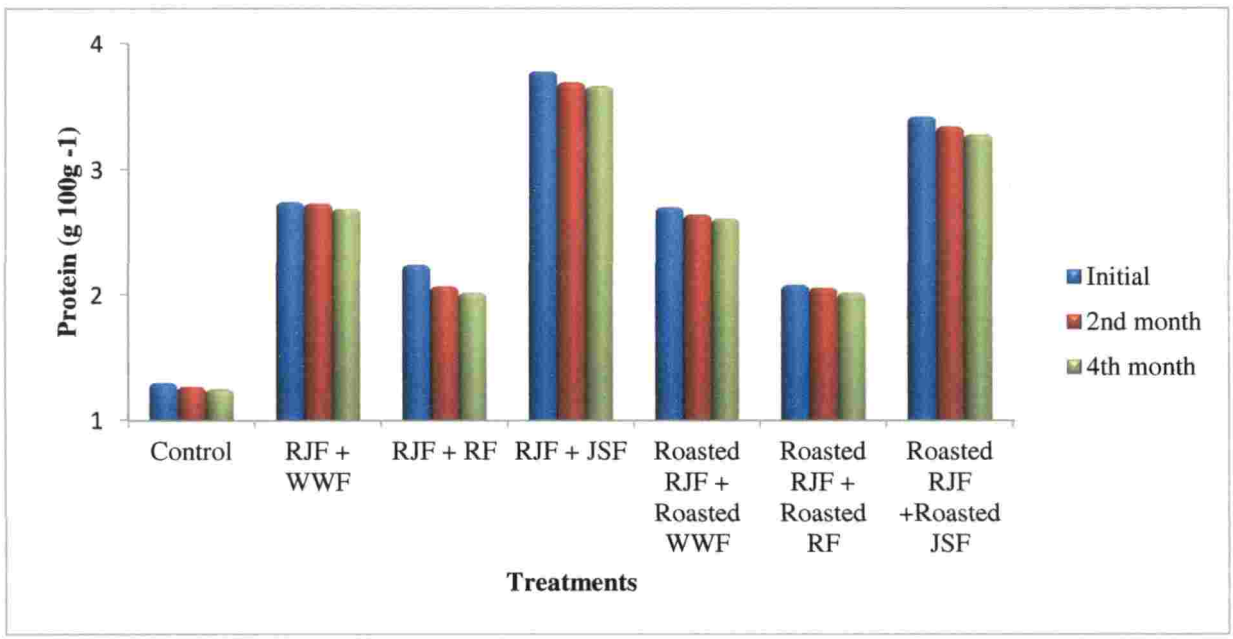

Fig. 4 Protein content of the selected jackfruit based vermicelli and control on storage

4.2.2.5. Total fat

The fat content present in selected jackfruit vermicelli with control were estimated and presented in the Table 25.

Table 25 reveal that there was decrease in fat content for all the treatment during storage. Initially the fat content present in jackfruit based vermicelli varied from 0.80 to 1.88g 100^{-1}, during second and fourth month of storage there was gradual decrease in fat content ranges from 0.69 to 1.76g 100^{-1} and 0.63 to 1.7g 100^{-1}. The highest and lowest fat content was observed in vermicelli prepared with RJF + WWF and roasted RJF + roasted JSF initially and during storage. The control vermicelli had low fat content of 0.40 (initial), 0.37(2^{nd} month) and 0.36g 100^{-1} (4^{th} month) than jackfruit based vermicelli. The fat content was significantly decreased during roasting and storage period. The relative difference was observed to be high in roasted RJF + roasted JSF vermicelli (13.75) and roasted RJF + roasted WWF vermicelli (33). There was a significant variation among all the treatments during initial, second and fourth month of storage.

Table 25. Fat content of selected jackfruit based vermicelli and control on storage

Treatments	Fat (g $100g^{-1}$)		
	Initial	2nd month	4th month
Control	0.40^{e}	0.37^{e} (6.6)	0.36^{d} (3.57)
RJF + WWF	1.88^{a}	1.76^{a} (6.38)	1.7^{a} (3.4)
RJF + RF	1.80^{a}	1.70^{a} (5.37)	1.63^{a} (4.3)
RJF + JSF	1.00^{c}	0.90^{c} (10)	0.86^{bc} (4.4)
Roasted RJF + Roasted WWF	1.20^{b}	1.14^{b} (5)	0.757^{bc} (33)
Roasted RJF + Roasted RF	1.20^{b}	1.13^{b} (5.83)	1.03^{b} (8.8)
Roasted RJF +Roasted JSF	0.80^{d}	0.69^{d} (13.75)	0.630^{cd} (8.69)
C.D (0.05)	0.178*	0.080*	0.369*
Significance	S	S	S

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour

Figure in parenthesis indicates per cent relative change over the previous month

Values with same alphabet for different treatments represented in each column form a homogenous group

4.2.2.6. Fibre

The changes in the fibre content of selected vermicelli during storage are tabulated in Table 26.

Table 26. Fibre content of the selected jackfruit based vermicelli and control on storage

Treatments	Fibre (g 100g $^{-1}$)		
	Initial	2nd month	4th month
Control	0.67^{f}	0.59^{f} (11.90)	0.51^{f} (12.9)
RJF + WWF	2.8^{d}	2.74^{d} (2.14)	2.71^{d} (1.09)
RJF + RF	2.2^{e}	2.18^{e} (0.90)	2.09^{e} (4.12)
RJF + JSF	3.13^{b}	3.05^{b} (2.44)	2.93^{b} (4.03)
Roasted RJF + Roasted WWF	2.9^{c}	2.84^{c} (2.06)	2.81^{c} (1.05)
Roasted RJF + Roasted RF	2.84^{cd}	2.79^{cd} (1.90)	2.76^{cd} (1.07)
Roasted RJF +Roasted JSF	3.89^{a}	3.82^{a} (1.79)	3.76^{a} (1.57)
C.D (0.05)	0.062*	0.070*	0.059*
Significance	S	S	S

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF-Jackfruit seed flour

Figure in parenthesis indicates per cent relative change over the previous month

Values with same alphabet for different treatments represented in each column form a homogenous group

As observed in Table 26, the fibre content was found to be the highest in roasted jackfruit and roasted seed flour based vermicelli with a value of 3.89g 100g $^{-1}$, and the lowest in control (0.67g 100g $^{-1}$). During second month and fourth month of storage, vermicelli prepared with roasted RJF + roasted JSF had a high fibre content

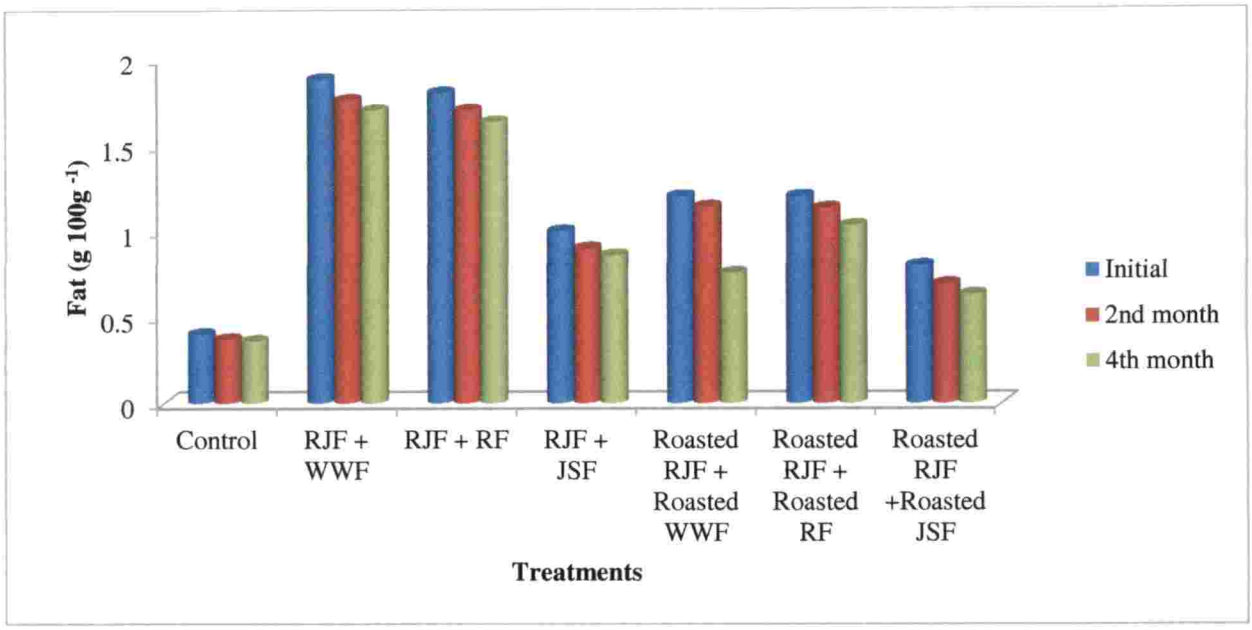

Fig. 5 Fat content of selected jackfruit based vermicelli and control on storage

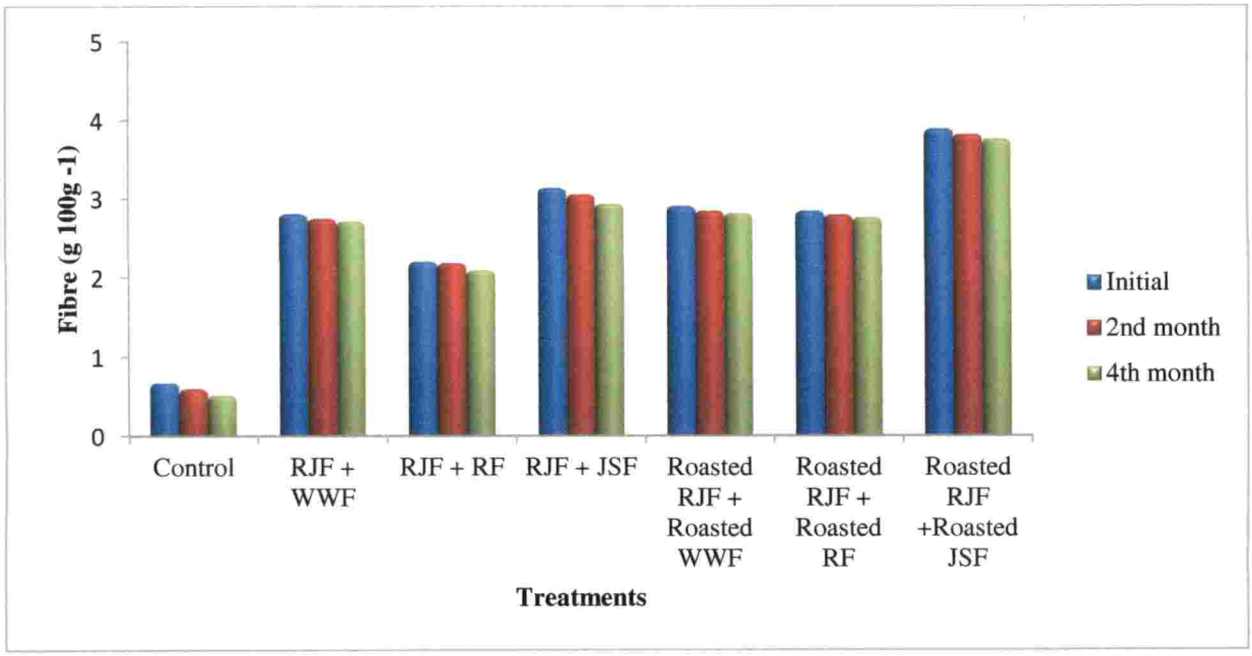

Fig. 6 Fibre content of the selected jackfruit based vermicelli and control on storage

of 3.82 and 3.76g 100g $^{-1}$ whereas control obtained a lowest value of 0.59 and 0.51g 100g $^{-1}$.

The fibre content of vermicelli decreased during storage period. Vermicelli prepared with roasted flour observed to be high in fibre content compared to vermicelli prepared with unroasted flours. There was a significant difference in the fibre content among all the treatments during initial, second and fourth month of storage with C.D value of 0.062, 0.070 and 0.059.

4.2.2.7. Starch

The starch content present in selected jackfruit based vermicelli along with control are detailed in Table 27.

Table 27. Starch content of the selected jackfruit based vermicelli and control on storage

Treatments	Starch (g 100g $^{-1}$)		
	Initial	2nd month	4th month
Control	83.48^{e}	82.57^{f} (1.08)	82.57^{d} (0.04)
RJF + WWF	85.70^{c}	84.93^{e} (0.89)	83.99^{cd} (1.10)
RJF + RF	86.34^{c}	85.53^{c} (0.93)	84.63^{c} (1.05)
RJF + JSF	96.17^{a}	95.17^{a} (1.03)	94.29^{a} (0.92)
Roasted RJF + Roasted WWF	84.40^{d}	82.54^{g} (1.05)	79.67^{e} (1.05)
Roasted RJF + Roasted RF	85.60^{c}	85.21^{d} (0.45)	84.96^{c} (0.29)
Roasted RJF +Roasted JSF	93.20^{b}	92.4^{b} (0.85)	91.64^{b} (0.74)
C.D (0.05)	1.323*	0.260*	1.615*
Significance	S	S	S

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour

Figure in parenthesis indicates per cent relative change over the previous month

Values with same alphabet for different treatments represented in each column form a homogenous group

Initially starch content of jackfruit based selected vermicelli varied from 84.40 to 96.17g 100g $^{-1}$ which is higher than control (83.48 g 100g $^{-1}$). During second and fourth month of storage jackfruit based vermicelli varied from 82.54 to 95.17 g 100g $^{-1}$ and 79.67 to 94.29 g 100g $^{-1}$. The starch content declined in all treatments on storage. The starch content present in selected vermicelli have a significant difference between all the treatments during initial, second and fourth month of storage. The vermicelli prepared from unroasted jackfruit flour was found to be high compared to roasted jackfruit flour vermicelli. As per DMRT there was a significant variation between control and jackfruit based vermicelli. Among the jackfruit based vermicelli, initially the treatment RJF+WWF was on par with RJF+RF and roasted RJF+ roasted RF.

4.2.1.8. Total soluble solids (TSS)

The TSS of the selected jackfruit based vermicelli in comparison with control was analysed using hand refractometer and presented in Table 28.

As observed in Table 28, TSS content of the jackfruit incorporated vermicelli varied from 6 to 6.4^0 brix, 6.20 to 6.60^0 brix and 6.40 to 6.90^0 brix during initial, second and fourth month of storage . On comparing all the treatments, control was found to have highest in TSS content of 10 (initial), 10.60 (second month) and 10.90^0 brix (fourth month). Vermicelli prepared from unroasted jackfruit flours observed the lowest TSS when compared to vermicelli prepared from roasted jackfruit flours. The relative change was observed to be high in vermicelli prepared with roasted jackfruit flour and roasted jackfruit seed flour (4.76 and 4.5) during second and fourth month of storage. All the treatment had significant difference in TSS content with the CD value of 0.162, 0.259 and 0.466 respectively.

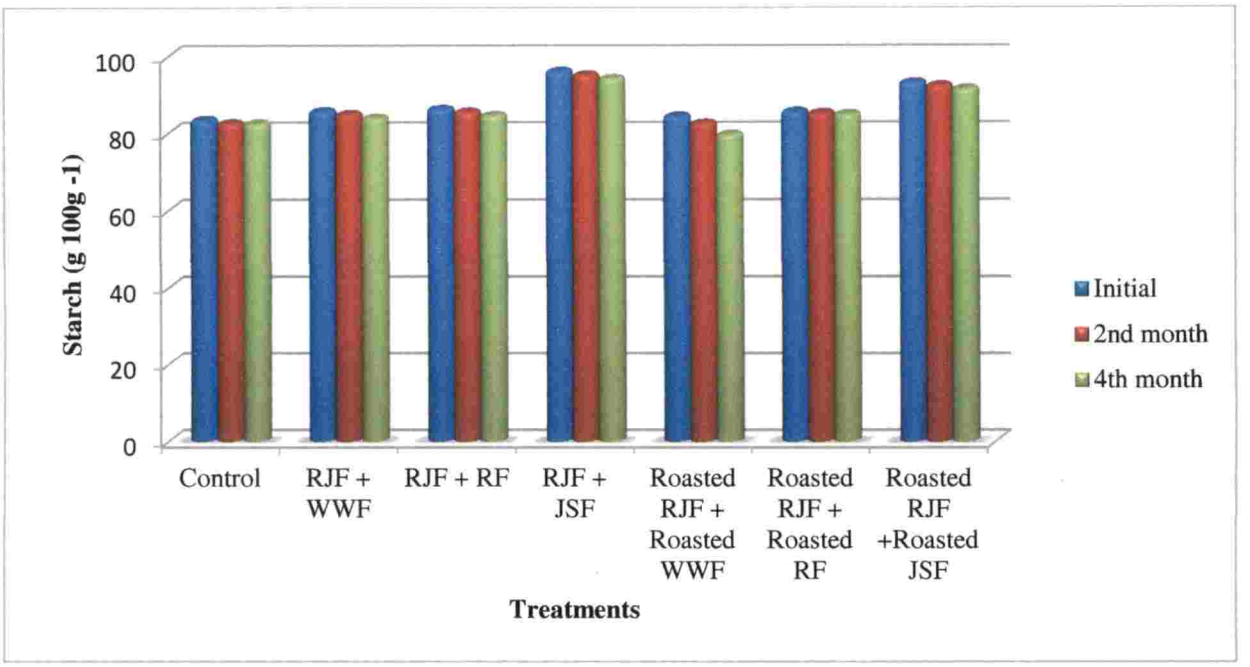

Fig. 7 Starch content of the selected jackfruit based vermicelli and control on storage

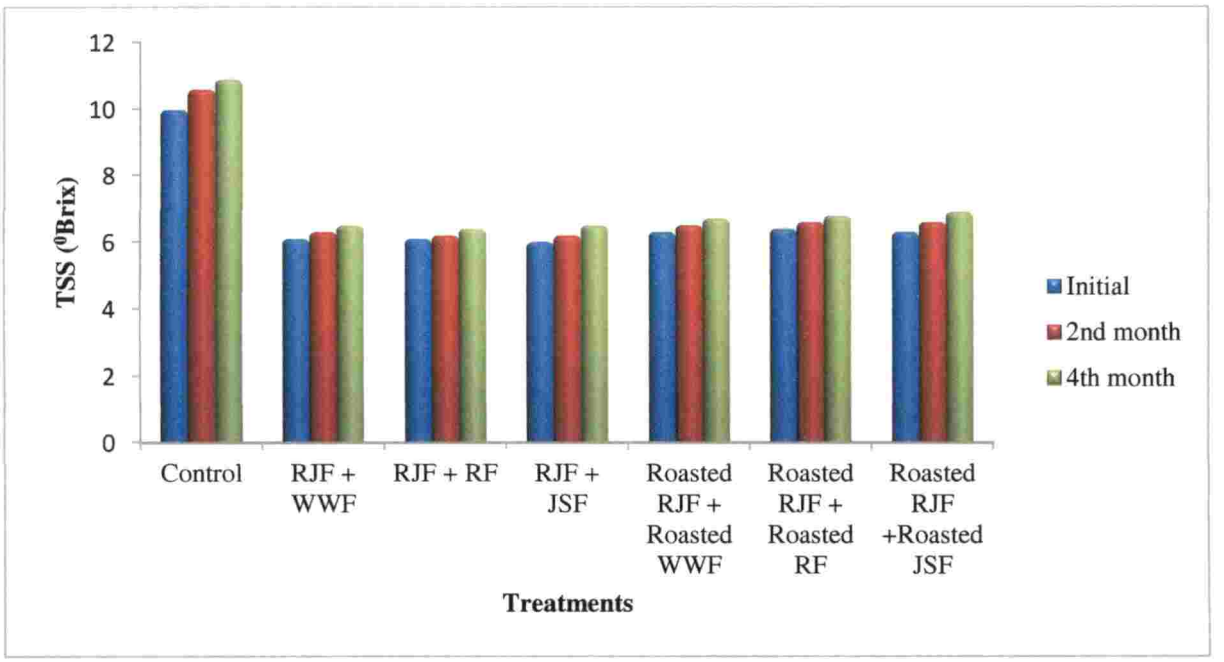

Fig. 8 TSS content of the selected jackfruit based vermicelli and control on storage

Table 28. TSS content of the selected jackfruit based vermicelli and control on storage

Treatments	TSS (^{0}Brix)		
	Initial	2nd month	4th month
Control	10[a]	10.6[a] (6.00)	10.90[a] (2.83)
RJF + WWF	6.10[c]	6.30c[d] (3.20)	6.50[bc] (3.17)
RJF + RF	6.10[c]	6.20[d] (1.60)	6.40[c] (3.22)
RJF + JSF	6.00[c]	6.20[d] (3.30)	6.50[bc] (4.08)
Roasted RJF + Roasted WWF	6.30[b]	6.50[c] (3.17)	6.70[bc] (3.07)
Roasted RJF + Roasted RF	6.40[b]	6.60[b] (3.12)	6.80[bc] (3.03)
Roasted RJF +Roasted JSF	6.30[b]	6.60[b] (4.76)	6.90[b] (4.50)
C.D (0.05)	0.162	0.259	0.466
Significance	S	S	S

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour

Figure in parenthesis indicates per cent relative change over the previous month

Values with same alphabet for different treatments represented in each column form a homogenous group

4.2.2.9. Reducing sugar

Table 29 revealed the percentage of reducing sugar in selected vermicelli during the storage. Reducing sugar content was found to highest in control (4.12%) followed by roasted RJF + roasted WWF (2.34%) during initial month of storage. During fourth month of storage reducing sugar content varied from 1.75 to 4.17%. There was gradual increase in the per cent of reducing sugar during storage. Among

the jackfruit based vermicelli, RJF + WWF was on par with RJF +RF and vermicelli from roasted RJF + roasted WWF on par with roasted RJF + roasted WWF during the entire storage period whereas RJF + WWF and RJF + JSF were on par during initial month. The reducing sugar content was more in vermicelli prepared with roasted jackfruit flour than unroasted jackfruit flour. All the treatments showed a significant difference in TSS content with the CD value of 0.197, 0.068 and 0.066.

Table 29. Reducing sugar content of the selected jackfruit based vermicelli and control on storage

Treatments	Reducing sugar (%)		
	Initial	2nd month	4th month
Control	4.12[a]	4.15[a] (0.72)	4.17[a] (0.48)
RJF + WWF	1.7[d]	1.79[d] (5.29)	1.90[d] (6.14)
RJF + RF	1.66[d]	1.74[d] (4.81)	1.86[d] (6.89)
RJF + JSF	1.56[d]	1.66[e] (6.41)	1.75[e] (5.42)
Roasted RJF + Roasted WWF	2.34[b]	2.49[b] (6.41)	2.57[b] (3.34)
Roasted RJF + Roasted RF	2.30[b]	2.45[b] (6.5)	2.57[b] (4.89)
Roasted RJF +Roasted JSF	2.07[c]	2.17[c] (4.9)	2.28[c] (5.09)
C.D (0.05)	0.197*	0.068*	0.066*
Significance	S	S	S

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour

Figure in parenthesis indicates per cent relative change over the previous month

Values with same alphabet for different treatments represented in each column form a homogenous group

4.2.2.10. Total sugar

The total sugar content was estimated for the selected combination of vermicelli and control presented in the Table 30. Among all the treatments, total

sugar content (initial) was high in control with 4.43% followed by Roasted RJF + Roasted RF with 3.78%. The total sugar content of vermicelli prepared with RJF + WWF and RJF + RF was on par during initial and second month of storage. During second and fourth month of storage highest total sugar content was shown in control (4.45% and 4.51%). Among the jackfruit based vermicelli, total sugar was found to be high in roasted RJF + roasted RF (3.86 %and 3.91%) with respective of second and fourth month of storage. The total sugar content increased for all treatments on storage. The result of the study showed that unroasted jackfruit flour based vermicelli exhibited low total sugar than roasted jackfruit flour vermicelli. As per DMRT there was a significant variation between control and jackfruit based vermicelli.

Table 30. Total sugar content of the selected jackfruit based vermicelli and control on storage

Treatments	Total sugar (%)		
	Initial	2nd month	4th month
Control	4.43[a]	4.45[a] (0.45)	4.51[a] (1.34)
RJF + WWF	2.64[e]	2.64[e] (0.37)	2.81[e] (6.4)
RJF + RF	2.69[e]	2.69[e] (4.5)	2.93[d] (8.5)
RJF + JSF	2.4[f]	2.51[f] (2.47)	2.63[f] (4.7)
Roasted RJF + Roasted WWF	3.63[c]	3.72[c] (2.94)	3.87[b] (4.2)
Roasted RJF + Roasted RF	3.78[b]	3.86[b] (2.11)	3.91[b] (1.29)
Roasted RJF +Roasted JSF	3.38[d]	3.5[d] (3.5)	3.59[c] (2.57)
C.D (0.05)	0.088*	0.073*	0.054*
Significance	S	S	S

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour

Figure in parenthesis indicates per cent relative change over the previous month

Values with same alphabet for different treatments represented in each column form a homogenous group

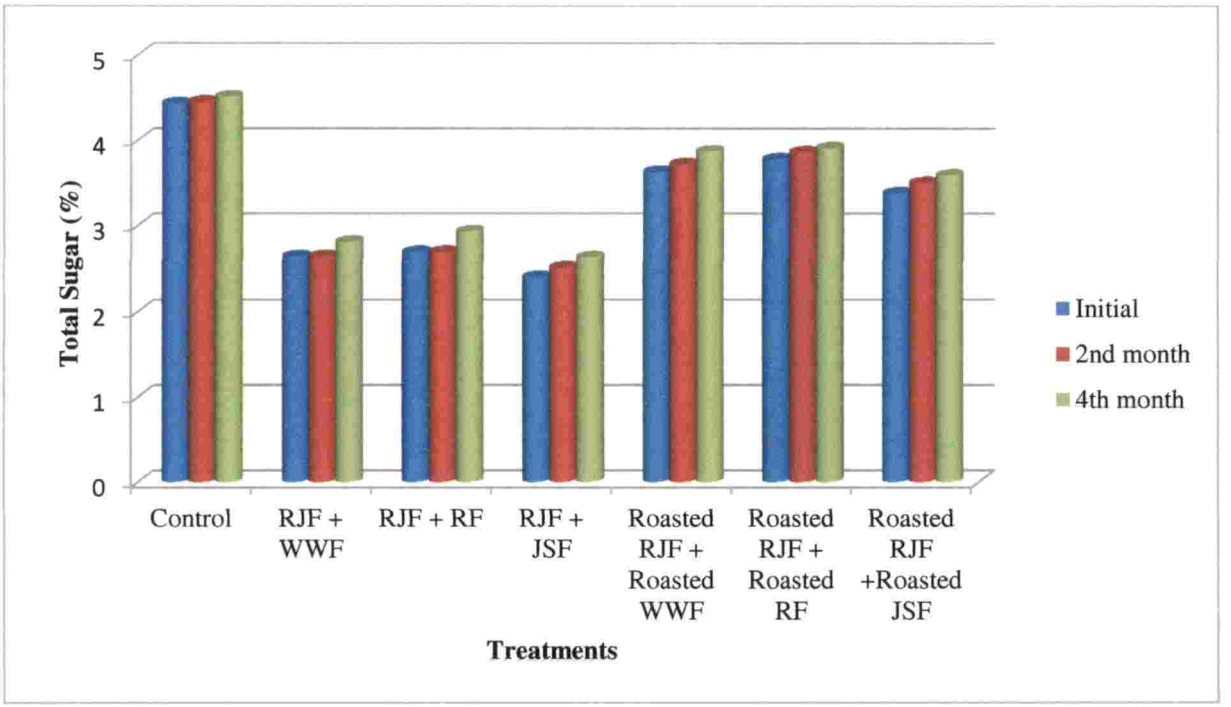

Fig. 9 Total sugar content of the selected jackfruit based vermicelli and control on storage

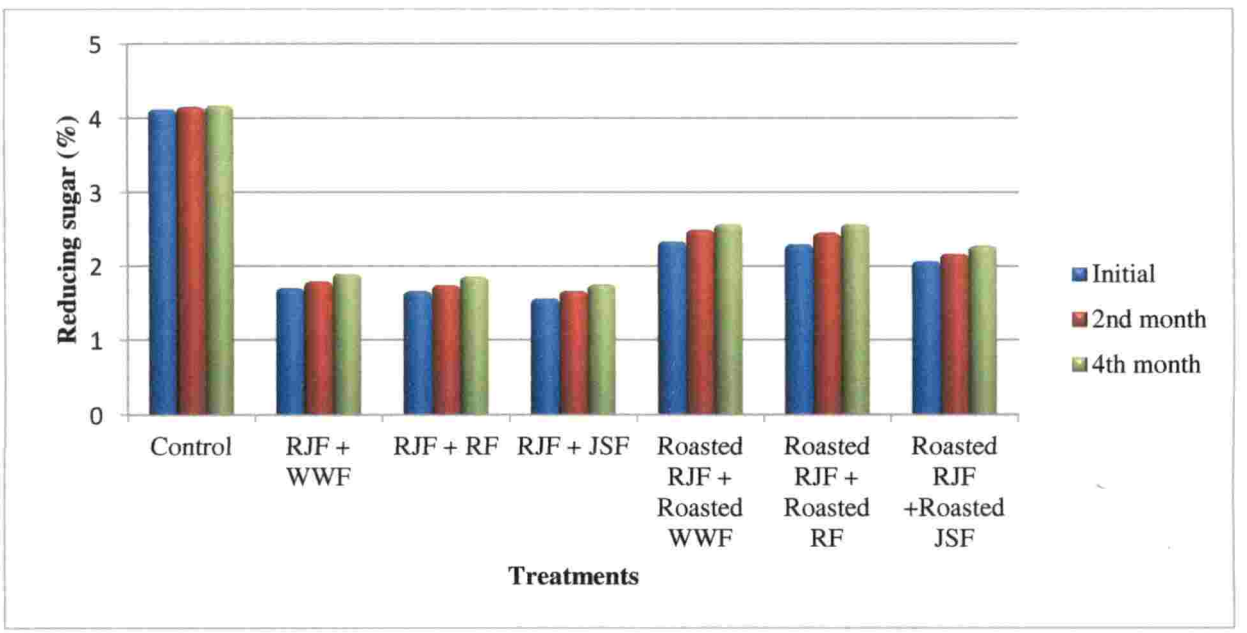

Fig. 10 Reducing sugar content of the selected jackfruit based vermicelli and control on storage

4.2.2.11. Iron

The changes in iron content of the selected jackfruit based vermicelli and control is presented in Table 31.

Table 31. Iron content of the selected jackfruit based vermicelli and control on storage

Treatments	Iron (mg 100 g^{-1})		
	Initial	2nd month	4th month
Control	2.66[d]	2.41[e] (9.51)	2.1[e] (12.86)
RJF + WWF	6.79[ab]	6.69[b] (3.80)	6.41[c] (4.18)
RJF + RF	6.64b[c]	6.53[cd] (1.65)	6.35[cd] (2.75)
RJF + JSF	6.46[c]	6.44[d] (0.27)	6.29[d] (2.63)
Roasted RJF + Roasted WWF	6.92[a]	6.81[a] (1.58)	6.72[a] (1.32)
Roasted RJF + Roasted RF	6.76[ab]	6.65[b] (1.62)	6.53[bc] (1.80)
Roasted RJF +Roasted JSF	6.65[bc]	6.57[c] (1.20)	6.46[c] (1.67)
C.D (0.05)	0.182*	0.075*	0.085*
Significance	S	S	S

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour

Figure in parenthesis indicates per cent relative change over the previous month

Values with same alphabet for different treatments represented in each column form a homogenous group

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Among the prepared jackfruit based vermicelli, initially the iron content varied from 6.46mg 100 g^{-1} (RJF+ JSF) to 6.92mg 100 g^{-1} (roasted RJF + roasted WWF vermicelli). At the fourth month of storage the iron content varied from 6.29mg 100 g^{-1} to 6.72mg 100 g^{-1}. In control (TC), iron content was found to be the lowest of 2.66 mg 100 g^{-1} on comparing with all the other treatments. The vermicelli prepared with roasted RJF + roasted WWF showed the highest iron content among the selected vermicelli's throughout the storage. Compared to unroasted jackfruit flour vermicelli, iron content was maximum in roasted jackfruit flour vermicelli. There was a reduction in the iron content throughout the storage. The critical difference (C.D) value showed a significant difference between the treatments during the entire storage period.

4.2.2.12. Calcium

Table 32 revealed the calcium content in jackfruit based vermicelli and control. Initially calcium content of jackfruit based vermicelli varied from 38.13mg 100 g^{-1} to 53.17mg 100g $^{-1}$ which was higher than control (10.14mg 100g $^{-1}$). During second and fourth month of storage calcium content of jackfruit based vermicelli varied from 38.01 to 53.06mg 100g $^{-1}$ and 37.90 to 49.93mg 100g $^{-1}$. The calcium content decreased in all treatments on storage. The vermicelli prepared from roasted jackfruit flour found to be high in calcium content compared to unroasted jackfruit flour vermicelli. The calcium content present in selected vermicelli have a significant difference between all the treatments initially and during second and fourth month of storage. As per DMRT there was a significant variation between control and jackfruit based vermicelli.

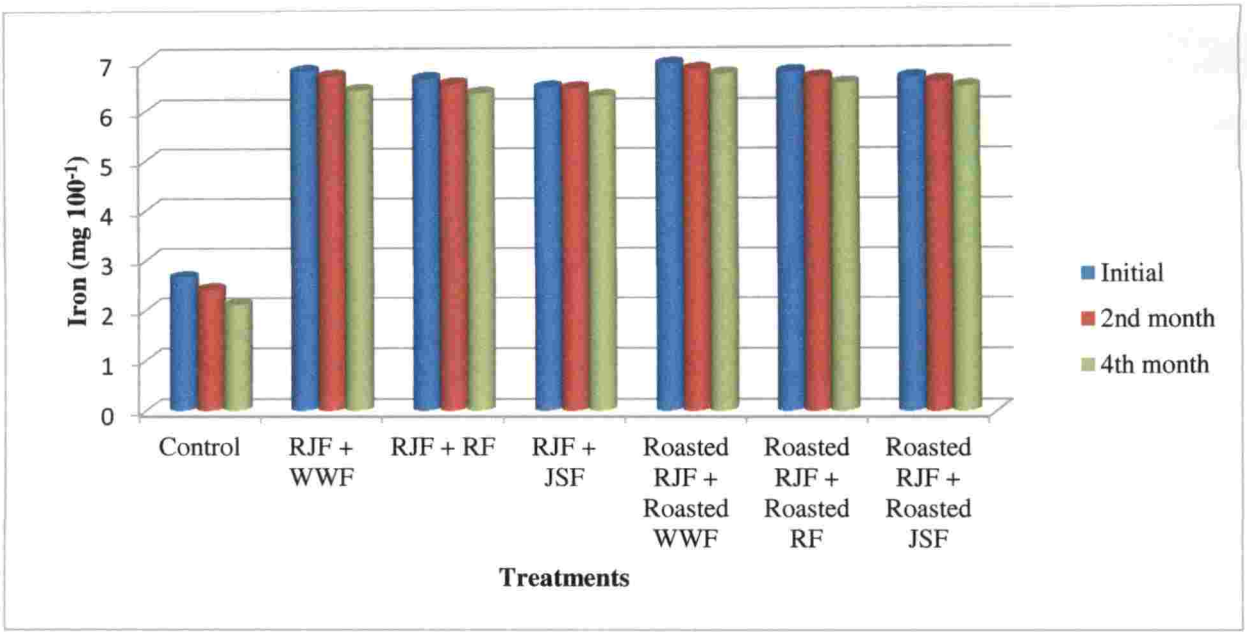

Fig.11 Iron content of the selected jackfruit based vermicelli and control on storage

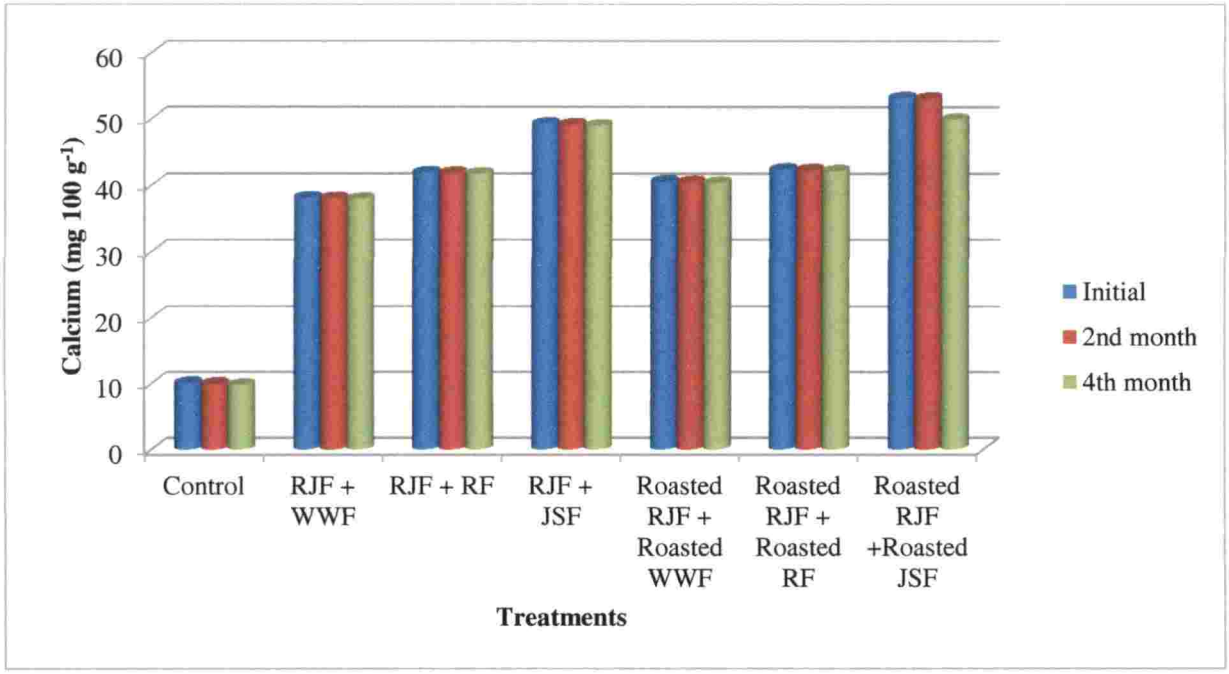

Fig. 12 Calcium content of the selected jackfruit based vermicelli and control on storage

Table 32. Calcium content of the selected jackfruit based vermicelli and control on storage

Treatments	Calcium (mg 100 g^{-1})		
	Initial	2nd month	4th month
Control	10.14[f]	10.02[g] (1.83)	9.85[f] (1.69)
RJF + WWF	38.13[e]	38.01[f] (0.31)	37.90[e] (0.28)
RJF + RF	41.92[c]	41.85[d] (0.16)	41.76[c] (0.21)
RJF + JSF	49.27[b]	49.15[b] (0.24)	48.99[b] (0.32)
Roasted RJF + Roasted WWF	40.57[d]	40.48[e] (0.22)	40.34[d] (0.34)
Roasted RJF + Roasted RF	42.37[c]	42.26[c] (0.25)	42.13[c] (0.30)
Roasted RJF +Roasted JSF	53.17[a]	53.06[a] (0.20)	49.93[a] (5.89)
C.D (0.05)	0.660*	0.203*	0.834*
Significance	S	S	S

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour

Figure in parenthesis indicates per cent relative change over the previous month

Values with same alphabet for different treatments represented in each column form a homogenous group

4.2.2.13. Sodium

The sodium content present in the vermicelli's during storage were analysed and tabulated in Table 33.

Table 33. Sodium content of the selected jackfruit based vermicelli and control on storage

Treatments	Sodium (mg 100 g^{-1})		
	Initial	2nd month	4th month
Control	5.50^{e}	5.14^{g} (6.54)	4.82^{f} (6.22)
RJF + WWF	15.10^{d}	14.93^{f} (1.12)	14.69^{e} (1.60)
RJF + RF	16.80^{bc}	16.71^{d} (0.53)	15.53^{d} (7.06)
RJF + JSF	17.39^{ab}	17.28^{b} (0.63)	17.09^{b} (1.09)
Roasted RJF + Roasted WWF	16.41^{c}	16.33^{e} (0.48)	16.20^{c} (0.79)
Roasted RJF + Roasted RF	17.12^{bc}	17.01^{c} (0.64)	16.89^{bc} (0.70)
Roasted RJF +Roasted JSF	18.14^{a}	18.03^{a} (0.60)	17.89^{a} (0.77)
C.D (0.05)	0.911*	0.207*	0.641*
Significance	S	S	S

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour

Figure in parenthesis indicates per cent relative change over the previous month

Values with same alphabet for different treatments represented in each column form a homogenous group

The sodium content present in selected vermicelli varied from 5.50mg 100 g^{-1} to 18.14mg 100 g^{-1}. Among the jackfruit based vermicelli, initially the sodium content in roasted RJF +Roasted JSF (18.14mg 100 g^{-1}) was found to be the highest followed by RJF+JSF (17.39mg 100 g^{-1}). The sodium content present in control (5.50mg 100 g^{-1}) was lower than jackfruit based vermicelli. The sodium content was found to be maximum in vermicelli prepared with roasted jackfruit flours. During the entire storage period, the sodium content was highest in vermicelli prepared with

roasted JSF+ roasted JSF. There was a significant variation among the control vermicelli and jackfruit based vermicelli during storage. The sodium content was observed to be least during the fourth month of storage in all the treatments.

4.2.2.14. Potassium

The potassium content of the vermicelli of different treatments during storage is detailed in Table 34.

As revealed in Table 34, the potassium content was found to be the highest in vermicelli prepared with roasted RJF+ roasted WWF (285.34mg 100 g^{-1}) initially which decreased to 281.59mg 100 g^{-1} on four months of storage. In control it was found to be 56mg 100 g^{-1} initially and reduced on storage (46.45mg 100 g^{-1}). The potassium content was high in roasted jackfruit flour vermicelli than unroasted jackfruit flour based vermicelli. There was a significant variation in all the treatments during the initial, second and fourth month of storage. There was a reduction in the potassium content of the selected vermicelli on storage. Among all the treatments, control was found to have high relative change in potassium content during second and fourth month (10.5 and 7.32) of storage.

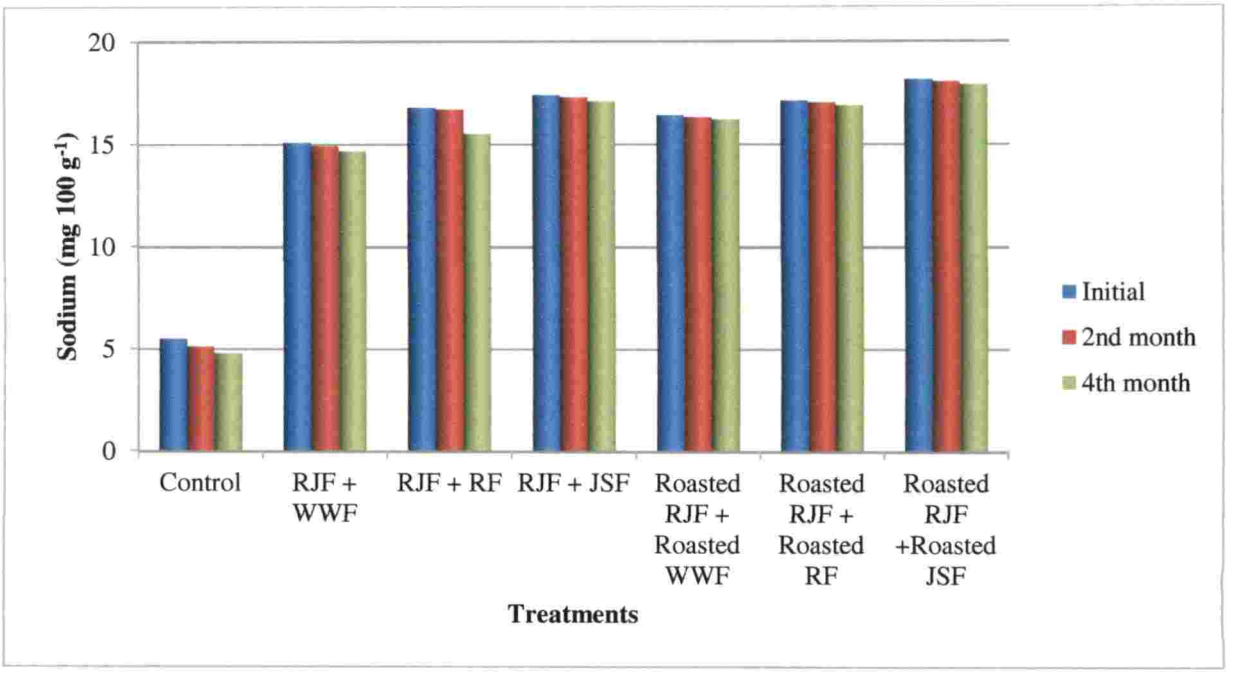

Fig. 13 Sodium content of the selected jackfruit based vermicelli and control on storage

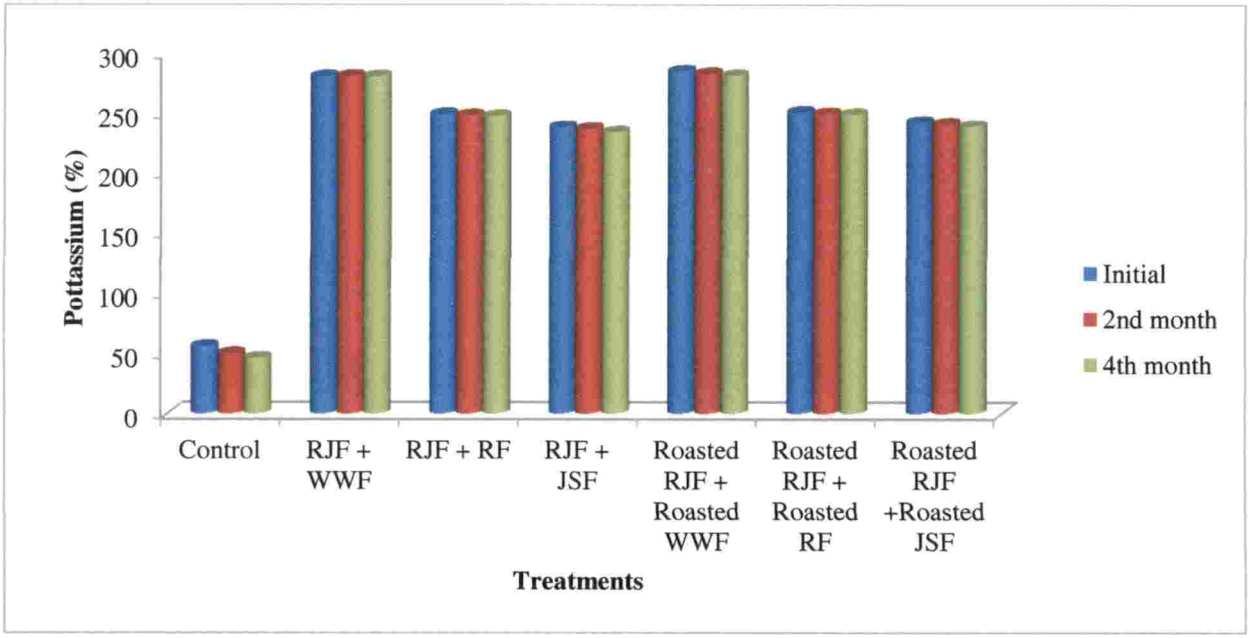

Fig.14 Potassium content of the selected jackfruit based vermicelli and control on storage

Table 34. Potassium content of the selected jackfruit based vermicelli and control on storage

Treatments	Potassium (%)		
	Initial	2nd month	4th month
Control	56[f]	50.12[d] (10.5)	46.45[f] (7.32)
RJF + WWF	281[b]	281.2[a] (0.07)	280.93[a] (0.09)
RJF + RF	249.7[c]	248.61[b] (0.43)	248.1[c] (0.20)
RJF + JSF	238.5[e]	237[c] (0.62)	234.25[e] (1.16)
Roasted RJF + Roasted WWF	285.34[a]	283.25[a] (0.73)	281.59[a] (0.58)
Roasted RJF + Roasted RF	251.4[c]	250.02[b] (0.54)	249.5[b] (0.20)
Roasted RJF +Roasted JSF	242.85[d]	241.35[c] (0.61)	239.57[d] (0.73)
C.D (0.05)	3.67*	1.02*	1.021*
Significance	S	S	S

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour

Figure in parenthesis indicates per cent relative change over the previous month

Values with same alphabet for different treatments represented in each column form a homogenous group

4.2.3. Microbial enumeration

The selected jackfruit based vermicelli and control was evaluated for microbial enumeration (bacteria, fungi and yeast) and the results are presented in Table 35.

Table 35. Total microbial count of the selected vermicelli during storage

Treatments	Microbial population (cfu/g)								
	Bacteria (10^6cfu/g)			Fungi (10^3cfu/g)			Yeast (10^3cfu/g)		
	Initial	2nd month	4th month	Initial	2nd month	4th month	Initial	2nd month	4th month
Control	0.66	1.67	2.34	ND	0.44	0.72	ND	ND	ND
RJF + WWF	0.33	1.44	1.82	ND	0.31	0.56	ND	ND	ND
RJF + RF	0.27	1.59	1.86	ND	0.45	0.67	ND	ND	ND
RJF + JSF	0.34	1.45	1.89	ND	0.41	0.63	ND	ND	ND
Roasted RJF + Roasted WWF	0.26	1.41	1.78	ND	0.27	0.49	ND	ND	ND
Roasted RJF + Roasted RF	0.29	1.52	1.79	ND	0.33	0.58	ND	ND	ND
Roasted RJF + Roasted JSF	0.24	1.40	1.74	ND	0.30	0.54	ND	ND	ND

RJF-Raw jackfruit flour, WWF-Whole wheat flour, RF-Raw rice flour, JSF- Jackfruit seed flour
ND- Not detected

As observed in Table 35, initially the bacterial count present in jackfruit based vermicelli varied from 0.24 x 10^6 cfu/g (Roasted RJF + Roasted JSF) to 0.34 x 10^6 cfu/g (RJF + JSF). In second and fourth month bacterial count varied from 1.40 x 10^6 cfu/g to 1.59 x 10^6 cfu/g and 1.74 x 10^6 cfu/g to 1.89 x 10^6 cfu/g whereas bacterial load was high in control (0.66 to 2.34 x 10^6 cfu/g) throughout the storage period. There was an increase in bacterial colony on four month of storage.

Initially, the fungal count was not detected in the jackfruit based vermicelli and control. During second month fungal count was within a range of 0.30 x 10^3 cfu/g to 0.45 x 10^3 cfu/g in jackfruit based vermicelli. The fungal count of the selected vermicelli was observed to be 0.49 x 10^3 cfu/g to 0.67 x 10^3 cfu/g on fourth month of storage. The fungal count was increased throughout storage which was higher in control than jackfruit based vermicelli. The yeast count was not detected in any of the vermicelli during the entire storage period.

4.2.4. Insect infestation

The selected jackfruit based vermicelli and control was packed in polyethylene pouches and stored in ambient condition. The insect infestation of the selected vermicelli was assessed initially and during the second and fourth month of storage. There was no insect infestation in any of the vermicelli throughout the storage period.

4.3. Standardisation of instant *payasam* mix

Jackfruit based instant *payasam* mix from roasted and unroasted flours of jackfruit with whole wheat, rice and jackfruit seed was standardised from the selected vermicelli. Instant *payasam* mix was prepared using 200g vermicelli with varying quantities of milk and sugar (treatment T_1 to T_6). In all the treatments 10g toasted cashew nuts and raisins, and 5g crushed cardamom were added.

4.3.1. Cooking time of instant *payasam* mix

Cooking time was observed for jackfruit instant *payasam* mix along with control and their result were tabulated and presented in Table 36.

Table 36. Cooking time of instant *payasam* mix

Treatments	Cooking time (minutes)
Control	8.00
RJF+WWF	5.25
RJF+RF	5.00
RJF+JSF	5.45
Roasted RJF+ Roasted WWF	4.30
Roasted RJF+ Roasted RF	4.00
Roasted RJF+ Roasted JSF	4.50

(RJF- Raw jackfruit flour, WWF- Whole wheat flour, RF- rice flour, JSF jackfruit seed flour)

As per Table 36, raw jackfruit flour and raw jackfruit seed flour based instant *payasam* mix took maximum time for cooking (5.45 min). Minimum cooking time (4 min.) was noticed in roasted RJF+ roasted RF followed by roasted RJF+ roasted WWF (4.30 min.) and roasted RJF+ roasted JSF (4.50 min.). All the treatments were found to have less cooking time than control. Roasting of flours decrease the cooking time of instant *payasam* mix.

4.3.2. Organoleptic qualities of instant *payasam* mix

The organoleptic evaluation of *payasam* prepared with the instant *payasam* mix with varying proportions of milk and sugar was carried out. For six set of instant *payasam* mix, organolpetic evaluation was carried out separately as follows.

4.3.2.1. Organoleptic qualities of jackfruit flour and whole wheat flour based *payasam* mix

Vermicelli prepared with 70 per cent raw jackfruit flour and 30 per cent whole wheat flour (T_1) was used to prepare instant *payasam* mix. *Payasam* prepared from the instant *payasam* mix, is shown in Plate 8. The sensory parameters like appearance, colour, flavour, texture, taste and overall acceptability were assessed by a panel of 15 judges. The mean score for the jackfruit based instant *payasam* mix are represented in Table 37.

Table 37. Mean scores for organoleptic evaluation of jackfruit flour and whole wheat flour based instant *payasam* mix

Treatments	Sensory parameters					
	Appearance	Colour	Flavor	Texture	Taste	Overall Acceptability
T_1 – 1 L M + 100 g S	6.44 (1.53)	6.75 (2.03)	6.73 (1.63)	6.48 (1.83)	6.62 (1.90)	6.66 (1.80)
T_2 – 1 L M + 125 g S	6.57 (1.80)	6.71 (1.83)	7.11 (2.87)	6.55 (2.10)	6.66 (1.97)	6.66 (1.80)
T_3 – 1 L M +150 g S	7.11 (2.73)	6.88 (2.47)	7.00 (2.20)	6.71 (2.30)	6.95 (2.53)	6.91 (2.37)
T_4 – 1.5 L M +100 g S	7.88 (4.10)	7.88 (4.37)	7.75 (3.97)	7.93 (4.67)	7.60 (4.00)	7.73 (4.13)
T_5 – 1.5 L M + 125 g S	8.31 (5.10)	8.28 (5.00)	7.97 (4.57)	8.04 (4.60)	8.02 (4.83)	8.11 (4.93)
T_6 – 1.5 LM + 150 g S	8.55 (5.10)	8.55 (5.60)	8.48 (5.77)	8.48 (5.50)	8.6 (5.77)	8.57 (5.73)
Kendalls W	.903**	.854**	.731**	.773**	.774**	.829**

(M – Milk, S –Sugar)
Value in parentheses is mean rank score based on Kendall's W
** Significant at 1% level

As revealed in table 37, the mean scores and mean rank score for appearance (T_1 to T_6) varied from 6.44 (1.53) to 8.55 (5.10). For colour mean score and mean rank score ranged from 6.75 (2.03) to 8.55 (5.60). The mean score for flavour, texture and taste differs from 6.73 (1.63) to 8.48 (5.77), 6.48 (1.83) to 8.48 (5.50) and 6.62 (1.90) to 8.6 (5.77) respectively. The overall acceptability was found to be in the range of 6.66 (1.80) to 8.57 (5.73). Among the treatments, T_6 (200g vermicelli with 1.5 L milk and 150 g sugar) was found to have maximum mean score for all the sensory parameters such as appearance (8.55), colour (8.55), flavour (8.48), taste (8.6) texture (8.48), and overall acceptability (8.57) respectively.

4.3.2.2. Organoleptic qualities of jackfruit flour and rice flour based instant *payasam* mix

For the standardisation of instant *payasam* mix, 60 per cent raw jackfruit flour and 40 per cent rice flour vermicelli (T_2) was used. *Payasam* prepared from the instant *payasam* mix, is shown in Plate 9. The mean score and mean rank score for the jackfruit based instant *payasam* mixes are presented in Table 38.

Among all the treatments T_1 had a minimum mean score and mean rank score for all parameters. The *payasam* prepared with T_1 had a score of 6.44 (2.07) for appearance, 6.66 (1.97) for colour, 6.73 (1.97) for flavour, 6.44 (1.70) for texture, 6.57 (2.00) for taste and 6.46 (1.60) for overall acceptability. As per the result T_6 had a maximum score for all quality parameters, 8.51 (5.67) for appearance, 8.51 (5.70) for colour, 8.22 (5.60) for flavor, 8.44 (5.53) for texture, 8.51 (5.70) for taste, and 8.6 (5.70) for overall acceptability. The Kendall's value showed significant agreement among judges for all the sensory parameters of jackfruit based instant *payasam* mix.

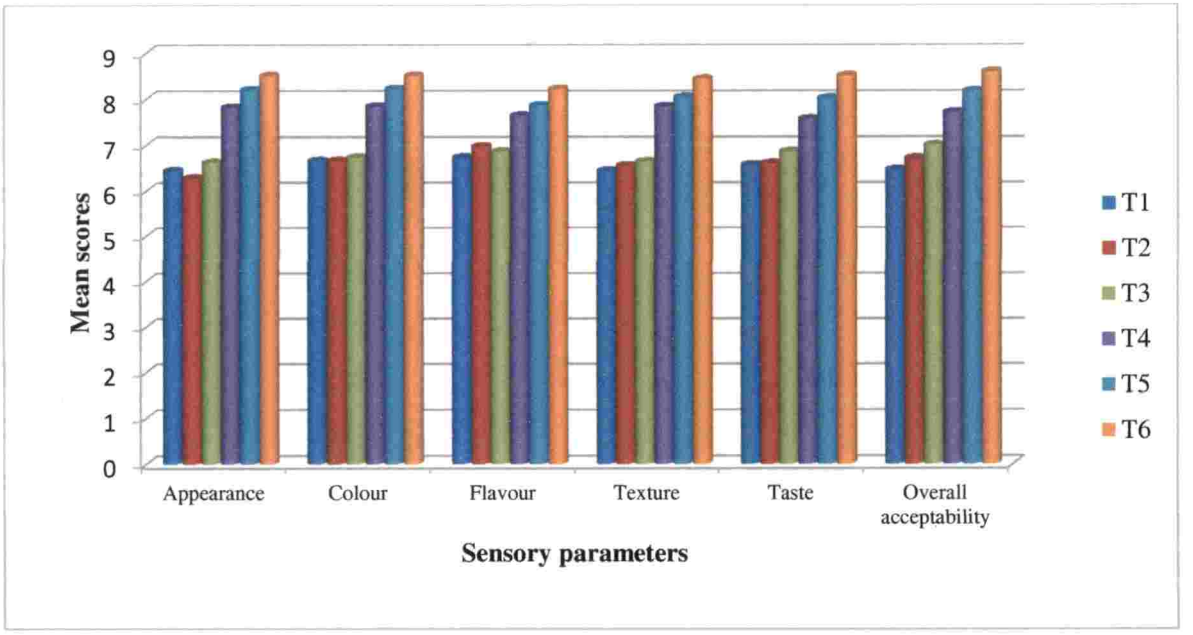

Fig.15 Mean scores for organoleptic evaluation of jackfruit flour and whole wheat flour based instant *payasam* mix

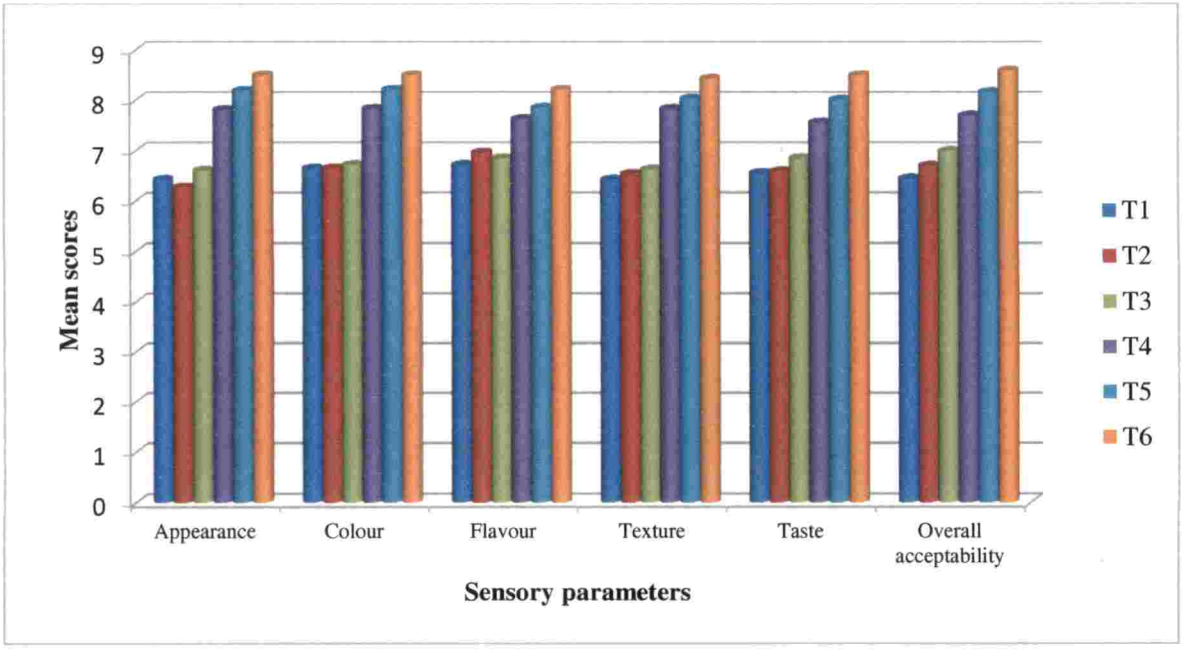

Fig. 16 Mean scores for organoleptic evaluation of jackfruit flour and rice flour based instant *payasam* mix

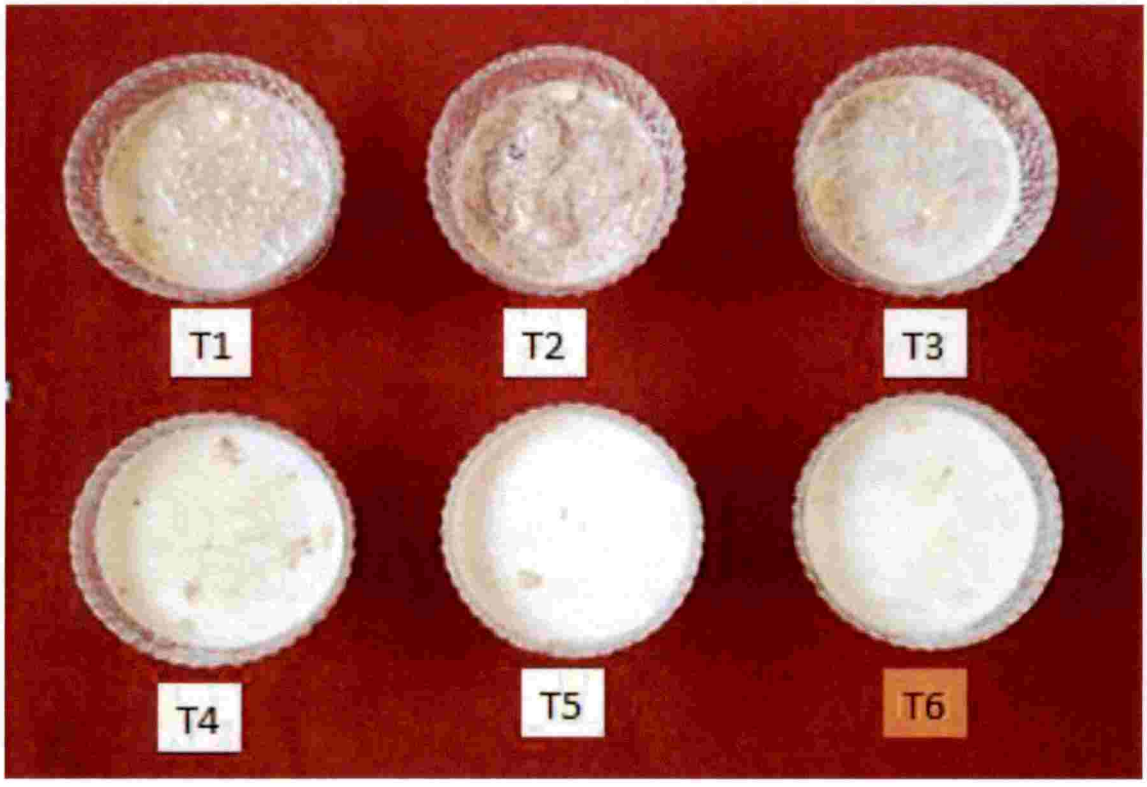

Plate 8. Raw jackfruit flour and whole wheat flour based instant *payasam*

Plate 9. Raw jackfruit flour and rice flour based instant *payasam*

Table 38. Mean scores for organoleptic evaluation of jackfruit flour and rice flour based instant *payasam* mix

Treatments	Sensory parameters					
	Appearance	Colour	Flavor	Texture	Taste	Overall Acceptability
T_1 – 1 L M + 100 g S	6.44 (2.07)	6.66 (1.97)	6.73 (1.97)	6.44 (1.70)	6.57 (2.00)	6.46 (1.60)
T_2 – 1 L M + 125 g S	6.28 (1.60)	6.66 (1.97)	6.97 (2.97)	6.55 (2.13)	6.6 (1.93)	6.71 (1.97)
T_3 – 1 L M + 150 g S	6.62 (2.37)	6.73 (2.10)	6.86 (2.30)	6.64 (2.30)	6.86 (2.50)	7 (2.73)
T_4 – 1.5 L M + 100 g S	7.82 (4.20)	7.84 (4.27)	7.64 (3.77)	7.84 (4.60)	7.57 (3.93)	7.71 (3.97)
T_5 – 1.5 L M + 125 g S	8.2 (5.10)	8.22 (5.00)	7.86 (4.43)	8.04 (4.73)	8.02 (4.93)	8.17 (5.03)
T_6 – 1.5 L M + 150 g S	8.51 (5.67)	8.51 (5.70)	8.22 (5.60)	8.44 (5.53)	8.51 (5.70)	8.6 (5.70)
Kendalls W	.255**	.499**	.393**	.481**	.655**	.538**

(M – Milk, S –Sugar)
Value in parentheses is mean rank score based on Kendall's W
** Significant at 1% level

4.3.2.3. Organoleptic qualities of jackfruit flour and jackfruit seed flour based instant *payasam* mix

Vermicelli prepared with 70 per cent raw jackfruit flour with 30 per cent jackfruit seed flour (T_1) was used to prepare instant *payasam* mix. The mean score and mean rank score for the jackfruit based instant *payasam* mix are presented in Table 39. Prepared *payasam* is shown in Plate 10.

The table 39 revealed that, for the different treatments (T_1 to T_6) mean score and mean rank score for appearance varied from 6.26 (1.70) to 8.46 (5.57), colour of the prepared *payasam* ranged between a score of 6.55 (1.67) to 8.37 (5.53), flavour from 6.62 (1.57) to 8.42 (5.77). The taste and texture varied from 6.53

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(1.87) to 8.44 (5.80) and 6.4 (1.80) to 8.48 (5.90). The overall acceptability of the *payasam* had a score of 6.37 (1.50) to 8.51 (5.73).

All the sensory attributes like appearance, colour, flavour, taste, texture and overall acceptability (8.46, 8.37, 8.42, 8.44, 8.48 and 8.51 respectively) was highest in T_6 (*payasam* prepared with 200g vermicelli, 1.5 L milk and 150 g sugar). Based on the statistical analysis, the mean scores obtained by the panel of judges showed significant agreement for all the sensory parameters by applying Kendall's W test.

Table 39. Mean scores for organoleptic evaluation of jackfruit and jackfruit seed flour based instant *payasam* mix

Treatments	Sensory parameters					
	Appearance	Colour	Flavor	Texture	Taste	Overall Acceptability
T_1 – 1 L M + 100 g S	6.26 (1.70)	6.55 (1.67)	6.62 (1.57)	6.4 (1.80)	6.53 (1.87)	6.37 (1.50)
T_2 – 1 L M + 125 g S	6.31 (1.80)	6.68 (2.07)	7.08 (3.10)	6.48 (2.00)	6.62 (2.00)	6.71 (2.17)
T_3 – 1 L M + 150 g S	6.64 (2.53)	6.8 (2.40)	6.66 (1.97)	6.6 (2.33)	6.84 (2.50)	6.88 (2.60)
T_4 – 1.5 L M + 100 g S	7.77 (4.20)	7.8 (4.50)	7.71 (4.00)	7.88 (4.50)	7.62 (4.07)	7.71 (4.10)
T_5 – 1.5 L M + 125 g S	8.24 (5.20)	4.83 (8.04)	7.93 (4.60)	8.04 (4.83)	7.88 (4.77)	8.11 (4.90)
T_6 – 1.5 L M + 150 g S	8.46 (5.57)	8.37 (5.53)	8.42 (5.77)	8.48 (5.90)	8.44 (5.80)	8.51 (5.73)
Kendalls W	.255**	.499**	.393**	.481**	.655**	.538**

(M – Milk, S –Sugar)
Value in parentheses is mean rank score based on Kendall's W
** Significant at 1% level

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4.3.2.4. Organoleptic qualities of roasted jackfruit flour and roasted wheat flour based instant *payasam* mix

The roasted jackfruit flour and roasted wheat flour based instant *payasam* were prepared and shown in Plate 11. The result of organoleptic evaluation is revealed in Table 40.

From the various treatments tried for the standardisation of instant *payasam* mix, the treatment T_6 (*payasam* prepared with 200g vermicelli, 1.5 L milk and 150 g sugar) obtained a highest mean score and mean rank score for appearance (8.66 and 5.80), colour (8.68 and 5.77), flavour (8.64 and 5.77), taste (8.86 and 5.86), texture (8.73 and 5.77) and overall acceptability (8.57 and 5.73). Based on statistical analysis, the mean scores obtained by the panel of judges showed a significant agreement for all the sensory parameters by applying Kendall's W test.

Table 40. Mean scores for organoleptic evaluation of roasted jackfruit flour and roasted wheat flour based instant *payasam* mix

Treatments	Sensory parameters					
	Appearance	Colour	Flavor	Texture	Taste	Overall Acceptability
T_1 – 1 L M + 100 g S	6.55 (1.53)	6.75 (1.77)	6.77 (1.50)	6.55 (1.57)	6.77 (1.89)	6.66 (1.80)
T_2 – 1 L M + 125 g S	6.66 (1.83)	6.86 (2.03)	7.2 (2.77)	6.77 (2.13)	6.86 (1.82)	6.73 (2.03)
T_3 – 1 L M + 150 g S	7.22 (2.77)	7.04 (2.24)	7.13 (2.33)	6.93 (2.47)	7.17 (2.54)	6.91 (2.37)
T_4 – 1.5 L M +100 g S	8 (3.97)	8.02 (4.37)	7.84 (3.90)	8.02 (4.47)	7.86 (3.89)	7.73 (4.13)
T_5 – 1.5 L M + 125 g S	8.44 (5.10)	8.31 (4.80)	8.22 (4.73)	8.13 (4.60)	8.37 (5.00)	8.11 (4.93)
T_6 – 1.5 L M + 150 g S	8.66 (5.80)	8.68 (5.77)	8.64 (5.77)	8.73 (5.77)	8.86 (5.86)	8.57 (5.73)
Kendalls W	.902**	.855**	.772**	.841**	.839**	.829**

(M – Milk, S –Sugar)
Value in parentheses is mean rank score based on Kendall's W
** Significant at 1% level

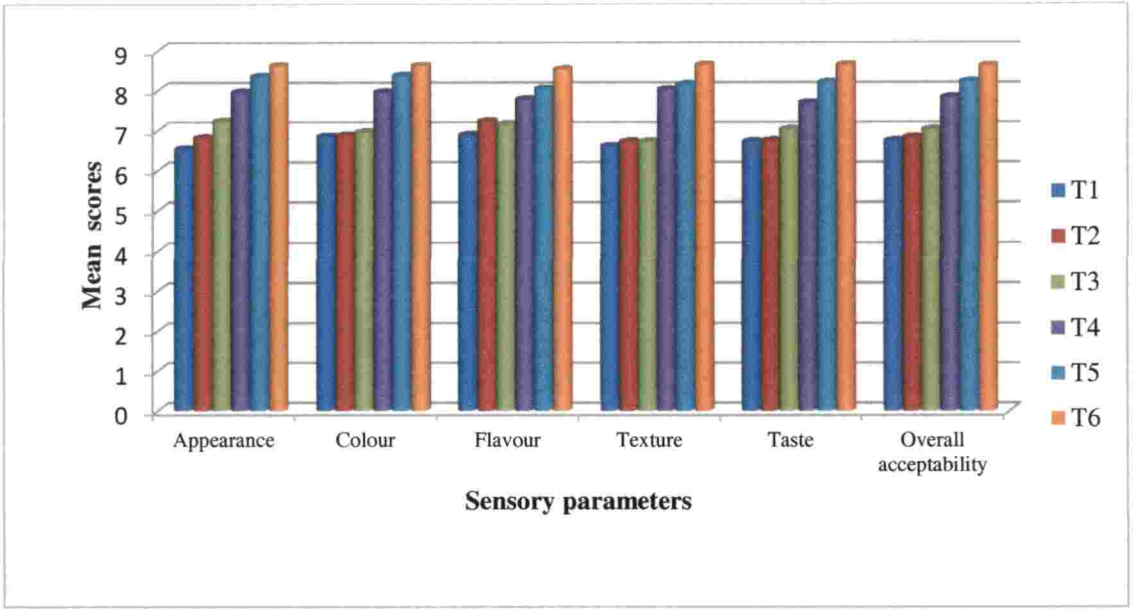

Fig. 17 Mean scores for organoleptic evaluation of jackfruit and jackfruit seed flour based instant *payasam* mix

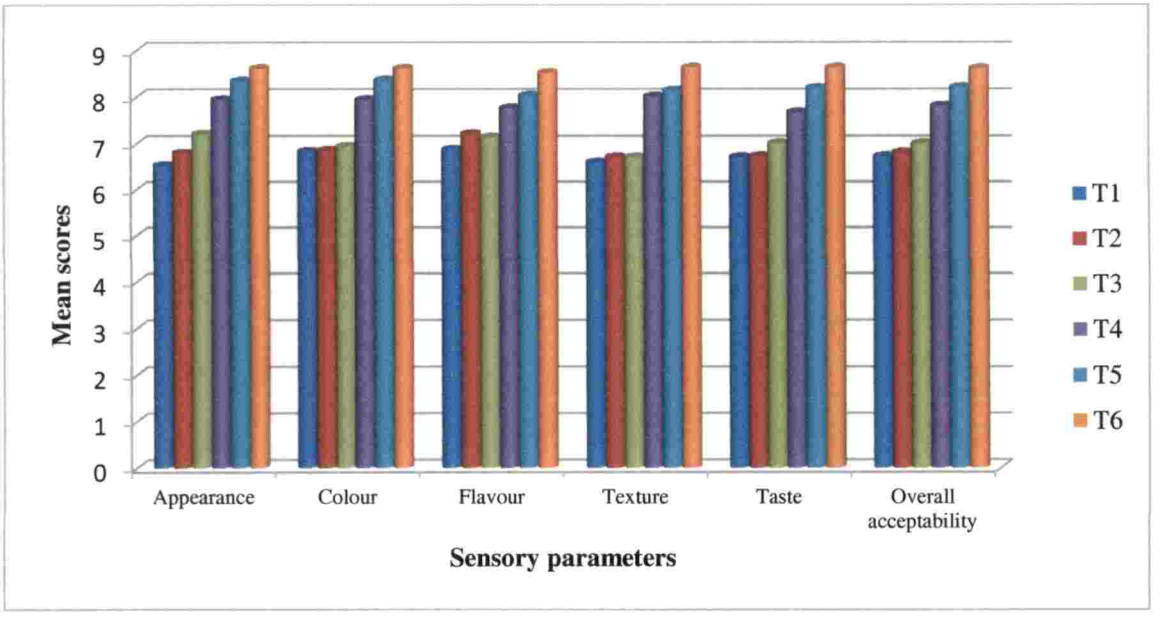

Fig. 18 Mean scores for organoleptic evaluation of roasted jackfruit flour and roasted whole wheat flour based instant *payasam* mix

Plate 10. Raw jackfruit flour and jackfruit seed flour based instant *payasam*

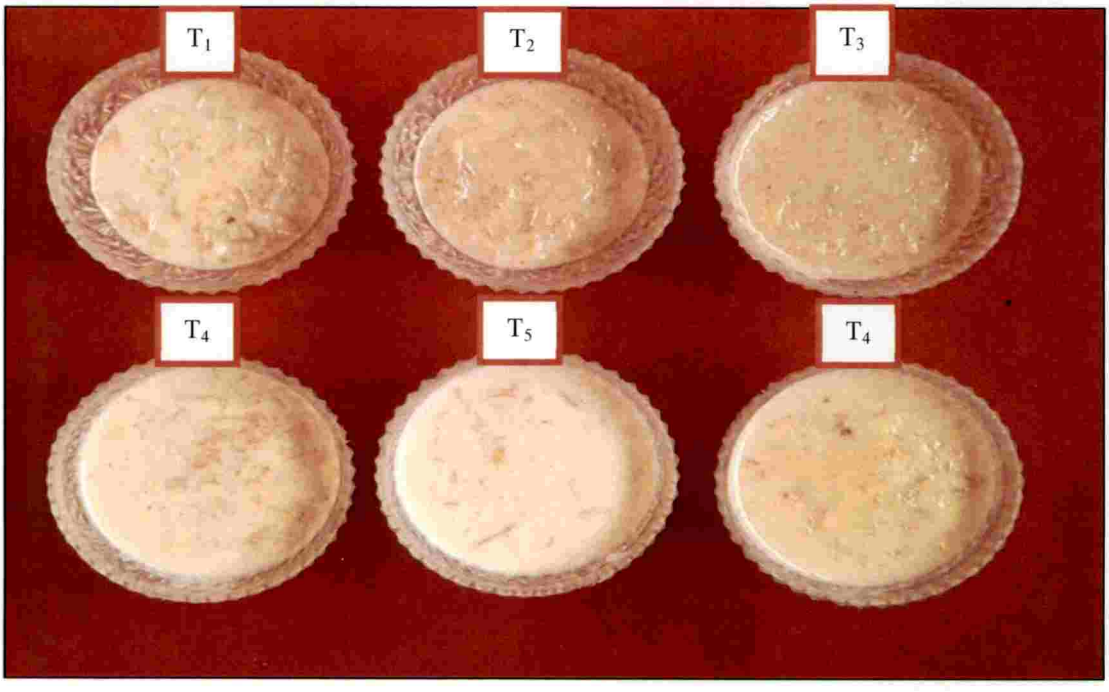

Plate 11. Roasted jackfruit flour and roasted whole wheat flour based instant *payasam*

4.3.2.5. Organoleptic qualities of roasted jackfruit flour and roasted rice flour based instant *payasam* mix

The instant *payasam* prepared with roasted jackfruit flour and roasted jackfruit seed flour is given in Plate 12. The mean scores of organoleptic evaluation for the prepared instant *payasam* is presented in Table 41.

Among the mean score for the appearance of the *payasam* prepared with different treatments, T_1 had a lowest score of 6.64 and highest score of 8.64 was obtained by T_6. Similarly the mean rank score was lowest in T_1 of 1.53 and highest in T_6 of 5.77. The colour of the instant *payasam* had a lowest mean score and mean rank score in T_1 (6.73 and 1.53). In T_6, *payasam* was found to have highest mean score and mean rank score for colour of 8.62 and 5.60. The mean score for the flavour, texture and taste of the *payasam* prepared with T_1 has the lowest score of 6.8, 6.48 and 6.82 whereas highest in T_6 of 8.57, 8.62 and 8.64. The overall acceptability, mean score and mean rank was lowest in T_1 (6.73 and 1.87) and highest in T_6 (8.68 and 5.80). The Kendall's value showed significant agreement among judges for all the sensory parameter of jackfruit based instant *payasam*

Table 41. Mean scores for organoleptic evaluation of roasted jackfruit and roasted rice flour based instant *payasam* mix

Treatments	Sensory parameters					
	Appearance	Colour	Flavor	Texture	Taste	Overall Acceptability
T_1 – 1 L M + 100 g S	6.64 (1.53)	6.73 (1.53)	6.8 (1.63)	6.48 (1.73)	6.82 (1.87)	6.73 (1.87)
T_2 – 1 L M + 125 g S	6.75 (1.77)	6.95 (1.97)	7.15 (2.83)	6.64 (2.10)	6.86 (2.10)	6.75 (1.93)
T_3 – 1 L M + 150 g S	7.24 (2.80)	7.11 (2.43)	7.04 (2.13)	6.82 (2.30)	7.02 (2.40)	6.97 (2.37)
T_4 – 1.5 L M + 100 g S	7.97 (4.13)	8.11 (4.53)	7.86 (4.13)	7.97 (4.47)	7.75 (4.00)	7.8 (4.13)
T_5 – 1.5 L M + 125 g S	8.4 (5.00)	8.33 (4.83)	8.04 (4.57)	8.2 (4.90)	8.2 (4.93)	8.15 (4.90)
T_6 – 1.5 L M + 150 g S	8.64 (5.77)	8.62 (5.60)	8.57 (5.70)	8.62 (5.50)	8.64 (5.70)	8.68 (5.80)
Kendalls W	.907**	.844**	.732**	.776**	.732**	.847**

(M – Milk, S –Sugar)
Value in parentheses is mean rank score based on Kendall's W
** Significant at 1% level

4.3.2.6. Organoleptic qualities of roasted jackfruit flour and roasted jackfruit seed flour based instant *payasam* mix

Vermicelli prepared with 70 per cent roasted jackfruit flour with 30 per cent roasted jackfruit seed flour was used to prepare instant *payasam* mix. The mean score and mean rank score for the jackfruit based instant *payasam* is presented in Table 42. Prepared *payasam* is shown in Plate 13.

As depicted in Table 42, the mean score for all the sensory attributes like appearance (8.62), colour (8.62), flavor (8.53), taste (8.64), texture (8.64) and overall acceptability (8.62) was highest in T_6 (*payasam* prepared with 200g

overall acceptability (8.62) was highest in T_6 (*payasam* prepared with 200g vermicelli, 1.5 L milk and 150 g sugar) than other treatments. Statistically analysis on the mean score obtained by the panel of judges showed significant agreement for all the sensory parameters by applying Kendall's W test.

Table 42. Mean scores for organoleptic evaluation of roasted jackfruit and roasted jackfruit seed flour based instant *payasam* mix

Treatments	Sensory parameters					
	Appearance	Colour	Flavor	Texture	Taste	Overall Acceptability
T_1 – 1 L M + 100 g S	6.53 (1.43)	6.84 (2.00)	6.88 (1.73)	6.6 (1.83)	6.71 (1.83)	6.73 (1.77)
T_2 – 1 L M + 125 g S	6.8 (1.83)	6.86 (1.97)	7.22 (2.70)	6.71 (2.27)	6.73 (2.00)	6.82 (1.93)
T_3 – 1 L M + 150 g S	7.22 (2.83)	6.95 (2.10)	7.15 (2.37)	6.71 (2.03)	7.02 (2.60)	7.02 (2.47)
T_4 – 1.5 L M + 100 g S	7.95 (4.03)	7.95 (4.33)	7.77 (3.90)	8.02 (4.40)	7.68 (3.93)	7.82 (4.20)
T_5 – 1.5 L M + 125 g S	8.35 (5.07)	8.37 (5.03)	8.04 (4.57)	8.15 (4.67)	8.2 (4.93)	8.22 (4.97)
T_6 – 1.5 L M + 150 g S	8.62 (5.80)	8.62 (5.57)	8.53 (5.73)	8.64 (5.80)	8.64 (5.70)	8.62 (5.67)
Kendalls W	.926**	.833**	.685**	.847**	.764**	.817**

(M – Milk, S –Sugar)
Value in parentheses is mean rank score based on Kendall's W
** Significant at 1% level

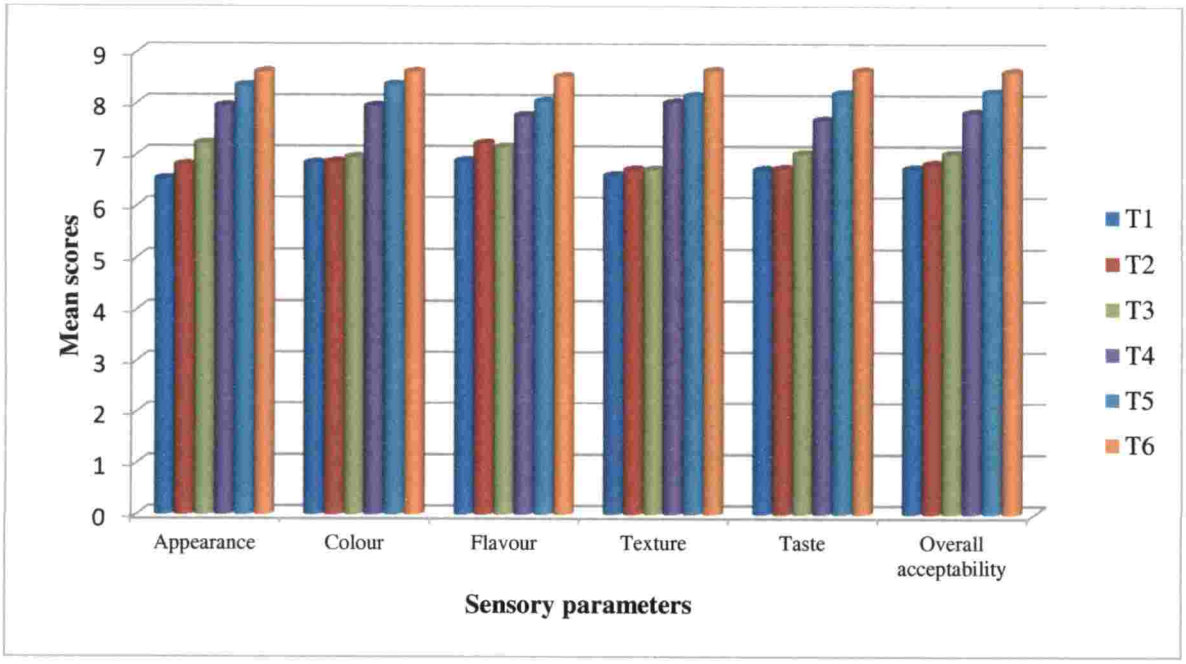

Fig. 19 Mean scores for organoleptic evaluation of roasted jackfruit and roasted rice flour based instant *payasam* mix

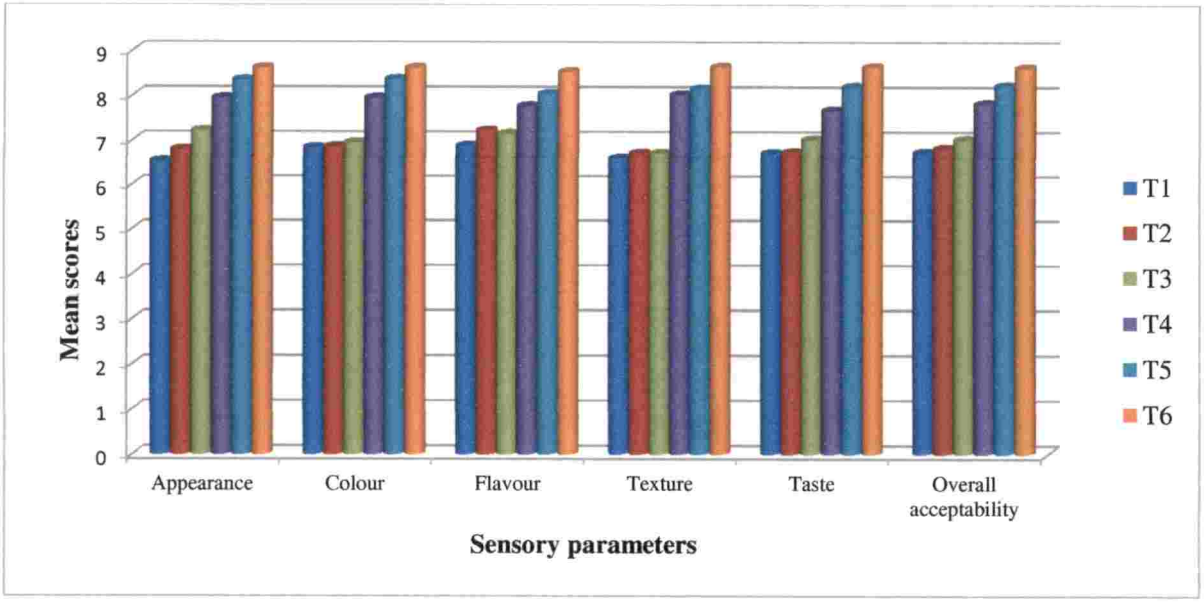

Fig. 20 Mean scores for organoleptic evaluation of roasted jackfruit flour and roasted jackfruit seed flour based instant *payasam* mix

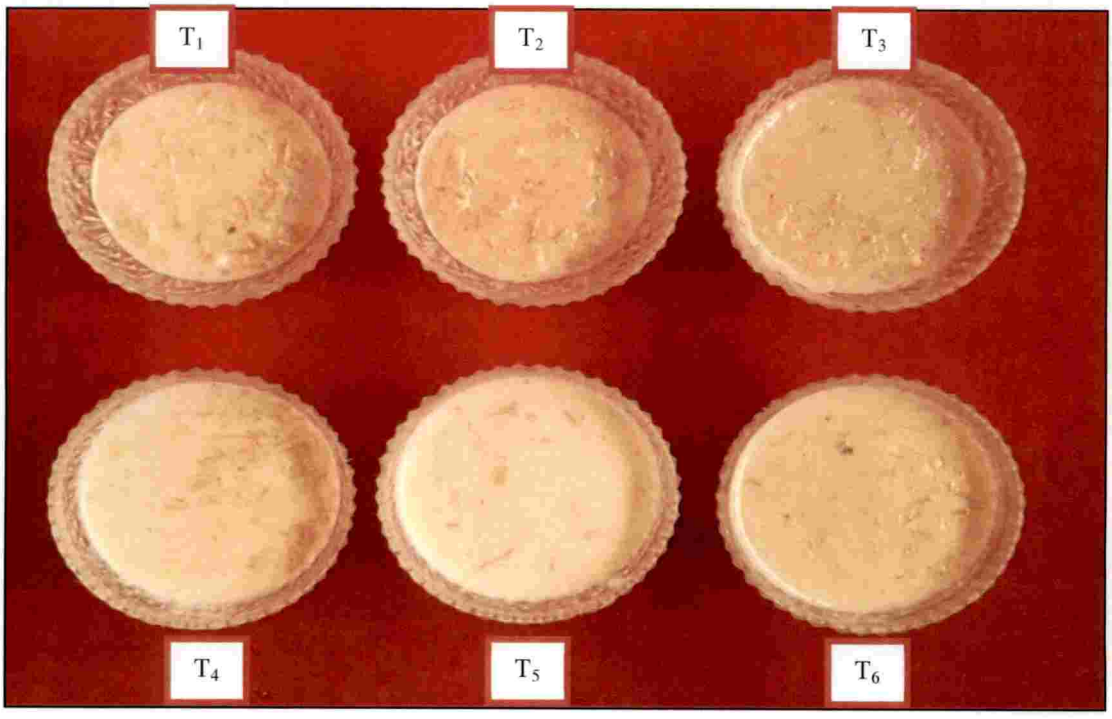

Plate 12. Roasted jackfruit flour and roasted rice flour based instant *payasam*

Plate 13. Roasted jackfruit flour and roasted jackfruit seed flour based instant *payasam*

4.3.3. Selection of most acceptable jackfruit based instant *payasam* mix

Based on different sensory attributes, 200 g of vermicelli with 1.5 litre of milk and 150 g of sugar (T_6) from each set was selected as the best for the preparation of instant *payasam* mix. The selected six set of instant *payasam* mix can be packed in laminated pouches

4.4. Cost of production for selected jackfruit based vermicelli and instant *payasam* mix

The cost of production for the selected jackfruit based vermicelli and instant *payasam* mix along with control was calculated for one kg and presented in Table 43.

Table 43. Cost of production for selected jackfruit based vermicelli and instant *payasam* mix

Treatments	Cost (Rs/Kg)	
	Vermicelli	Instant *payasam* mix
Control (Refined wheat flour)	76.24	230.24
RJF + WWF	86.46	240.46
RJF + RF	82.54	236.54
RJF + JSF	81.36	235.36
Roasted RJF + Roasted WWF	88.21	242.21
Roasted RJF + Roasted RF	84.29	238.29
Roasted RJF +Roasted JSF	83.11	237.11

The cost of production of control vermicelli (76.24 Rs/Kg) and instant *payasam* mix (230.24 Rs/Kg) was lower compared to jackfruit based vermicelli

and instant *payasam* mix. The cost of selected jackfruit based vermicelli varied from 81.36 Rs/Kg to 88.21 Rs/Kg and jackfruit based instant *payasam* mix ranged from 235.36 Rs/Kg to 242.21 Rs/Kg. Among the jackfruit based vermicelli and instant *payasam* mix, roasted RJF + Roasted WWF was found to have the highest price whereas cost of the products formulated with RJF + RF was observed to be lowest.

DISCUSSION

5. DISCUSSION

Results of the study entitled "Process optimisation and quality evaluation of jackfruit (*Koozha* type) based vermicelli" are discussed under the following headings

5.1. Standardisation of jackfruit based vermicelli

5.2. Quality evaluation of selected jackfruit based vermicelli on storage

5.3. Standarisation of jackfruit based instant *payasam* mix

5.4. Cost of production of the most acceptable combinations of jackfruit vermicelli's and instant *payasam* mix.

5. 1. Standardisation of jackfruit based vermicelli

Jackfruit based vermicelli prepared using raw jackfruit flour, whole wheat flour and jackfruit seed flour (roasted and unroasted) in different combinations along with control (refined wheat flour vermicelli) were evaluated for various organoleptic qualities like appearance, colour, flavor, texture, taste and overall acceptability by using a score card having nine point hedonic scale. The results of the standardised jackfruit based vermicelli are discussed below.

5.1.1. Organoleptic qualities of vermicelli and *payasam* prepared with raw jackfruit flour and whole wheat flour

Jackfruit based vermicelli were prepared with varying proportions of raw jackfruit flour and whole wheat flour along with control (refined wheat flour vermicelli). *Payasam* was prepared from the jackfruit based vermicelli and subjected to sensory evaluation and the results indicated that vermicelli and *payasam* prepared with 70 per cent incorporation of raw jackfruit flour with 30 per cent whole wheat flour was highly acceptable than other treatments. The maximum score for sensory attributes was observed for control vermicelli (T_0).

The results of the organoleptic evaluation shows that mean score and mean rank score obtained for 70 per cent incorporation of raw jackfruit flour with 30 per

cent whole wheat flour vermicelli (T_1) were 8.2 (3.40) in appearance, 8.08 (3.10) in colour, 8.34 (2.90) in flavor, 7.91 (3.00) in taste, 7.86 (2.90) in texture and 7.86 (2.83) in overall acceptability. For *payasam*, the mean score for appearance, colour, flavor, taste, texture and overall acceptability were 8.64 (3.83), 8.64 (4.17), 8.6 (4.00), 8.48 (3.43), 8.51 (3.60) and 8.68 (3.87) respectively.

Das and Nirmala (2014) prepared pasta from jackfruit along with wheat flour and green gram flour. The jackfruit incorporated pasta was highly acceptable for the sensory score of 4.8, 4.7, 4.8, and 5.0 for appearance, flavour, colour and overall acceptability based on 5 point hedonic scale. According to Aziah (2012) bread prepared with 5 percent incorporation of raw jackfruit flour with wheat flour had better sensory scores for colour (4.03/5), flavor (4.06/5) and overall acceptability (4.03/5).

Kumari (2015) standardised jackfruit based noodles with raw jackfruit flour, jackfruit seed flour and wheat flour in different combination (T_1-40:30:30, T_2-50:25:25, T_3-50:30:20, T_4-50:40:10, T_5-50:10:40, T_6-50:20:30). The prepared noodles and control (commercial noodles) was cooked and evaluated by 10 panel members. Overall acceptability of prepared noodle revealed that treatment T_5 (4.81) had high score followed by T_3 and T_6 with the score of 4.71 and 4.14 respectively. All the treatments had lower values than control (4.96).

Thirty per cent incorporation of raw jackfruit with blend of sago and cassava starches (1:1) produced fried crackers with the most acceptable physicochemical characteristics (Mustapha *et al.*, 2015). Biscuits processed from refined wheat flour supplemented by 25 per cent raw jackfruit flour had high sensory score initially and throughout the storage (30 days) period (4.58 and 4.16 out of 5) (Hosamani *et al.*, 2016).

The present study reveals that as the level of incorporation of jackfruit flour increases, the sensory qualities also increased. This finding was very compatible with Sahoo (2016), who prepared raw jackfruit based rusk and buns

along with wheat flour in different proportions (40:60, 45:55, 50:50,60:40, 70:30, and 80:20) along with control (refined wheat flour). Buns and rusk prepared with 80 per cent of raw jackfruit flour was highly acceptable for taste, texture, flavor and overall acceptability than other treatments.

Wheat is the major ingredient used for the preparation of extruded products like noodles, pasta etc. because of its special dough characteristic like cohesiveness and viscoelastic properties (Uthayakumaran and Wrigley, 2010). The finding of the present study states that replacement of wheat flour with raw jackfruit flour helps to improve the nutritional and sensory qualities of vermicelli.

5.1.2. Organoleptic qualities of vermicelli and *payasam* prepared with raw jackfruit flour and rice flour

Jackfruit based vermicelli and *payasam* were prepared from raw jackfruit flour and rice flour along with control. Based on sensory evaluation, 60 per cent incorporation of raw jackfruit flour with 40 per cent rice flour vermicelli and *payasam* had high mean score. The *payasam* prepared with jackfruit based vermicelli shows high mean score for flavor and texture compared to control.

In the present study, treatment T_2 vermicelli and *payasam* had a high score for all sensory attributes like appearance (8.28 and 8.75), colour (8.17 and 8.73), flavor (7.88 and 8.64), taste (8.24 and 8.4), texture (8.6 and 8.37), and overall acceptability (7.82 and 8.82).

The rice flour is an important ingredient in both traditional and novel products across the world (Villareal *et al.*, 1993). Rice becomes an attractive ingredient in the extruded food products due to its bland taste, attractive white colour, hypoallergenicity and ease of digestion (Kadan *et al.*, 2003). Absence of gluten makes rice suitable as an alternative to wheat in product preparations (Prakash *et al.*, 2010).

Karoline (2004) prepared tuber based vermicelli (taro and dioscorea) with rice and refined wheat flours in different proportions (60:30:10 and 50:40:10).

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The product was highly acceptable based on sensory attributes and the vermicelli incorporated with 60 per cent tuber flour, 30 per cent rice flour and 10 per cent refined wheat flour had high score for appearance (3.90), colour (3.90), flavor (3.40), texture (3.50), and taste (3.30) than 50 per cent tuber flour incorporated vermicelli.

Marti *et al.* (2010) conducted a study to prepare pasta from parboiled brown and milled rice flours by using conventional and extrusion-cooking methods. Pasta obtained from brown rice was highly acceptable with firm structure than milled rice flours based pasta.

Karpagavalli and Amutha (2015) prepared vermicelli with rice flour, sorgum flour and green gram flour and the product scored maximum for all sensory attributes like colour (8.6), flavor (8.7), texture (8.6), taste (8.5) and overall acceptability (8.6). Sharma *et al.*(2015) conduct a study to prepare ready to eat extrudates from rice flour and corn flour and deoiled rice bran at different level of moisture (14%, 15% and 16%) and temperature (120^0C and 130^0C). The prepared products were highly acceptable for sensory attributes.

Folorunso *et al.* (2016) standardised a ready to eat extruded snack from rice flour and evaluated its sensory qualities by the panelist. The prepared snack was highly acceptable in colour (4.50/5), texture (4.50/5), aroma (4.35/5), taste (4.60/5) and overall acceptability (4.70/5).

5.1.3 Organoleptic qualities of vermicelli and *payasam* prepared with raw jackfruit flour and jackfruit seed flour

Jackfruit based vermicelli and *payasam* was prepared with raw jackfruit flour and jackfruit seed flour and compared with control. The organoleptic evaluation of vermicelli and *payasam* prepared with control was high followed by raw jackfruit flour and jackfruit seed flour with a combination of 70:30.

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The result of organoleptic evaluation concluded that vermicelli and *payasam* prepared with 70 per cent jackfruit flour and 30 per cent jackfruit seed flour (T_1) had high mean score for appearance (8.4 and 8.35), colour (8.35 and 8.37), flavor (8.33 and 8.31), texture (8.26 and 8.33), taste (8.2 and 8.4) and overall acceptability (8.31 and 8.4) than T_2 (vermicelli prepared with 60 per cent jackfruit flour and 40 per cent jackfruit seed flour).

Pandey (2004) prepared biscuits from 30g of jackfruit seed flour, 100g of wheat flour and 35g of coconut powder. Based on organoleptic evaluation the prepared product was highly acceptable for appearance (4.34/5), colour (4.20/5), flavour (4.18/5), texture (4.14/5) crispness (4.06/5) and overall acceptability (4.18/5). Fifty per cent incorporation of jackfruit seed flour and refined wheat flour *laddoo* had high mean score of 4.60/5, 4.45/5, 3.90/5, 4.02/5, 3.92/5 and 4.17/5 for appearance, colour, flavour, texture, taste and overall acceptance.

Ozioma (2010) conduct a study to prepare nutrient rich cookies incorporated with 30 percent fermented jackfruit seed flour, 20 per cent raw jackfruit flour and 30 per cent whole wheat flour and compared with control (refined wheat flour vermicelli). The prepared product was highly acceptable for sensory attributes like flavour (7.4), taste (7.3) and crumb colour (7.3). The thermoplastic nature and sugary taste of jackfruit flour increased the sensory quality of cookies. Addition of fermented jackfruit seed flour helps to increase the level of vitamin A and C in cookies.

Twenty five per cent incorporation of jackfruit seed flour bread shows good sensory qualities with a score of 7.65, 7.62, 7.42 and 7.15 for colour, flavour, texture and overall acceptability. Cake with jackfruit seed flour (20 to 25 % replacement of wheat flour) was best on overall acceptability. Increase in the substitution of seed flour results decrease in colour, flavour, texture, taste and overall acceptability of the prepared product (Aziah, 2012). Faridah and Aziah (2012) developed a low calorie cake incorporated with jackfruit seed flour (18 per cent) and wheat flour. The prepared product was highly acceptable for sensory qualities.

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Sulthana *et al.* (2014) prepared *chapathi* with jackfruit seed flour, whole wheat flour and bengal gram flour in the proportion of 15:80:5, 30:55:15 and 45:45:10. *Chapathi* incorporated with 15 per cent jackfruit seed flour was highly acceptable than other treatments in terms of colour, flavour, texture and overall acceptability (8, 7.9, 7.7 and 7.7). Abraham and Jayamuthunagai (2014) observed that the firmness of pasta increased with the addition of jackfruit seed flour. Ten per cent jackfruit seed flour substituted pasta showed greater consumer acceptability, in relation to flavour, mouth feel, appearance, colour and overall quality.

Kumari *et al.* (2015) developed raw jackfruit based noodles by mixing refined flour, raw bulb flour and jackfruit seed flour at different proportions. The noodles developed with addition of raw jackfruit flour and jackfruit seed flour has desirable organoleptic properties. Based on sensory analysis, noodles prepared with 10 to 20 per cent incorporation of jackfruit seed flour was highly acceptable. The results of study indicated that samples of jackfruit bulb flour and jackfruit seed flour added noodles contained more protein, fibre and minerals and was less in energy and carbohydrate as compared to control (refined wheat flour noodles) sample.

5.1.4 Organoleptic qualities of jackfruit based vermicelli and *payasam* prepared from roasted flours.

In this study, vermicelli and *payasam* were prepared by using roasted jackfruit flour with roasted whole wheat flour, roasted jackfruit flour with roasted rice flour and roasted jackfruit flour with roasted jackfruit seed flour. Based on sensory evaluation of vermicelli and *payasam*, treatment T_1 (70:30) was selected as best combination from roasted jackfruit flour with roasted whole wheat flour and same trend was observed in the case of roasted jackfruit flour with roasted jackfruit seed flour. Vermicelli and *payasam* prepared with roasted jackfruit flour

and roasted rice flour in the proportion of 60:40 (T_2) had high mean score for appearance (8.28 and 8.75), colour (8.17 and 8.73), flavour (7.88 and 8.64), texture (8.6 and 8.37), taste (8.24 and 8.4) and overall acceptability (7.94 and 8.82).

Chompreeda *et al.* (1987) developed noodles incorporated with roasted peanut flour and wheat flour and it was observed that replacement of 15 % wheat flour with peanut flour resulted in noodles with acceptable sensory qualities. Bread prepared with roasted pinto and navy beans *(Phaseolus vulgaris)* flour had excellent flavor (Silaula *et al.*, 1989).

The present study shows that vermicelli prepared from roasted jackfruit flour (RJF+WWF, RJF+RF and RJF+JSF) had high mean rank score for appearance (14.38, 17 and 7.8), colour (15.50, 14.75 and 7.50), flavour (17, 14.25 and 8.75), texture (16.25, 17.75 and 8.33), taste (15.45, 17 and 8.75) and overall acceptability (16.63, 16 and 9) than unroasted jackfruit flour vermicelli. The comparison of roasted and unroasted jackfruit based *payasam* shows that, roasted flour based *payasam* (RJF+WWF, RJF+RF and RJF+JSF) had maximum mean rank score of 16.8, 15.17 and 8.32 for appearance, 14.67, 16, and 8.33 for colour, 14.58, 15.75 and 6.75 for flavour, 15.50, 15.17 and 8.50 for texture, 16.25, 15.50 and 8 for taste, and 15.50, 15.65 and 8.25 for overall acceptability. The result of the study concluded that roasting increased the sensory attributes of prepared jackfruit based vermicelli and *payasam.*

Roasting is a most important pre-treatment for flours and starches by the application of dry heat. Roasting of flours enhances the colour and texture of products. As a result of roasting, smaller units of starch called dextrin is formed and it is easily digested by the body (Srilakshmi, 2010). Singh and Singh (1991) conducted a comparative study on raw and roasted peanut in food formulations. He concluded that, roasted peanut had a pleasant aroma, nutty flavor and desirable texture than raw peanut.

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Roasted jackfruit flour was suitable the preparation of extruded products due to the less soluble capacity than raw jackfruit flour (Odoemelam, 2005). Roasting increases the amylose content in jackfruit seed flour (Ejiofor, 2014). Incorporation of medium amount of roasted jackfruit seed flour for the preparation of different food was acceptable.

Roasting increases the antioxidant activity, brown colouration and enhances the flavour of products due to the formation of maillard reaction products (Lee and Lee, 2009). Salve *et al.* (2011) formulated supplementary food (*panjiri*) from roasted flours (70 to 80^0 C at low flame) of wheat, soyabean and chickpea. The prepared product was highly acceptable and roasting gave a pleasant flavour to the product.

Mridula *et al.* (2007) conducted a study to know the effect of roasting on texture, colour and flavour of soyabean flour for the preparation of *sattu*. The incorporation of roasted soyabean flour (200^0C for 45 seconds) was found to be more acceptable in terms of colour (7.83), texture (8.11), flavour (8.11) and overall acceptability (7.72).

Addition of roasted flour in food products result in good taste and slight crispy texture (Singson, 2012). Incorporation of roasted flax seed flour in biscuits increase the flavour, texture and overall acceptability than biscuits prepared from raw flax seed flour (Masoodi *et al.*, 2012).

A study was conducted by Ravi *et al.* (2014) to determine the impact of pretreatment of rice flour on the quality characteristics of snack (*seedai*). The product was prepared by using raw (control) and roasted rice flours. The *seedai* prepared with roasted rice flour had higher sensory scores than control. The study revealed that roasting as a method of pretreatment for rice flours to improve the quality of food products. Baba *et al.* (2015) prepared bread from toasted banana flour and wheat flour in 30:70 proportions and the prepared products was highly acceptable in terms of sensory attributes.

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Kinfe *et al.* (2015) conducted a comparative study on roasted and boiled products prepared using chickpea varieties. Based on sensory qualities, roasted flour of chickpea (local variety) was more acceptable in texture and overall acceptability (7.21 and 7.17) than boiled chickpea. Roasted maize flour can be easily transformed into ready-to-eat, digestible, palatable, healthy and nutritious food products (Bala, 2016).

Higo *et al.* (2016) prepared cookies from raw and roasted flours of rice, wheat, maize and foxtail millets. Cookies prepared with roasted flours reduce the hardness and enhance the flavour, taste and overall acceptability than cookies prepared with raw rice. Sharma *et al.* (2017) standardised 3 types of biscuits from foxtail millet flour, roasted flax seed flour and carrot flour (30 per cent) with wheat flour (80 per cent). Based on sensory evaluation, roasted flaxseed flour incorporated biscuits exhibited highest score for colour (7.73), appearance (7.26), taste (7.53), flavour (7.76), crispness (7.96) and overall acceptability (7.73).

5.2. Quality evaluation of selected jackfruit based vermicelli during storage period

The selected six combinations of jackfruit based vermicelli along with control (refined wheat vermicelli) were packed in 250 guage polyethylene pouches for a period of four months. The packed vermicelli was analysed for nutritional, organoleptic and keeping qualities initial and during the second and fourth month of storage.

5.2.1. Effect of storage on the nutritional qualities of selected jackfruit based vermicelli

Moisture is an important parameter of quality determination in food products. The products with low moisture content have enhanced shelf life quality by lowering the microbial load (Abraham and Jayamuthunagai, 2014). Rathore *et al.* (2007) also reported that lower moisture content will give longer shelf stability. In the present study, moisture content was maximum in control (7.75%)

followed by unroasted jackfruit flour based vermicelli (7.53% to 7.62 %) and the least score was found in roasted jackfruit based vermicelli (7.15% to 7.18%). The moisture content increase during storage period especially when the relative humidity is higher around the storage vicinity. The moisture content of prepared jackfruit vermicelli was found to be low compared with the results of Ritthiruangdej *et al.* (2011) who prepared noodles from raw banana flours and the moisture content was 8.67 per cent. Moisture content of rice based vermicelli varied from 10.2 to 12 per cent (Sirirat *et al.*, 2005) and banana based vermicelli had the moisture content of 8 to 9.05 per cent (Indra and Kowsalya, 2014). Rustom (2001) formulated macaroni and vermicelli with semolina and observed moisture content of 7.22 and 6.62 per cent respectively. Kumari and Divakar (2016) reported that moisture content present in raw jackfruit flour and jackfruit seed flour was 7.23% and 7.97% respectively and moisture content of jackfruit noodles (6.40%) had higher moisture content than control (5.79%). The result of the present study showed that moisture content decreased in roasted jackfruit flour vermicelli than unroasted jackfruit vermicelli and the similar result were observed by Agume *et al.* (2017). They conducted a comparative study on the moisture content of roasted and unroasted soya bean flour and found that moisture content decreased in roasted soya bean flour (8.8%) than unroasted soya bean flour (6.9%) and concluded that roasting decrease the ability of flours to interact with water and eliminate water more quickly due to high temperature.

In the present study, energy value of the selected jackfruit vermicelli varied from 267.02 to 282.64 Kcal initially which decreased to 262.54 to 277.63 Kcal during fourth month of storage which was lower than control (3.17 Kcal). The value obtained for jackfruit seed flour incorporated vermicelli was close to the value reported by Torres *et al.* (2010), they observed an energy content of 277.02 Kcal in jackfruit seed flour incorporated cereal bar. The energy content was high in vermicelli prepared from roasted jackfruit flour (257.32 to 282.64 Kcal) than raw jackfruit flour based vermicelli (267.02 to 280.52 Kcal). These finding was in line with the result of Gunashree *et al.* (2014). They reported the

calorific value was increased in roasted wheat flour (367.92 Kcal) when compared to raw flour (335.34 Kcal). Kumari (2015) conducted a study on raw jackfruit and jackfruit seed flour incorporated noodles and reported that energy content of prepared noodles varied from 291.60 to 380 Kcal. Sarah *et al.* (2017) reported that vermicelli prepared with 75 per cent of raw banana flour and 25 per cent of whole wheat flour obtained 304 Kcal of energy. The energy content decreased on storage due to the decreased amount of protein, carbohydrate and fat.

Carbohydrate content in the jackfruit based vermicelli varied from 61.45g 100g $^{-1}$ (RJF + WWF) to the highest of 63.73g 100g $^{-1}$ (roasted RJF + roasted JSF). There was a decrease in the carbohydrate content of the prepared products with a range of 59.18g 100g $^{-1}$ (RJF + WWF) to 62.13g 100g $^{-1}$ (roasted RJF + roasted JSF) on four months of storage. The complex carbohydrate present in vermicelli was converted to simple sugar molecules on storage (Hayakawa *et al.*, 2004). In the present study jackfruit seed flour incorporated vermicelli had high carbohydrate content compared to other treatments. Nandkule *et al.* (2015) prepared noodles incorporated with 20 per cent jackfruit seed flour and the carbohydrate content was found to be 67g 100g $^{-1}$ and it was decreased on second month of storage (65g 100g $^{-1}$). The present study revealed that carbohydrate content of vermicelli prepared from roasted flours was slightly higher than unroasted flours. This observation is similar to the finding of Inyang *et al.* (2015) where the carbohydrate content was low in raw (32g 100g $^{-1}$) compared to roasted (32.58g 100g^{-1}) flours of conophor nut. Khan and Saini (2016) reported that carbohydrate content of roasted flax seed flour (26.72g 100g $^{-1}$) was higher than raw flax seed flour (29.03g 100g $^{-1}$) and they concluded that decrease in the carbohydrate content of raw flax seed flour is due to increased fat, protein, and ash content. Alonso and Grant (2001) reported that inclusion of roasted pea flour in extruded products improved their nutritional quality without reducing the hyper cholesteromic properties.

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In the study, initially the maximum protein content observed in RJF + JSF vermicelli (3.78g $100g^{-1}$) and minimum protein content in roasted RJF + roasted RF vermicelli (2.08g $100g^{-1}$). During fourth month of storage protein content of jackfruit based vermicelli varied from 2.02 to 3.66g $100g^{-1}$ which was significantly lower than control. There was a reduction in protein content on storage. The amino acids present in the products chemically bind with simple sugars to form brown pigments through millard reaction. These complex products decreased the nutritional value and bio availability of protein (Hirsch *et al.*, 1993). During storage protein content of jackfruit seed flour incorporated noodles was decreased day by day due to proteolysis (Nandkule *et al.*, 2015). The result of present study indicates that protein content decreased in vermicelli prepared with roasted flours than raw flours. Kavitha and Parimalavalli (2014) conducted a comparative study on protein content in roasted and unroasted maize flour and the result of the study shows that protein content decreased during roasting from 5.67g $100g^{-1}$ to 4.24g $100g^{-1}$. As a result of roasting, the proteins are coagulated and some amino acids are destroyed (deamination reaction) to form carbanion (Adeyeye, 2010). The Protein present in jackfruit flour consists of subunit structures that dissociate on heating (Odoemelam, 2015). Adegunwa *et al.* (2012) observed that crude protein content of the roasted beniseed (*Sesamum indicum*) flour (18.90g $100g^{-1}$) were lower than that of the raw seed flour (16.45g $100g^{-1}$).

Fat content in jackfruit based vermicelli (initially) varied from 0.80 (roasted RJF+ roasted JSF) to 1.88g $100g^{-1}$ (RJF + WWF) during second and fourth month of storage there was gradual decrease in fat content ranges from 0.69 to 1.76g $100g^{-1}$ and 0.63 to 1.70g $100g^{-1}$. The decrease in fat content during storage could be attributed to the lipolytic activities of the enzyme *lipase* and *lipoxidase* which resulted in the decline in fat content (Murugkar and Jha, 2011). The roasted jackfruit vermicelli (0.8 to 1.2g $100g^{-1}$) had the lowest fat content when compared to raw jackfruit vermicelli (1 to 1.8 g $100g^{-1}$). Goswami *et al.* (2010) reported that the fat content of the raw jackfruit seeds were 0.60 - 0.80g $100g^{-1}$ and roasted jackfruit seeds were 0.54 - 0.71g $100g^{-1}$. During roasting fat

present in flours breaks into free fatty acids, esters and formic acid. Decline in fat content upon heat treatment is due to starch- lipid complex formation (Camire, 2001). Aji *et al.* (2016) observed the fat content of 0.04 g $100g^{-1}$ in jackfruit based meat analog. Morga and Midha (2013) reported that fat content present in wheat vermicelli was 2.7g $100g^{-1}$. Sahoo (2016) prepared jackfruit incorporated bread and buns, and the fat content was very high (2.95 and 3.15 g $100g^{-1}$) than present study.

Total fibre content ranged from 2.2 to 3.89 g $100g^{-1}$ which was decreased to 2.09 to 3.76 g $100g^{-1}$ on fourth months of storage. Among the prepared vermicelli the highest value was observed in roasted RJF + roasted JSF based vermicelli (3.89g $100g^{-1}$) followed by unroasted RJF+JSF based vermicelli (3.13g $100g^{-1}$) and low in control (0.67g $100g^{-1}$). This result is similar with the findings of Thed and Phillips (1995) who reported the fibre content of roasted potato products was higher than unroasted potato products and concluded that increase dietary fibre in roasted flours may be attributed to formation of maillard reaction products. The crude fibre content in raw jackfruit flour observed to increase after roasting from 4.20g $100g^{-1}$ to 4.80g $100g^{-1}$ (Ndyomugyenyi *et al.*, 2014). The fibre content in jackfruit vermicelli helps to protect the colon mucous membrane by decreasing exposure time as well as binding to cancer causing chemicals in the colon (APAARI, 2012). Nandkule *et al.* (2015) reported that 20 per cent incorporation of jackfruit seed flour noodles observed the fibre content of 1.6g $100g^{-1}$ and it was decreased to 1.4g $100g^{-1}$ on 2 months of storage. Crude fibre percentage was decreased on storage due to hydration of fibre because of moisture gain. Hirsch *et al.* (1993) also reported that decrease in fibre content on storage due to degradation of polysaccharide into simple form.

Initially, starch content of jackfruit based vermicelli varied from 84.40 to 96.17 per cent. However there was a decrease in the starch content of vermicelli on storage (79.67 to 94.29 per cent) this may be due to breakdown of starch molecule into simple sugar molecules. Among the six combinations, the highest

starch content of 96.17 and 93.20 per cent was observed in jackfruit seed flour (raw and roasted) incorporated vermicelli. These values were consistent with the findings of Madruga *et al.* (2014), who observed that starch content of jackfruit seed flour was 92.8 to 94.5 per cent. As per the analysis it was found that starch content was reduced in roasted jackfruit flour vermicelli. During roasting the starch present in flours undergo degradation and forms dextrins, the simpler units of carbohydrates (Srilakshmi, 2010). Dry heating had a detrimental influence on the starch digestibility which might be due to the trans-glycosidation reaction. On roasting, a typical glycoside bonds are formed between glucose molecules, increase amylose content and helps in the formation of resistant starch (Ruchi and Mini, 2011).

As reported by Mehta *et al.* (2002) total soluble solids (TSS) is an important criteria for overall acceptability of the products. TSS content of the jackfruit incorporated vermicelli varied from 6 to 6.4^0 brix which is lower than control vermicelli of 10.2^0 brix. The storage period increased the TSS of the prepared vermicelli due to accelerated conversion of poly saccharides into sugars (Kumar and Manimegalai, 2003). TSS of the raw jackfruit varied from 2 to 3.46^0 Brix (Kalpana *et al.*, 2016) and during ripening it was increased to 19^0 Brix (Devi *et al.*, 2014).

As per the result, total sugar and reducing content of jackfruit based vermicelli initially varied from 2.4 to 3.78 per cent and 1.56 to 2.34 per cent. During fourth month of storage total sugar and reducing sugar content varied from 2.81 to 3.91 per cent and 1.75 to 2.5 per cent respectively. The reducing sugar and total sugar were higher in control throughout the entire period of storage. There was an increase in reducing and total sugars content on storage period due to the formation of simple sugars like sucrose, glucose and fructose on starch degradation. In the present investigation vermicelli prepared with roasted and unroasted jackfruit seed flour based vermicelli exhibit low total sugar and reducing sugar when compared to other treatments. These finding was in line with

the result of Pandey (2004) who observed total sugar and reducing sugar in the seeds were 4.60 and 2.70 per cent whereas the raw jackfruit contain 5.42 and 3.38 per cent. Kalpana *et al.* (2016) prepared a spiced health drink mix prepared from raw jackfruit seed flour recorded value of 35.57 per cent for total sugar and 9.09 per cent for reducing sugar and it increased significantly with storage.

The mineral content of jackfruit based vermicelli was compared with control. Among the prepared jackfruit based vermicelli, iron and potassium content was observed to be highest in vermicelli prepared with roasted RJF+ roasted WWF of 6.92mg 100 g^{-1} and 285.34mg 100 g^{-1} respectively, whereas calcium and sodium content was highest in roasted RJF+ roasted JSF vermicelli of 53.17mg 100 g^{-1} and 18.14mg 100 g^{-1} respectively (initially). Mineral content in all treatments decreased on storage may due to the utilisation of nutrients for the growth and multiplication of microbes present in food products (Sunday and Dayo, 2012). These results agree with Balfour *et al.* (2014), they prepared extruded snack from corn flour and rice flour with an iron content of 4.53mg 100 g^{-1} (initially) which decreased to 4.214.53mg 100 g^{-1}on second month of storage. The calcium content of rice flour and bengal gram flour based extruded product was found to be decrease from 342.02mg 100 $g^{-1}$to 322.02mg 100 g^{-1}during four months of storage (Shadan *et al.*, 2014). A similar result was observed by Sharon (2010), Lakshmy (2011), Mohan (2014) and Anaveri (2016) they reported that mineral content of the products decreased on storage. The present study also revealed that roasting of flour increases the mineral content of jackfruit vermicelli. These finding was in line with the result of Inyang *et al.* (2015), they conducted a comparative study on the mineral content of conophor nut flour and found that potassium, calcium, sodium and iron content was maximum in roasted flour (597.30mg 100 g^{-1}, 166.09mg 100 g^{-1}, 64.73mg 100 g^{-1} and 19.98mg 100 g^{-1}) than unroasted flour (586.94mg 100 g^{-1}, 168.51mg 100 g^{-1}, 72.71mg 100 g^{-1} and 21.19mg 100 g^{-1}). Roasting improves the quality of minerals (Liener, 1976). Roasting reduces the activity of anti-nutrients especially oxalates and phytates and increase the bioavailability of essential minerals like calcium, potassium,

magnesium and iron that usually form complexes with these compounds (Grosvernor and Smolin, 2002; Akindahunsi and Salawu, 2005).

5.3.2. Effect of storage on the sensory qualities of selected jackfruit based vermicelli and *payasam*

The selected jackfruit based vermicelli were evaluated for the organoleptic evaluation and compared with control. The mean score obtained for jackfruit based vermicelli and *payasam*, initially varied from 8.20 to 8.53 and 8.35 to 8.82 (appearance), 8.08 to 8.51 and 8.37 to 8.79 (colour), 7.88 to 8.48 and 8.31 to 8.66 (flavour), 7.86 to 8.60 and 8.33 to 8.57 (texture), 7.91 to 8.40 and 8.40 to 8.71 (taste) and 7.82 to 8.55 and 8.40 to 8.73 (overall acceptability) respectively. The sensory qualities of jackfruit based vermicelli were gradually decreased on storage.

Zeb *et al.* (2017) formulated wheat flour based vermicelli and packed in polyethylene pouches for a period of 30 days. They reported that prepared vermicelli was found to be highly acceptable in sensory properties upto 30 days of storage.

Morga and Midha (2013) prepared malted wheat flour based vermicelli and stored in polyethylene bags for two months. They observed that mean score for appearance and taste was 7.3 and 7.5 initially which decreased to 7.2 and 7.3 at the end of storage.

Sowbhagya *et al.* (2000) formulated maize based vermicelli and packed in polypropylene and polyethylene packs. They reported that maize based vermicelli was found to be highly acceptable in sensory properties up to 100 days of storage. Vermicelli prepared with 50 per cent maize flour and wheat flour was acceptable for consumption throughout the storage period of six months (Shobha *et al.*, 2015).

Karpagavalli and Amutha (2015) formulated pasta by incorporating 5 to 10 per cent of cereal pulse blend in wheat semolina flour and evaluated the sensory parameters initially and at end of storage (180 days). The prepared product was highly acceptable throughout the storage.

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Barhua (2014) prepared biscuits with 30 per cent of jackfruit flour and whole wheat flour. The sensory attributes of fresh biscuits decreased from 8.2 to 8 (colour), 7.2 to 7 (texture), 8.4 to 8.2 (taste) and 8.4 to 8 (overall acceptability) during storage.

5.3.3. Effect of storage on the total micro flora of jackfruit based vermicelli and control

In the present study, the bacterial count (initial) varied from 0.24 x 10^6 cfu/g to 0.34 x 10^6 cfu/g which was lower than control vermicelli (0.66 x 10^6 cfu/g). The bacterial count increased during fourth month of storage (1.74 x 10^6 cfu/g to 1.89 x 10^6 cfu/g). Initially, the fungal count was not detected but during second and fourth month it was observed in the range of 0.30 x 10^3 cfu/g to 0.45 x 10^3 cfu/g and 0.49 x 10^3 cfu/g to 0.67 x 10^3 cfu/g respectively which wass less than control vermicelli (0.44 x 10^3 cfu/g and 0.74 x 10^3 cfu/g). The yeast count was not detected in any of the vermicelli during the entire storage period. Thomas *et al.* (2015) carried out a study on the microbial load of rice based vermicelli. They reported that bacterial load varied from 3.54 x 10^6 cfu/g to 6.83 x 10^6 cfu/g and yeast count ranged from 0.98 x 10^3 cfu/g to 1.12 x 10^3 cfu/g. Shobha *et al.* (2015) conducted a study on the microbial load of maize based vermicelli and reported that bacterial load varied from 2.33 to 2.86 x 10^4 cfu/g whereas yeast and mould was found to absent in maize vermicelli. Baskaran *et al.* (2011) prepared noodles and stored in polythene pouches for 2 months. The standard plate count of noodles enriched with skimmed milk powder at 5% level increased from 138.83 to 287.5 cfu/g during storage. The yeast and mould count of noodles was 11.83 initially and increased to 59.66 cfu/g. According to Shobha *et al.* (2011) food with low moisture content and low water activity along with hygienic handling of the product reduce the growth of microorganisms.

5.3. Standardisation of instant *payasam* mix

5.3.1. Cooking time for instant *payasam* mix preparation

Cooking time is an important parameter for instant *payasam* mix. In the present study cooking time of jackfruit based instant *payasam* varied from 4 to 5.45 minutes. The treatments which contained high amount of jackfruit bulb flour took more time for cooking. Similar result (8.26 - 9.26 minutes) was reported by Kumari (2015) in jackfruit based noodles.

Singh and Shurpalekar (1989) prepared *kheer* mix with 30% wheat vermicelli (roasted at 145°C), 30% powdered sugar, 40% whole milk powder, 5% each of preprocessed cashew nuts and raisins and 0.7% cardamom powder. The ready-mix could be processed within 5 min. into *kheer* of the desired taste, aroma and consistency.

Jha *et al.* (2000) prepared ready cook instant *kheer* mix with rice flour, milk powder and sugar, and packed in laminated pouches for 6 months. They found that formulated *kheer* mix had an optimum cooking time of 10 minutes.

Ali (2008) standardised instant *kheer* mix by using rice (25% to 65%), sugar (30% to 50%), modified food starch (7% to 11%), skim milk powder (3% to 7%) and dehydrated carrot (1.5% to 4%). The cooking time of prepared *kheer* mix was found to be less than 8 minutes to produce a *kheer* with an improved appearance, texture, mouth feel and flavor.

Fernandes *et al.* (2013) prepared instant pasta by incorporating modified rice flour and egg albumin in rice flour. They reported that all the formulated pasta had an optimum cooking time of 3 minutes. Rekha *et al.* (2013) prepared instant pasta from vegetables (carrot, beetroot and spinach) and the time required for cooking was 2 to 3 minutes

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Taneya *et al.* (2014) prepared instant noodles from wheat flour incorporated with sweet potato flour at the level of 20 and 30 per cent. The cooking time of the instant noodles was found to be less (2 min.) compared to commercial noodles.

Kashyap (2016) prepared instant *kheer* mix from kodo millet (25%), sugar (37.5%), and milk powder (37.5 %), and standardised the cooking time with control. The prepared *kheer* mix had less cooking time (10.10 minutes) than control *kheer* mix (15 minutes).

Sarma *et al.* (2016) developed ready to cook wheat based instant *payasam* mix and evaluated the sensory acceptability of *payasam* (with 350 ml of milk and sugar) prepared from instant mix. Based on sensory evaluation the prepared *payasam* was highly acceptable. The cooking time of payasam mix was was found to be 15-20 minutes.

5.3.2. Organoleptic qualities of instant *payasam* mix

Payasam, the south Indian counterpart of *kheer* is made in several variations with distinct characteristic attributed to area specific traditional methods of preparation. Normally *payasam* is prepared with rice, vermicelli, green gram and sago, in addition to milk and sugar. The consistency varies from free flowing to semi solid, corresponding to total solids content of 30 to 40 per cent (Unnikrishnan *et al.*, 2000).

Payasam is a most common traditional food item for majority of the population in the country for people of all age groups. The demand of instant food mixes is increasing day by day due to increase in urbanisation, breaking up of the traditional joint family system, time, and convenience and changing lifestyles. *Payasam* mix is a most common food item which consists of roasted vermicelli

along with toasted raisins and cashew nuts, mixed with other ingredients, packed in polypropylene bags (Srinivasan and Nirmala, 2014).

In the present study, Instant *payasam* mix was standardised from selected 6 set of jackfruit based vermicelli with varying proportions of milk (1 L and 1.5 L) and sugar (100,125 and 150g). Based on organoleptic evaluation, 200 g of vermicelli with 1.5 litre milk, 150g sugar, 10g toasted cashew nuts and raisins, and 5g crushed cardamom were highly acceptable for appearance, colour, flavour, texture, taste and overall acceptability.

Sensory quality and shelf stability of carrot *kheer* mix was evaluated by Manjunatha *et al.* (2003) and it was reported that the mix remained acceptable upto 9 months at 25-30^{0}C and 37^{0}C temperature in paper aluminum foil – polypropylene laminate pouches. The reconstituted *kheer* contains 17.70g protein, 57.19 per cent total sugars, 2.5 per cent ash, 1.11 g crude fibre and 23. 9 mg of carotenoid. Unnikrishnan *et al.* (2003) developed an easy to prepare dry mix for *Palada payasam*, which could be stored for one year and was comparable to the traditional product in terms of sensory properties.

A study was undertaken by Kadam *et al.* (2011) to develop a suitable formulation of *kheer* instant mix using roasted and raw basmati rice, sugar and whole milk powder (WMP) in different proportions. *Kheer* mix formulation containing 25 per cent rice with 37.5 per cent of milk powder and sugar produced the desirable quality *kheer* in respect of colour, consistency, flavour and overall acceptability. The *Kheer* with desirable consistency was prepared by reconstituting 100g of *kheer* mix in 600 ml water.

Bunkar *et al.* (2012) developed millet based instant *kheer* mix with 15g of sugar, 30g of dairy whitener and 20g of pearl millet. The reconstituted product from the formulated *kheer* mix had an overall acceptability score of 7.66. The

moisture, fat, protein, carbohydrate and ash contents of the dry mix product were 2.8, 4.38, 5.84, 85.88 and 1.1 %, respectively

Kumar *et al.* (2015) conducted a study to formulate the *Phirni* mix powder and reconstituted it with different proportions of milk (25:75, 50:50 and 75:25). The maximum sensory scores were obtained for a proportion of 50:50 for all sensory attributes namely appearance (7.17), flavour (7.17), texture (7.56) and overall acceptability (7.63).

Gupta *et al.* (2014) standardised cowpea based instant *kheer* mix with 100 ml of toned milk, 25 g instant *kheer* mix, and 10g of sugar and cardamom powder. The prepared *kheer* was highly acceptable based on sensory attributes evaluated using 5 point composite rating scale. The mean scores for appearance, color, taste, consistency, after taste of optimum recipe were 4.53, 4.53, 4.46, 4.73 and 4.66 respectively.

Divakar *et al.* (2014) developed instant banana based *payasam* mix which can be reconstituted with 950 ml of coconut milk, 300 g of sugar, and 10g of cashew nuts, raisins and sago. The prepared *payasam* was highly acceptable in terms of colour (4.88/5), mouth feel (4.92/5), taste (5/5), flavour (4.9/5) and overall acceptability (4.9/5). Gupta *et al.* (2014) developed instant *kheer* mix with cowpea, malted wheat flour, rice, skimmed milk powder and sugar. The optimised product was high in protein (10.27) and had good sensory characteristics (8.05).

Jha *et al.* (2015) prepared wheat based *dalia* (porridge) mix with 17.82 per cent milk powder. This formulation was found to more acceptable with sensory scores (Max. 100) of 85.35, 41.98 and 67.27 for mouth feel, consistency and flavor respectively. Khan *et al.* (2012) found that instant porridge (*dalia*) mix remained stable for 9-12 months respectively in polypropylene (PP) and metallized polyester (MP) pouches under ambient temperature (15-34°C).

Salunkhe *et al.* (2015) prepared carrot based *kheer* with 85 per cent of milk, 8 per cent of sugar and 2 per cent of cardamom. The prepared product was highly acceptable for appearance (42/45), flavour (33.91/35), taste (18.37/20) and overall acceptability (8.13/9).

Sivakumar and Malathi (2016) prepared instant ice cream mix by using mango powder (100g), milk powder (750 g) and sugar (788g). The prepared product was highly acceptable for sensory attributes like appearance, colour, flavour and overall acceptability.

Shahanas *et al.* (2017) prepared jackfruit based instant pudding mix from 40g of raw jackfruit flour, 60g of corn flour, 75g of skimmed milk powder, 75 g of sugar and 2.5 g of thickening agent. The prepared pudding mix was highly acceptable with a mean score of 8.97.

Remya *et al.* (2017) conducted a study to standardise the jackfruit based instant shake mix with a varying proportions of pre-gelatinised raw jackfruit flour, skimmed milk powder and sugar. Based on sensory evaluation, shake mix prepared with 50 per cent raw jackfruit flour was best with a mean score of 8.7 followed by 70% incorporated shake mix (8.3).

Zeb *et al.* (2017) prepared instant *kheer* mix from wheat flour vermicelli (200g), milk powder (500g), sugar (28.34g) and powdered almonds (14.17g) were packed in polythene bag. The prepared product was highly acceptable up to 8 months of storage with a mean score of 8.4, 8.8, 6.5 and 8.5 for taste, texture, flavour and overall acceptability.

5.4. Cost of production of the most acceptable combinations of jackfruit vermicelli's and *payasam* mix.

The cost of jackfruit based vermicelli and instant *payasam* mix varied from 81.36 to 88.21 Rs/Kg and 235.36 to 242.21 Rs/Kg which higher than control (refined wheat flour) of 76.24 and 230.24 Rs/Kg. The cost of prepared vermicelli and *payasam* mix was lower than the market price. The market price of wheat vermicelli, ragi vermicelli, and wheat based instant vermicelli *payasam* mix was observed as 165 Rs/Kg, 180 Rs/Kg and 500 Rs/Kg respectively. Kumari (2015) reported the cost of raw jackfruit flour based noodles was 108 Rs/Kg. Jackfruit based laddoo (90 Rs/Kg), instant drink mix (88 Rs/Kg) and biscuits (50 Rs/Kg) standardised were found to be reasonable in price (Pandey, 2004). Low calorie and high nutritious instant food mixes are most preferred by consumers (Kharthi, 2015). Chahal (2015) reported that instant porridge mix formulated with raw flours of mango and banana was cost effective and highly preferred by the consumers. Incorporation of underutilised fruits like jackfruit for the development of instant mixes increased the nutritive value and reduced the cost.

SUMMARY

6. SUMMARY

The present study entitled "Process optimisation and quality evaluation of jackfruit (*koozha* type) based vermicelli" was proposed to develop jackfruit based vermicelli incorporating raw jackfruit flour, whole wheat flour, rice flour and jackfruit seed flour and to evaluate the acceptability, nutritional and shelf life qualities. The study also aims to develop acceptable instant *payasam* mix with the standardised vermicelli.

The jackfruit based vermicelli was prepared with different combination of raw jackfruit flour at the level of 40 to 70 per cent with 30 to 60 per cent of whole wheat flour/ rice flour / jackfruit seed flour (both roasted and unroasted). Refined wheat flour vermicelli served as the control. Based on organoleptic evaluation, the jackfruit based vermicelli and *payasam* incorporated by roasted and unroasted raw jackfruit flour with whole wheat flour, and raw jackfruit flour with jackfruit seed flour was observed to have highest mean score in treatment T_1 (70:30) and vermicelli prepared with raw jackfruit flour and rice flour (roasted and unroasted) was found to have highest mean score in treatment T_2 (60:30) for all sensory attributes.

The best selected jackfruit based vermicelli (RJF+WWF, RJF+RF, RJF+JSF, roasted RJF+ roasted WWF, roasted RJF+ roasted RF and roasted RJF+ roasted JSF) along with control was packed in polyethylene pouches of 250 gauge and kept in ambient conditions for a period of four months. The selected vermicelli was evaluated for nutritional qualities, organoleptic and microbial evaluation initially and during the second and fourth month of storage.

The moisture content of the jackfruit based vermicelli varied from 7.15 to 7.62 per cent which was lower than control. There was a significant difference between jackfruit based vermicelli and control and the moisture content increased throughout the storage period. The energy content ranged from 267.02 to 282.64 Kcal 100 g^{-1} in selected jackfruit based vermicelli which decreased on storage.

Initially, jackfruit vermicelli observed to have a carbohydrate content of 61.45 to 63.73g 100 g^{-1}, protein of 2.08 to 3.78 g 100 g^{-1} and the fat content varied from 0.80 to 1.88g 100 g^{-1} which gradually decreased on storage. The fibre content was found to highest in roasted jackfruit and roasted jackfruit seed flour based vermicelli with a value of 3.89g 100g $^{-1}$, which decreased during storage to 3.76g 100g $^{-1}$ and lowest fibre content was in control (0.67g 100g $^{-1}$). During roasting, the carbohydrate and fibre content increased whereas protein and fat content decreased.

The starch content declined in all treatments on storage. Initially starch content of jackfruit based selected vermicelli varied from 84.40 to 96.17g 100g $^{-1}$ which was higher than control (83.48 g 100g $^{-1}$). TSS content of the jackfruit incorporated vermicelli varied from 6 to 6.4^0 brix, 6.20 to 6.60^0 brix and 6.40 to 6.90^0 brix initially and during second and fourth month of storage. The reducing and total sugar content present in selected vermicelli increased during storage. The total sugar and reducing sugar content of jackfruit vermicelli, initially ranged from 2.4 (RJF+JSF) to 3.78 per cent (roasted RJF+ roasted RF) and 1.56 (RJF+JSF) to 2.34 per cent (roasted RJF+ roasted RF) which was observed to be lower than control (4.43 and 4.12 per cent). During fourth month total sugar and reducing sugar increased with a variation of 2.63 (RJF+JSF) to 3.91 per cent (roasted RJF+ roasted RF) and 1.75 (RJF+JSF) to 2.57 per cent (roasted RJF+ roasted RF) was lower than control (4.51 per cent and 4.17 per cent).

The mineral content of the selected jackfruit based vermicelli was higher than control. Initially, the selected jackfruit based vermicelli was noted with a variation of 38.13 to mg 53.17g^{-1} (calcium), 6.46 to 6.92 mg 100 g^{-1} (iron), and 15.10 to 18.14mg 100 g^{-1} (sodium) and 238.5 to 285.34mg 100 g^{-1} (potassium). The mineral content decreased on storage. During fourth month calcium and iron content varied from 37.93 to 49.93mg 100 g^{-1} and 6.29 to 6.72 mg 100 g^1. The sodium and potassium content differed from 14.69 to 17.89mg 100 g^{-1}, 234.25 to 280.93 mg 100 g^{-1} respectively.

During storage organoleptic scores of the vermicelli and *payasam* prepared with RJF+WWF, RJF+RF, RJF+JSF, roasted RJF+ roasted WWF, roasted RJF+ roasted RF and roasted RJF+ roasted JSF gradually decreased but maintained an acceptable level throughout the storage. The present study revealed that, the mean score of jackfruit based vermicelli was lower than control throughout the storage whereas jackfruit vermicelli *payasam* (roasted RJF+ roasted RF) was found to have highe score for appearance and colour than control.

Among, the jackfruit vermicelli bacterial load varied from 0.24 x 10^6 cfu/g to 0.33 x 10^6 cfu/g which was lower than control. The fungal count was absent at initially, which increased from 0.27 (roasted RJF+ roasted WWF) to 0.45x 10^3 cfu/g (RJF+RF) at the end of storage. The yeast count was not detected during the storage. No insect infestation was seen in stored vermicelli during four month of storage.

In the present study, instant *payasam* mix was prepared using selected jackfruit based vermicelli with varying quantities of milk (1 and 1.5 L), sugar (100, 125 and 150g), 10g toasted cashew nuts and raisins, and 5g crushed cardamom. Based on organoleptic evaluation, 200g of selected jackfruit vermicelli with 1.5 litre of milk and 150g of sugar (T_6) was selected as the best for the preparation of instant *payasam* mix. The cooking time of jackfruit based vermicelli varied from 4 to 5.45 minutes which was less than the cooking time required for control (8 minutes). The cost of production of jackfruit based vermicelli varied from 81.36 to 88.21 Rs/Kg whereas for control vermicelli it was 72.51 Rs/Kg. The cost for jackfruit based instant *payasam* mix differs from 235.36 to 242.21 Rs/Kg which were higher than control instant *payasam* mix of 230.24 Rs/Kg.

The study concluded that vermicelli and *payasam* prepared with 70% RJF:30% WWF, 60% RJF:40% RF, 70% RJF:30% JSF, 70% RJF:30% WWF, 60% RJF:40% RF and 70% RJF:30% was acceptable in all the sensory

qualities and have good nutritional profile. The selected jackfruit based products were shelf stable without any deterioration up to four month of storage in polyethylene pouches (250 gauges).

Jackfruit vermicelli has highly acceptable sensory attributes with a good nutritional profile, better shelf life, convenience and affordability. Development of vermicelli from raw jackfruit highlights the future prospects and strategy for jackfruit production and utilisation.

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APPENDICES

APPENDIX – I

Score card for the organoleptic evaluation of jackfruit based vermicelli

Name :

Date :

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

9 point hedonic scale

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

Signature

APPENDIX – II

Score card for the organoleptic evaluation of jackfruit vermicelli *payasam*

Name :

Date :

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

9 point hedonic scale

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

Signature

APPENDIX – III

Score card for the organoleptic evaluation of jackfruit based instant *payasam*

Name :

Date :

S No	Parameter	Treatments					
		T_1	T_2	T_3	T_4	T_5	T_6
1	Appearance						
2	Colour						
3	Flavour						
4	Texture						
5	Taste						
6	Overall acceptability						

9 point hedonic scale

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

Signature

PROCESS OPTIMISATION AND QUALITY EVALUATION OF JACKFRUIT (*KOOZHA* TYPE) BASED VERMICELLI

By

AJISHA K. H.
(2015-16-003)

ABSTRACT OF THE THESIS

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ABSTRACT

Jackfruit (*Artocarpus heterophyllus* Lam.), the biggest tree borne fruit in the world, widely available in India, is considered as a wonder fruit. It is a good source of protein, vitamin C, calcium and potassium. Along with nutrients it contain appreciable amount of phytonutrients and antioxidants, and their health benefits are wide ranging from anticancer, antihypertensive, antiaging, antimicrobial and antiulcer. However, the fruit is perishable and cannot be stored for long time because of its inherent compositional and textural characteristics. Jackfruit having firm flesh is called *varikka* and soft textured, fibrous and melting bulbs are referred to as *koozha*. The fruits of *koozha* variety is wasted more than *varikka*. The market potential of jackfruit can be promoted if the fruits are made available to the consumer in a ready to eat or ready to cook form throughout the year. Hence, the present study entitled "Process optimisation and quality evaluation of jackfruit (*koozh*a type) based vermicelli" was undertaken to develop jackfruit based vermicelli and to evaluate its quality attributes. The study also aims to develop acceptable instant *payasam* mix with the standardised vermicelli.

Jackfruit based vermicelli were prepared with different combinations of raw jackfruit flour, whole wheat flour, rice flour and jackfruit seed flour (both roasted and unroasted). Among these, vermicelli prepared with 70% incorporation of raw jackfruit flour and 30% whole wheat flour/ jackfruit seed flour and vermicelli prepared with 60% incorporation of raw jackfruit flour and 40% rice flour (roasted and unroasted) were highly acceptable. The best selected jackfruit based vermicelli along with control was packed in polyethylene pouches of 250 gauge and kept in ambient condition for a period of four months.

The moisture content of the jackfruit based vermicelli varied from 7.15 to 7.62%, which increased on storage. The selected freshly prepared vermicelli were observed to have an energy content of 267.02 to 282.64 Kcal $100g^{-1}$, carbohydrate of 61.45 to 63.73g $100g^{-1}$, protein of 2.08 to 3.78 g $100g^{-1}$, fat of 0.80 to 1.88 g $100g^{-1}$, fibre of 2.2 to 3.89 g $100g^{-1}$ and starch of 84.40 to 96.17 g $100g^{-1}$, which decreased on storage. Initially TSS, reducing and total sugar content varied from 6

to 6.4°brix, 1.56 to 2.34% and 2.4 to 3.78%, which increased to a range of 6.44 to 6.90°brix, 1.75 to 2.57% and 2.63 to 3.91% respectively on storage.

Initially, the mineral content of selected jackfruit based vermicelli was noted with a variation of 6.46 to 6.92 mg $100g^{-1}$ (iron), 38.13 to 53.17mg $100g^{-1}$ (calcium), 15.10 to 18.14 mg $100g^{-1}$ (sodium) and 238.5 to 285.34 mg $100g^{-1}$ (potassium). During fourth month of storage, iron and calcium content varied from 6.29 to 6.72 mg $100g^{-1}$ and 37.93 to 49.93 mg $100g^{-1}$. The sodium and potassium content differed from 14.69 to 17.89 mg $100g^{-1}$ and 234.25 to 280.93 mg $100g^{-1}$ respectively.

Microbial enumeration of the jackfruit vermicelli was done and found to be within the permissible limits throughout the storage. The mean scores for overall acceptability of jackfruit based vermicelli and *payasam,* initially varied from 7.82 to 8.55 and 8.4 to 8.72, which gradually decreased, but still remained at an acceptable level throughout the storage. The products were shelf stable without any deterioration upto four months of storage, in polyethylene pouches (250 gauge).

In the present study, instant *payasam* mixes were prepared using selected jackfruit based vermicelli with varying quantities of milk (1 and 1.5 L), sugar (100, 125 and 150g), 10g toasted cashew nuts and raisins and 5g crushed cardamom. Based on organoleptic evaluation, 200g of selected jackfruit vermicelli with 1.5 litre of milk and 150g of sugar was selected as the best for the preparation of instant *payasam* mix. The cooking time of jackfruit based vermicelli varied from 4 to 5.45 minutes. The cost of production of jackfruit based vermicelli varied from 81.36 to 88.21 Rs/Kg. The cost of jackfruit based instant *payasam* mix comes in between 235.36 to 242.21 Rs/Kg.

Jackfruit vermicelli has highly acceptable sensory attributes with a good nutritional profile, better shelf life, convenience and affordability. Development of vermicelli from raw jackfruit highlights the future prospects and strategy for jackfruit production and utilisation.