Development of Jack Fruit Based Ready -To - Cook (RTC) Instant Mixes

by

LIJI A.J

(2012 – 16 - 107)

DEPARTMENT OF HOME SCIENCE

COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM-695 522

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THESIS

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KERALA, INDIA

2014

DECLARATION

I, hereby declare that this thesis entitled **"Development of Jack Fruit Based Ready - To - Cook (RTC) Instant Mixes"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associate ship, fellowship or other similar title, of an other University or Society.

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Certified that this thesis entitled **"Development of Jack Fruit Based Ready - To - Cook (RTC) Instant Mixes"** is a record of research work done independently by **Ms. Liji A.J.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associate ship to her.

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Dedicated to my family

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LIST OF ABBRIVATIONS

cfu/g	- colony forming unit per gram
Fig	- figure
g	- gram
g/100g	- gram per 100 gram
Kcal/100g	- kilocalories per 100 gram
min	- minute
ml	- milliliter
OVQ	- overall visual quality
PE	- polyethylene
PLW	- physiological loss of weight
RTC	- Ready to cook

Introduction

1. INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* Lam.) is the largest edible fruit in the world. Jackfruit is widely grown in Southeast Asia. It is also grown in parts of Central and Eastern Africa, Brazil, and in islands of West Indies such as Jamaica. It is the national fruit of Bangladesh and Indonesia. The tree is well adapted to the the humid tropical climate. A tree may yield as many as 150 large fruits annually which are attached to the trunk and its lateral branches, while some exotic varieties bear even 250 to 500 fruits per year (Kumar *et al*., 2012).

The total area in India under jackfruit cultivation is around 97,000 ha and the jack tree is largely grown in southern states viz., Kerala, Tamil Nadu, Karnataka and Andhra Pradesh. They are grown to a lesser extent in Assam, Bihar, Orissa, Maharashtra and West Bengal (DAC, 2014).

The interior of a fruit consists of large, yellow bulbs (fully developed perianths), which constitutes 25-30 per cent of the total fruit. They are mixed along with narrow ribbons of thin undeveloped perianths and a central pithy core. Each bulb encloses a smooth, oval, light brown seed (endocarp) covered by a thin white membrane (exocarp). The seed is 2-4 cm long and 1.5 – 2.5 cm thick. There may be 100-120 or upto 500 seeds in a single fruit comprising 5-6 per cent of the total fruit (Molla *et al.*, 2008).

Jackfruit (*A. heterophyllus*) is a good source of vitamins, fibre and minerals. It can be incorporated into food products to increase the nutritional content. It possesses a wide variety of nutritional elements such as carotene, Vitamin-B_1, Vitamin-B_2 and potassium. Fructose, glucose and sucrose are found to be the major sugars it contains Carpic, myristic, lauric, palmitic, oleic, stearic and linoleic are found as the major fatty acids found, with varying proportions in different parts of jackfruit.

Jackfruit is well known for its ethnic taste and is used in various cuisines in different countries. In northern Thailand, boiled jackfruit is used in the thai salad called '*tam kanun*'. In West Bengal green jackfruit is used as a vegetable to make various spicy curries, side dishes and fillings for cutlets and chops. In Indonesia,

mature jackfruit is cooked as '*gudeg*'. In many parts of China, jackfruit is a frequent ingredient in sweets and dessert. In Vietnam, jackfruit is used to make jackfruit '*che*' and *jackfruit puree*. In Reunion Island it is cooked either alone or with animal flesh such as shrimp or smoked pork. The seeds are generally eaten in boiled or roasted form or used in many culinary preparations, as it contains similar constituents as that of grains.

Varied dishes like' idi chakka thoran' and 'theeyal' from unripe fruits; jack fruit chips from the not so mature fruits, 'chakka puzhukku', 'avial', 'chakka punju thoran' from the core, jack fruit, seed fry, seed covering fry and many more dishes form an important part of Kerala cuisine (Anitha, 2014).

In Kerala, though jackfruit is not cultivated intentionally, it grows widely in many parts of the state and it is common knowledge that a significant portion of the production goes waste due to many reasons. Invariably the production season coincides with monsoon, making the fruits unacceptable in taste. Besides, difficulties in harvesting, extracting the edible ripe fruit making the hand sticky, attraction of flies are some of the main reasons constraining its wide scale use.

Besides jackfruit is perishable and cannot be stored for a long time because of its inherent compositional and textural characteristics. Every year, a considerable amount of jackfruit, specially obtained in the glut season (June-July) goes waste due to lack of proper postharvest knowledge during the stage of harvesting, transporting and storing, which affects both the quality and quantity. Proper postharvest technology for prolonging shelf life has therefore become necessary. Besides, alternate ways of using jackfruits in season can reduce postharvest losses. Here- in, processing techniques have a major role. It adds diversified and attractive food items in daily meals, as well as contributes to the generation of income and employment, when commercially processed.

Though a variety of products have been made from jackfruit, its consumption has decreased over the years. This is mainly due to its cumbersome handling procedures, which is making it unpopular even in rural areas. In this context, developing a convenient ready to cook (RTC) product with this ethnic fruit maintaining all its sensory qualities would be of tremendous value for urban

as well as rural housewives. Moreover, for the Malayalees staying away from Kerala in particular, jackfruit means nostalgia. Therefore, there is ample scope for marketing such RTC jack fruit based products to these migrated population. Such an effort would cater to the needs of such Malayalees and also to the larger population who crave for variety. Therefore, this study envisages to develop value added products from raw jackfruit and evaluate its quality parameters.

Review of literature

2. REVIEW OF LITERATURE

The literature of the present study entitled " Development of jackfruit based Ready To Cook (RTC) instant mixes", is presented under the following subheads:-

2.1. Importance of dehydration of vegetables

2.2. Nutritional significance of jackfruit

2.3. Health benefits of jack fruit

2.4. Value added products from jackfruit

2.1. IMPORTANCE OF DEHYDRATION OF VEGETABLES

Drying is one of the oldest methods for the preservation of food products. Newer techniques of drying such as heated air drying with hygienic and economic considerations have been developed. This method has been referred to as dehydration (Das *et al.*, 2004; Motevali *et al.*, 2010).

Removal of water from foods is the critical to enhance the shelf life of vegetables and dehydration is one such technique, widely used to preserve agricultural produce. Dehydration simultaneously combines heat and mass transfer. The fundamental aspect of food dehydration is to reduce the availability of water in food to such an extent, that it is favourable for microorganisms and favorable for minimizing rates of chemical reactions. Dehydration is one of the oldest methods of food preservation and an important stage in food processing (Lima *et al.*, 2002). Dehydration not only facilitates reduction in the bulk of fresh material, but also facilitates easy transport because of the reduced weight and volume and also increases availability of food throughout the year.

Dehydration is an important method adopted in food processing industries. Drying aims at removing the water in the food up to a level where microbial spoilage and deterioration reactions are greatly minimized. There is a wide variety of dehydrated foods available nowadays to the consumer in the form of snacks, soups or dried fruits, dry pickles etc. The shelf life and energy saved compared to other materials make it inevitable in the food industry (Krokida *et al.*, 2003).

Dried food could be consumed directly or treated as secondary raw material (Menges and Ertekin, 2006). The hot-air drying of food materials has advantages such as better control of product quality, achievement of hygienic conditions, and reduction of product loss (Corzo *et al*., 2008). Food scientists have found that by reducing the moisture content of food to between 10 and 20%, bacteria, yeast, mold and enzymes are all prevented from spoiling it. Flavor and most of the nutrients are preserved and concentrated through this method (Dennis, 1999)

Dried items are rich sources of energy, assorted vitamins, i.e vitamin K and B, minerals, i.e magnesium and phosphorus, anti-oxidants, i.e iron and folic acid and fibres (soluble fibres). This is mainly due to the concentration of nutrients during processing (Konopacka *et al.*, 2009), thereby providing necessary energy to the body.

Pardeshi *et al*. (2009) have identified that the structure of dried foods depends on the drying methods and conditions such as temperature, relative humidity, air velocity and initial physico-chemical characteristics of the product. Also, the quality of end product in terms of sensory and other physico-chemical factors is significantly influenced by drying conditions (Simal *et al*., 2005).

Cucumber is a fruit which has low sugar content and low calorific value and has a high nutritional value (Maroto, 1995). Henriques *et al*. (2008) reported that, the air drying (60ºC) and freeze drying of cucumber produced products with properties more similar to the fresh cucumber, thus allowing to preserve the characteristics of this food product with respect to its colour, texture, chemical properties, antioxidant activity and phenolic compounds.

According to USDA (2009), besides carbohydrates, sweet potato is also rich in dietary fiber and has high water content and also provide 359 kJ energy with low total lipid content, which is only about 0.05 g per 100 g. In addition, sweet potatoes also are high in minerals such as potassium, calcium, magnesium, sodium, phosphorus, and iron. Sweet potatoes began to be pureed and then dried to produce flakes, which could be easily reconstituted for direct use in various products like curries, pies and other products (Dawkins and Lu, 1991). Truong *et al*. (1998) reported that, dried sweet-sour sweet potato could be made with boiled

sweet potato slices (0.3 mm thick) which were then soaked in 60° Brix syrup containing 0.8 - 1.0% citric acid and dried at 65°C.

Papaya (*Carica papaya* L.) is a nutritious fruit which is widely consumed. Drying is one of common processes to preserve papaya for longer shelf-life. Hot air drying is widely used in agro-industry to dry fruits and vegetables due to the simple and flexible processes (Zhang *et al*., 2006).

Gupta *et al*. (2013) reported that cauliflower dried in convective hot air drier at 60°C gave the best product with respect to maximum vitamin C content, higher rehydration ratio and minimum browning.

Gokhale and Lele (2011) developed red beet root powder by convective hot air drier. The author found that the final colour of beet was temperature dependant and maximum colour retention was achieved at a drying temperature of 65°C. Best drying conditions required sequential reduction in temperature resulting in good colour retention.

Dehydrated chips of cassava is an unfermented product. Drying improved the shelf life of the tuber and also helped in the process of detoxification (Irinkoyenikan *et al*., 2008)

To overcome the high perishability of fresh tubers due to the high moisture contents, yams were processed into flour by peeling, slicing, blanching and sun-drying (Akissoe *et al*., 2001). Dried and milled yam is less perishable and can be consumed throughout the year, mainly to produce starch (Akingbala *et al*., 1995).

Pua *et al*. (2007) developed drum dried jack fruit powder with different concentrations of soy lecithin and gum arabic. The study revealed that jack fruit puree with incorporation of 2.65 per cent soy lecithin and 10.28 per cent gum arabic were suitable for the production of good quality jack fruit flour.

Vishwanathan *et al*. (2010) reported that hot air assisted infrared (IR) drying of potato and carrot improved the quality of products. Higher rehydration ratio and lower browning index values were observed. Dehydration of carrot shreds was carried out by concentrating the material first in sucrose solution (50° Brix) at room temperature prior to drying in cabinet drier at 55±1°C. Half the initial moisture content was removed during the initial 30 minutes of osmosis and

additional 6 hours were required to reduce the moisture content of the osmosed carrot shreds to 5.8 per cent.

Studies on combined IR and hot air drying of onions indicated an improvement in product quality as compared to hot air drying (Praveenkumar *et al.*, 2005).

Pumpkins are good sources of carotenoids, and some varieties are rich in provitamin A, mainly α-carotene and β-carotene (Marek *et al.*, 2008). Pumpkin fruit is also a valuable source of other vitamins, e.g., B6, K, thiamine, and riboflavin, as well as minerals, like potassium, phosphorus, magnesium, iron and selenium (USDA 2004). Lee and Lim (2011) reported that osmotic dehydration using sucrose solution was able to improve the quality of hot air dried pumpkin slices in term of the colour, shrinkage, texture, aroma as well as sensory acceptability.

Dehydrated tomato products are increasing all over the world due to the possibility of using them in pizza toppings, snacks and other savoury dishes (Gisele *et al*., 2004; Lewicki *et al.*, 2002).

Microwave vacuum drying (MWVD) is the combined application of microwave heating and vacuum condition. It has been applied in the drying of mint (Therdthai and Zhou, 2009) and durian (Baingew *et al*., 2011) to improve rehydration ability and texture of dried products, respectively.

Nimmanpipug and Therdthai (2013) reported that lower hardness and chroma were observed in microwave vacuum dried papaya after osmotic – dehydration. It yielded fine porous structure and the rehydration rate which was significantly higher than hot air drying.

Besides reducing the drying time, osmotic dehydration is used to treat fresh produce before further processing to improve sensory, functional and even nutritional properties. It has been proven to improve the texture characteristics of thawed fruits and vegetables (Chiralt *et al.*, 2001; Talens *et al.*, 2002).

Osmo-air dried bitter gourd slices upon rehydration had higher sensory score for flavour, colour and appearance, body and texture and overall acceptability. The moisture content in dried bitter gourd slices ranged from 2.5 -3.0%. The

rehydration and dehydration ratio in osmo-air dried bitter gourd slices varied from 2.12 – 2.28 and 5.6 – 6.5, respectively. The extent of browning was in the range of 0.11 to 0.12 in osmotic drying. The values for Vitamin C and carotenoids were in the range of 2.22 – 2.42 and 3.2 – 4.9 mg/100 g, respectively (Singh *et al*., 2009).

Mui *et al*. (2002) developed a process for drying banana chips. The process involved removal of 90 per cent moisture by drying followed by vacuum microwave drying. The resultant banana chips were crispier with markedly higher volatile levels and sensory ratings than air dried.

Choudhary and Ahmed (1995) reported that osmotically dehydrated papaya slices had good colour, flavor and texture, it could be used as snacks.

Onion powder was prepared by osmotic dehydration of onion slices 5 mm thickness after drying in a cabinet drier at 62°C for ten hour which could be stored for six months (Sagar, 2001).

Osmotic dehydration is described as the partial dehydration of fruits through the process of osmosis, which involves immersion of fruits in hypertonic solution at given temperature for specific periods of time (Ponting, 1973). The combination of osmo-convective dehydration with a mild drying process such as microwave drying is considered to be worth because of its high potential to improve the overall quality of dehydrated fruit products in shorter time than other drying methods (Prothon *et al*., 2001).

Kaur and Singh (2014) reported that, the osmotic dehydration in combination with hot air followed by microwave finish drying can be used for preservation of beetroot slices with retention of quality.

2.2. NUTRITIONAL SIGNIFICANCE OF JACK FRUIT (*Artocarpus heterophyllus* Lam.)

Fresh vegetables contain nutritional and health promoting constituents, including minerals, antioxidant components, vitamins, such as C, E and A, phytochemicals such as folates, glucosinolates, carotenoids, flavonoids and phenolic acids, lycopene, selenium and dietary fibers along with being relatively low in calories (Murcia, 2009).

Artocarpus heterophyllus Lam. contains various chemical constituents such as several flavone colorings, morin, dihydromorin, cynomacurin, artocarpin, isoartocarpin, cyloartocarpin, artocarpesin, oxydihydroartocarpesin, artocarpetin, norartocarpetin, cycloartinone, and artocarpanone (Rao *et al*., 1973).

Srivastava (1953), Hossain and Haque (1977) reported that Jack fruits are normally very fibrous and are composed of mono, di, and polysaccharides. The ripe fruits are reported to contain glucose, fructose and sucrose which impart sweetness to the fruit. The total sugar content is reported to be 14.50 per cent of which alpha glucose, beta glucose, fructose and sucrose constitute 3.63, 2.33, 1.74 and 6.90 per cent respectively (Chan and Hen, 1975).

Roy and Mitra (1970) reported that carbohydrate is one of the main components of the seed starch being the most abundant source of polysaccharide for human consumption.

Bobbio *et al*. (1978) reported that the seeds contain starch, which is characterized by rounded or bell shaped granules of size from 7 - 11µ with an amylase content of 15 – 28 per cent and a glucose composition of more than 99 per cent. The starch was found to form a highly rigid gel; the initial pasting temperature was 74.50°C with a peak viscosity at 94°C.

Kumar *et al*. (1988) analyzed the proximate composition of jack seeds (Variety Kathari and Bharat Baremasi). They reported that jack fruit seeds were good sources of carbohydrate, protein and minerals.

Sadasivam and Neelkantan (1976) found that jack fruit bulbs are rich in sugars and contained fair amounts of carotene, protein and minerals. Nunjundaswamy and Mahadeviah (1993) reported that the edible bulb yield from jack fruit is about 29 per cent which contained 25 per cent carbohydrate and 1 per cent total ash.

Gomes and Zitade as early as (1954) evaluated the biological quality of dehydrated jack fruit. They reported that jack fruit contained about 1.90 per cent protein on fresh weigh basis.

Novis and Coutinho (1952) reported that the protein content of jack fruit seeds was 9.40 per cent. The digestibility-coefficient and biological value of the seed protein was reported to be 71.50 per cent and 28 per cent respectively.

The total lipids (24.40 per cent) of wild jack fruit comprised of 63 per cent neutral lipids, 21 per cent glycolipids and 16 per cent phospho lipids (Ngiefu *et al.*, 1976). Bose and Mitra (1990) reported that fats present in the ripe fruit were quite low (0.1g/100g of edible portion) as compared to 0.3g/100g of edible portion in tender fruit. More over fat present in the seed were reported to be more (0.4g/100g of edible portion).

Jack fruit is a rich source of carotene, but is poor souce of vitamin C content. Hossain and Haque (1979) reported that jack fruit contained 2.64 – 11.77 mg of ascorbic acid and 250 – 1440 mg of carotene.

Candish (1983) reported that jack seeds are good source of vitamin B_1 and B_2. Lal and Pattambiraman (1976) reported that mineral content of seeds is 1.5 per cent, containing calcium (0.05mg) and phosphorous (0.13mg).

Wong and Kah (1982) reported that jack bulbs yielded 0.8 – 1.5 per cent ash, which contains a number of elements including nitrogen, phosphorous, potassium,calcium, magnesium, sulphur, boron, chloride, copper, iron, manganese, molybdenum, zinc, cobalt, chromium, nickel, lead and mercury.

The carotenoids of *A. heterophyllus* were identified as carotenes β-carotene, α-carotene, β-zeacarotene, α-zeacarotene, and β-carotene-5,6-epoxide, as well as a dicarboxylic carotenoid and crocetin (Chandrika *et al.*, 2005). The main carotenoids in jackfruit were shown to be all-trans-lutein (24% to 44%), all-trans-β-carotene (24% to 30%), all-trans-neoxanthin (4% to 19%), 9-cis-neoxanthin (4% to 9%), and 9-cis-violaxanthin (4% to 10%) (Faria *et al.*, 2009). Jackfruit is a good source of provitamin A carotenoids, though not as good as papaya (Chandrika *et al.*, 2005).

Jackfruits have more protein, calcium, thiamine, riboflavin and carotene than banana but less nutritious than mango (Hossain *et al.*, 1979)

A portion of 100 g of jackfruit pulp provides 4 mg niacin (Soobrattee *et al.*, 2005). Every 100 g of ripe fruit pulp was found to contain 18.9 g carbohydrate,

1.9 g protein, 0.1 g fat, 77% moisture, 1.1 g fiber, 0.8 g total mineral matter, 20 mg calcium, 30 mg phosphorus, 500 mg iron, 540 I.U. vitamin A, 30 mg thiamin, and 84 calories (Samaddar, 1985).

Jackfruit seed powder contained manganese and magnesium elements (Barua and Boruah 2004). Jackfruit seed contained phenolic compounds (Soong and Barlow 2004) and about 6.03 mg/g of extracted nonreducing sugar (Nuallaong *et al*., 2009).

The fruit is rich in carotene, potassium, carbohydrates and moderately rich in ascorbic acid (Samaddar, 1985). They also reported that the seed is mainly used in curries, and reported to be more nutritious than the bulb, being richer in protein, fat, potassium and carbohydrate with considerable amount of phosphorus and calcium.

Vitamin C (ascorbic acid) is a water-soluble free radical scavenger. The daily recommended dietary allowance is 60 mg. In jackfruit 12 to 14 mg vitamin C is present per 100g serving as a normal protecting antioxidant (Narasimham, 1990). Bobbio *et al*. (1978) reported protein, crude lipid, and carbohydrate contents of jackfruit seeds as 31.9%, 1.3%, and 66.2%, respectively. The fresh seed contained crude proteins (6.6 g), fat (0.4 g), carbohydratres (38.4 g), fiber (1.5 g), ash (1.25 to 1.50 g), and moisture (51.6 to 57.77 g) (Morton, 1987).

Hossain *et al*. (2000) reported that tender jack fruit contained 85 per cent moisture, 0.81 per cent ash, 2.40 per cent protein, 7.58 per cent total sugar, 12.48 per cent ascorbic acid, 86.31 per cent β–carotene, 31.22 per cent calcium, 1.46 per cent iron and 38.13 per cent phosphorus.

2.3. HEALTH BENEFITS OF JACK FRUIT

Epidemiological studies have shown a strong and consistent protective effect of vegetable consumption against the risk of several age-related diseases such as cancer, cardiovascular diseases, cataract and macular degeneration (Turkmen *et al*., 2005).

Although most people love to eat jack fruit for its sumptuos taste, only a few are aware of the benefits it provides to our body. In spite of the fact that it is high in carbohydrates and calories, the health benefits of jack fruits are numerous.

The functional components of jackfruit reduce the various diseases such as blood pressure, heart disease, strokes and bone loss. It helps to improve muscle and nerve function and reduce homo cysteine levels in the blood. The potassium in the jackfruit is found to help in lowering blood pressure and reverse the effect of sodium that causes a rise in blood pressure and affects the heart and blood vessels. This helps in preventing heart disease and strokes. Potassium also helps in preventing bone loss and improves muscle and nerve function. Another heart-friendly property found in the jackfruit is due to presence of vitamin B6 that helps to reduce homo cysteine levels in the blood thus lowering the risk of heart disease (Fernando *et al*.,1991).

Fresh fruit is a good source of potassium, magnesium, manganese, and iron. Potassium is an important component of cell and body fluids that helps control heart rate and blood pressure (SCUC, 2006)

Jackfruit is gluten-free and casein-free, thus offering systemic anti-inflammatory benefits to skin. Jackfruit also contains antioxidants and has vitamin C, flavonoids, potassium, magnesium and fiber. Vitamin C is vital to the production of collagen, a protein that provides skin with structure and gives it its firmness and strength (Babitha *et al*., 2004).

Due to the side effects of using some drugs for ulcer there is a need to find new anti ulcerogenic compounds with potentially less or no side effects. Medicinal plants have always been the main sources of new drugs for the treatment of gastric ulcer (Borrelli and Izzo 2000) One of the plants that have been traditionally used in Indian and Malay folklore medicine to treat gastric ulcer is *A. heterophyllus L* (Rates, 2001).

The presence of high fiber content (3.6 g/100 g) in the jackfruit prevents constipation and produces smooth bowel movements. It also offers protection to the mucous membrane of colon by removing carcinogenic chemicals from the large intestine (colon) (Siddappa, 1957).

Jackfruit is rich in magnesium (27 mg/100 g in young fruit and 54 mg/100 g in seed) (Gunasena *et al.*, 1996). It is a nutrient important in the absorption of calcium and works with calcium to help strengthen the bone and prevents bone-related disorders such as osteoporosis (Singh *et al.*, 1991).

Priya (2014) reported that the seeds of jack fruit have been found to increase blood circulation, which helps in promoting the healthy growth of hair. They also contain good amount of Vitamin A, one of the most important vitamins essential to maintain the proper growth and health of the hair.

Jackfruit also contains iron (0.5 mg/100 g), which helps to prevent anemia and also helps in proper blood circulation (Singh *et al.*, 1991).

Copper plays an important role in thyroid gland metabolism, especially in the hormone production and absorption of iodine and jackfruit is loaded with this important micromineral (Gunasena *et al.*, 1996).

Another benefit of eating jackfruit is that it is a good source of vitamin C. The human body does not make vitamin C, so one must eat foods that contain vitamin C to reap its health benefits. The health benefits of vitamin C are that it is an antioxidant that protects the body against free radicals, strengthens the immune system, and keeps our gums healthy (Umesh *et al.*, 2010).

Root of jackfruit has been found to help those suffering from asthma. Consuming the extract of the root of the jackfruit tree has been found to control asthma. Jackfruit root has also been used to treat skin problems. The extract of jackfruit root is believed to be able to help cure diarrhoea and fever (Samaddar, 1985). Jackfruit contains useful antioxidants (Devasagayam *et al.*, 2004), which prevent many human diseases. Antioxidants are substances that neutralize free radicals or their actions (Sies, 1996). The natural antioxidants in fruits and vegetables have gained increasing interest among food scientists, nutrition specialists, and consumers, as they are claimed to reduce the risk of chronic diseases and promote human health (Ribeiro *et al.*, 2007).

Carotenoids present in the jack fruit can protect humans against certain specific chronic ailments, including cancer, cardiovascular disease, and age-related macular degeneration (Mayne, 1996; Giovannucci, 1999).

Phytonutrients are natural compounds found in plant-based foods that give plants their rich pigmentation, as well as their distinctive taste and aroma. They are essentially the plant's immune system and offer protection to humans as well (Umesh *et al.*, 2010). There are thousands of phytonutrients that may help prevent cancer as well as provide other health benefits (Ko *et al.*, 1998).

Jacalin, the major protein from *A. heterophyllus* seeds, is a tetrameric two-chain lectin combining a heavy chain of 133 amino acid residues with a light *β*chain of 20 to 21 amino acid residues. It is highly specific for the O-glycoside of the disaccharide Thomsen-Friedenreich antigen (Galβ1-3GalNAc), even in its sialylated form. This property has made jacalin suitable for studying various O-linked glycoproteins, particularly human IgA_1 (Kumar *et al.*, 1988). Jacalin's uniqueness in being strongly mitogenic for human $CD4^{+T}$ lymphocytes has made it a useful tool for the evaluation of the immune status of patients infected with human immunodeficiency virus HIV-1 (Pereiradisilva *et al.*, 2006). Seeds also contain 2 lectins namely jacalin and artocarpin. Jacalin has been proved to be useful for the evaluation of the immune status of patients infected with human immunodeficiency virus 1 (Haq, 2006).

Theivasanthi and Alagar (2011) studied the antibacterial effect of nanosized particles of jackfruit seed against *E. coli* and *B. megaterium* microbes and revealed the efficacy of jackfruit seed nanoparticles as an antibacterial agent. Specific surface area (SSA) analysis of jackfruit seed has concluded that nanoparticles in jackfruit seed can lend antimicrobial effects to hundreds of square meters of its host material. Jackfruit seeds may therefore be developed into therapeutic agents capable of treating infectious diseases and preventing food contamination by food-borne pathogens.

2.4. VALUE ADDED PRODUCTS FROM JACK FRUIT

Krishnaveni *et al.* (2000) opined that the jackfruit is a rich source of phytochemicals, including phenolic compounds, and offers opportunities for the development of value-added products, such as neutraceuticals and food applications to enhance health benefits. They also opined that jack fruits are

consumed in fruit as well as raw forms for various culinary preparations. The author further reported that the fruit has a delicious taste, captivating flavor, attractive colour and excellent quality which makes it suitable for processing and value addition.

Shruthy (2005) observed that jack fruit possesses excellent processing qualities with good sensory appeal and hence it is highly suitable for value addition and processing.

Madhavan (1994) is of the opinion that inspite of the huge production of jack fruit, its processing has not gained much attention when compared to other fruits. Nunjundasway and Mahadeviah (1993) reported that the difficulty in the collection of fruit, separation of bulb from the rind, uncertainly and variability in the yield and quality are the major problems involved in the utilization of jack fruit.

2.4.1. Jackfruit Wine

Joshi and Bharathkumar (2004) reported that wine is the oldest known fermented food revealed in the ancient scriptures. Joshi *et al*. (1991) stated that there is considerable scope for fruit based fermented beverages in India, especially wine and vinegar. Two fermented products, which can be prepared from jack fruit pulp are wine and vinegar.

The ripe jackfruit contains a good amount of fermentable sugars, which may be exploited for the commercial production of vinegar and wine. Amit and Ambarish (2010) reported that the maximum alcohol content in jack wine was 10% (v/v), with a sugar utilization of 14% of total sugar solids. These results show promise for the use of this fruit for commercial wine production. A certain maturity level and ripeness of jackfruit (29 to 30 °Brix) are essential for the production of jackfruit wine. The jackfruit wine may protect against antioxidant and DNA damage and could become a valuable source of antioxidant rich neutraceuticals. Additionally, the wine could be a commercially valuable bi product for the jackfruit growers (Umesh *et al*., 2011).

Almost every civilization had characteristic wine or other alcoholic beverages. Composition wise, fruit wines are far more nutritious than distilled

beverages due to the possession of sugars, acids, minerals and vitamins. Jack fruit, in general contains high amount of easily fermentable sugars which make it a suitable medium for the growth of wine yeast. Krishnaveni *et al.* (2000) standardized wine from two varieties (*Local* and *Vellipala*) of jack fruit. Organoleptic qualities of the wine fermented were found to be acceptable and comparable with grape wine.

Dahiya and Prabhu (1977) studied alcoholic beverages made by fermentation of jackfruit pulp. The tribal people of Nagaland, Tripura, and other eastern hilly areas of India consume jackfruit wine. The wine contains 7 per cent to 8 per cent (v/v) alcohol. Junkai and Wang (2008) reported that when using jackfruit as the main material, wine was produced by temperature-controlled fermentation. With comparative tests, the optimal processing parameters were determined. The additional amount of pectinase was 100 mg/L, SO_2 content 50 to 100 mg/L, fermentation temperature 24 ^oC, sugar content adjusted to 21 per cent and the active dry yeast 5 per cent.

2.4.2. Jackfruit Vinegar

Vinegar is another fermented product which can be formulated from jack fruit. Datta and Biswas (1972) had described the process for making vinegar from the fruit juice. They further reported that the jack fruit vinegar recovered from the ripe fruit yielded 7 per cent alcohol and 6 per cent acetic acid upon formulation.

Khader (1999) standardized a method for preparation of vinegar from jack fruit, which was found to have a shelf life of one year.

2.4.3. Jackfruit Squash

Bhatia *et al.* (1956) standardized a refreshing beverage with pleasant taste and aroma from the bulbs of ripe jack fruit, which was found to have a shelf life of 60 weeks when stored in room temperature (24°C - 30°C).

Sadasivam and Neelkantan (1976) found that jack fruit squash could be stored for one year at room temperature without any change in quality except for a slight reduction in vitamin C content. Singh *et al.* (2001) standardized a method for producing squash from jack fruit.

Bhatia *et al.* (1956) suggested the fortification of jack fruit squash with vitamin C and found that ascorbic acid was 50 – 70 per cent when stored at room temperature and 88 – 97 per cent when stored at 2.5°C. The ascorbic acid fortified sample exhibited increased browning especially at high temperature during storage. Mondal *et al.* (2013) also standardized the production of squash from jack fruit.

2.4.4. Canned Jackfruit Product

Shanmugam *et al.* (1992) pointed out that canning is widely practiced to extend the period of availability of fruits. Jack fruit bulbs both raw and ripe could be successfully canned for subsequent use in vegetable curries and also for table purpose (Berry and Kalra,1987).

Giridharilal *et al.* (1960) standardized a method for canning raw jack fruit bulb in brine solution containing 0.5 – 0.75 per cent citric acid.

Bhatia *et al.* (1956) reported that canned jack fruit when stored at room temperature (24 – 30°C) was found to retain normal colour and characteristic taste and aroma however the product when stored at 37°C for 19 weeks depicted deteriorative changes. Siddappa and Bhatia (1956) reported that canned jack fruits were found to retain β carotene content even after 6 months of storage.

Bhatia *et al.* (1957) investigated the retention of ascorbic acid in canned jack fruit and found that the stability of the vitamin was low in canned jack fruit when compared with other commercially important canned fruits.

2.4.5. Jackfruit Nectar

Nectar is the pulp of the fruit blended with sugars and citric acid to obtain a product of 15 – 20 Brix with mild acid taste. (CFTRI, 1977). Fruit nectar is the concentrated form of fruit pulp having honey like consistency. Singh *et al.* (2001) opined that nectar is a ready to serve beverage like juice. They formulated ready to serve beverages from jack fruit pulp with 10 per cent pulp content, 12 TSS and 0.3 per cent acidity. Chopra and Chouhan (2001) developed ready to serve beverage from jack fruit with a composition of 10% of juice, 10% of TSS and 0.3% acidity. Shruthy (2005) standardized fruit nectar. Two varieties of jack fruits

were utilized for formulating fruit nectar individually and by blending with other fruit pulps so that nectar of different flavor and taste could be formulated.

2.4.6. Dehydrated Jackfruit

Diamante (2009) reported that dehydrated jackfruit is a nutritious snack item when made from ripe jackfruit pulp. It is golden-yellow to orange and has a chewy texture with a sweet and sour taste. Unlike other dehydrated products it is free from sulfite preservatives thus it will not trigger allergic reaction in sensitive consumer.

Bhatia *et al*. (1956) recommended steeping of jack fruit bulbs in 0.1 per cent KMS solution for 30 minutes in order to improve the quality of the dried products. Good quality dehydrated products were obtained (drying ratio 3:1) when sulphured at the ratio of 16 lbs sulphur/ton/fruit/1000 cfl space (Shanmugam *et al*., 1992).

Zuniga *et al*. (2004) developed osmotically dehydrated jackfruit (*Artocarpus integrifólia*) slices. Jackfruit was dehydrated with sucrose solutions at 30°C (40 °Brix, 50 °Brix and 60 °Brix) for three hours. Kinetics of drying was conducted using a convective tray drier at 50°C, 60 °C and 70°C.

Taib *et al*. (2013) developed microwave vacuum and hot air dehydrated jackfruit. Results revealed that microwave vacuum dehydrated jackfruit bulbs obtained higher rehydration ability, scored higher in the sensory evaluation in term of colour, appearance and aroma attributes.

2.4.7. Preserved Jackfruit Bulbs

Fresh jackfruit bulbs are a consumer preferred commodity and relished well by all sections of population. Ready-to-eat fresh jackfruit bulbs along with seeds were preserved under vacuum (760 mm lbs) by treating with 1.5% KMS and 0.5% sodium benzoate (Ukkuru and Pandey, 2005). Preserved bulbs depicted negligible changes in the chemical constituents and were organoleptically stable for a period of 15 days under refrigeration. Singh and Mathur (1954) investigated the freezing of jackfruit bulbs.

2.4.8. Clarified Juice

Khader (1999) reported that the juice extracted from the various fruits contain mainly sugars and small quantities of vitamins and minerals. John and Narasimham (1993) standardized the preparation of clarified juice from jackfruit in which jack fruit pulp was subjected to enzyme treated at 0.3 per cent level. Clarified juice recovery was 60 per cent with a pH of 0.15 to 0.20 per cent. Shruthy (2005) developed a clarified juice. Enzyme treatment was attempted to get clarified juice from jack. Maximum yield of juice from jack fruit pulp was obtained when the pulp was treated with 1 per cent enzyme incubated for two hours at 40°C.

2.4.9. Dehydrated Jack Fruit Flakes

Dehydrated jack fruit flakes with a shelf life of one year was standardized at KAU (1999). The flour prepared from dehydrated jack fruit flakes was found to be suitable for preparing chapathis, 'pazhampori' and 'baji' by replacing wheat flour, maida or bengal gram flour respectively with jack fruit flours.

2.4.10. Jackfruit Chips

Jagadeesh *et al.* (2006) reported on the findings about jackfruit chips. The starch content and dry matter content of the raw material determined the yield of the processed product. Flake thickness, bulb length, total sugar solids, and reducing sugars were found to be important for improving the yield and quality of jackfruit chips. Molla *et al.* (2008) stated that preparation of jackfruit chips is very simple and can easily be done.

2.4.11. Jackfruit Bar

Ready to eat fruit bars are well-relished products which are being commercially prepared in our country. Fruits like mango, papaya, pineapple, guava, jamun, jack fruit and banana individually or in combination could be used for preparing fruit bars (Krishnaveni *et al.*, 1999).

Krishnaveni *et al.* (1999) standardized the preparation of jack fruit bar from two varieties of jack fruit. They also investigated the suitability of different packing methods for the storage of the products. The results indicated that jack

fruit bar stored in MAP recorded high per cent of nutrient retention and minimum microbial count.

2.4.12. Cereal Bars with Jackfruit

Santos *et al*. (2011) developed a home made and alternative cereal bar using dehydrated jackfruit and seed meal as a fiber source, due to the availability of this fruit in the region, without reducing the nutritional values.

2.4.13. Jackfruit Powder

Kumar *et al*. (2012) standardized jack fruit powder by applying dehydration or drying and freeze drying techniques. Jack fruit juice could be made with jack fruit powder.

2.4.14. Jackfruit Pickles

CFTRI (1977) presented tender jack fruit in the form of pickles *viz*., sweet oil pickle, spiced vinegar pickle and plain vinegar pickle.

Mondal *et al*. (2013) standardized green pickle and assessed its quality parameters. It was found to have high vitamin C content (3.44 mg/100 g) and also high amount of (22.78 mg/100 g) carotenoids.

2.4.15. Jackfruit Bulb in Sugar Syrup

After selecting the fully ripened jackfruit and extracting the bulbs, seeds were removed from the bulb. The bulbs were added into sugar solution (25% sugar and 0.5% citric acid). The bottles could be stored at room temperature (28-32°C) for 10 months (IOTC, 2013).

2.4.16. Jackfruit Papad

Jackfruit bulbs, which are neither fully mature nor completely raw could be used for preparing jack fruit papads (Bhatia *et al*., 1956). They found that jack fruit papads had a shelf life of 4-6 month at room temperature (24 - 30°C) wrapped in paper. Ukkuru and Pandey (2005) standardized jackfruit papads of different taste and flavour from raw jackfruit which were very crispy and tasty when fried.

2.4.17. Candied Jackfruit

Candying of fruit is widely practiced to extend its utilization. Giron *et al.* (1975) prepared candied jack fruit by osmotic dehydration. Jack fruit bulbs were sliced and immersed in sugar syrup of 70°Brix. It was then dried at 60°C.

Bindu (1995) conducted a study to standardize osmotic dehydration in two varieties of jack fruit. Result indicated that organoleptically acceptable and shelf stable products could be prepared by applying a pre-treatment of 30 min immersion in 70° brix at 50°C for soft flesh variety of jack fruit. Same treatment without any preservatives could be applied for the firm flesh variety of jack fruit.

2.4.18. Jackfruit Jelly

Jack fruit rind contain fair amounts of sugar and pectin which could be used for pectin extraction. Siddappa and Bhatia (1956) have standardized a method for preparing jelly and suggested an extract - sugar ratio of 1:1 with 0.6 and 0.8 acid for preparing a good quality jelly.

Mondal *et al.* (2013) developed jackfruit rind jelly after separation of the rind from the fully matured, fresh ripened jackfruit. High total soluble solids (65.00 %) and pH (5.04) were found in this jelly on qualitative analysis. But vitamin C content was found to be lower(1.61 mg/100 g). They also developed jack fruit bulb jelly, whose total soluble solids was found to be 64 per cent.

2.4.19. Jackfruit Jam

The fruit pulp can be used to make jam with the addition of a synthetic flavoring agent such as ethyl or n-butyl ester of 4-hydroxybutyric acid at 100 and 120 ppm. This greatly improved the taste of the jackfruit products (ICUC, 2004). Mondal *et al.* (2013) developed jack fruit jam. Qualitative analysis inferred that the retention of vitamin C was about 1.77mg/100 g and carotenoids was (9.607 mg/100 g). Most of the fruit jams in supermarkets are prepared with a generous amount of sugar. Jackfruit jam is full of natural sugars and low in calories making it an ideal food source to reduce body weight.

2.4.20. Jackfruit Jam Blended with Avocado and Kokum

Kushala *et al.* (2012) developed a blended jack fruit jam with jack fruit, avocado and kokum in an effort to improve its quality and sensory evaluation.

Results showed that the jack fruit jam could be blended with avocado and kokum containing 55 per cent juice, 0.5 per cent of acidity and 70° Brix. It was found to be acceptable with good organoleptic scores for appearance (4.12), aroma and flavour (4.33), taste (4.27) and overall acceptability (4.09). The product was free from spoilage for 120 days of storage.

2.4.21. Jackfruit Leather

Solar dried jack fruit leather was standardized by Okiya *et al*. (2010). Ukkuru and Pandey (2005) standardized plain and blended jackfruit leather from two varieties of jackfruit which proved to have distinct taste and flavour. Blending papaya pulp with jackfruit pulp imparted better appearance, colour and textural qualities, while blending with mango pulp resulted in better flavour, taste and overall acceptability. Products exhibited good keeping quality and consumer acceptance.

2.4.22. Jackfruit Based Sweets

Various sweet delicacies such as halwa elayappam, ada, jack fruit payasam could also be prepared from jack fruit bulbs. KAU (1999) standardized jack fruit halwa by using pulp of varikka and koozha varities. Halwa prepared in hot sugar syrup was found to be highly acceptable to the consumers. A dairy based jack fruit dessert was standardized at Andalas University (Ahamad and Pulia, 2010). Ukkuru and Pandey (2005) standardized jackfruit halwa (varatty) - a traditional product of Kerala and toffee by using pulp of varikka and koozha varieties. The product remained stable for a period of 12 months and was found to be highly acceptable to the consumers.

2.4.23. Ready- To -Eat (RTE) Tender Jackfruit Curry

Lakshmana *et al*. (2013) standardized Ready to Eat (RTE) tender jackfruit curry which was prepared and processed by using steam air retort with an overriding pressure of 15 lbs. The cumulative lethality value was 6.0 with a total processing time of 45 minutes. The tender jack fruit curry was stored under ambient (27 - 30°C). The product was acceptable and stable up to 12 months under ambient condition with good texture and sensory characteristics.

2.4.24. Jackfruit Seed Flour

Gandhi *et al.* (1974) reported that jack seed may be converted into flour after inactivating the antinutritional factors present by drying. The flour prepared from jack fruit seeds can be used for making chapattis by blending with wheat flour (25:75).

Singh *et al.* (1991) analysed jack fruit seed flour and found that it contained 16.3 per cent protein and globulins. In vitro digestibility of seed protein was 89 per cent with emulsion capacity of 17 per cent.

Rajarajeshwari and Prakash (1999) studied the properties of seed protein and its utilization in product development. They found that jack fruit seeds were a good source of protein and exhibited low water and fat absorption capacity. Hence flour could be incorporated in the preparation of deep fried products.

Studies conducted by KAU (1999) found that jack seed flour can be used for preparing cereal/ pulse based fried preparations like 'vada', 'pazhapori', 'baji' and 'puri' by replacing 50 per cent of flour of cereal/ pulses. The products were found to be highly acceptable in the sensory evaluation tests. It was further reported that flour from seeds of varikka variety were better than koozha for the preparation of various products.

Tananuwong *et al.* (2002) evaluated the possibility of substitution of jack seed flour in bread preparation. With 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. The study revealed that, less than 5 per cent of wheat flour can be replaced with jack seed flour in the bread preparation.

Shruthy and Ukkuru (2011) standardized acceptable jack seed flour based health mixes and confectionary products.

Naik (2007) incorporated 10 to 50 per cent jack seed flour in the ratio of 50:50 blend of wheat flour (maida and full wheat flour) for the preparation of cookies. The product at 20 and 30 per cent incorporation were acceptable with

good sensory profile, while 50 per cent incorporation was acceptable but had hard texture.

Airani (2007) developed jack seed flour biscuits. The diameter of biscuits gradually increased with increase in the proportion of seed flour. It was observed that, 50 per cent seed flour based biscuits exhibited highest diameter (4.21 cm). Ocloo *et al.* (2010) reported that the jackfruit flour produced may be used as thickening and binding agent in food systems.

The roasted jack seeds were reported to resemble chestnut in nutritive value and flavor and also much liked by people (Berry and Kalra 1987). However the shelf life of fried seeds was low, these could not be stored for more than a few days at room temperature (24 - 30°C) (Bhatia *et al.*, 1956).

2.4.25. Traditional Preparations from Raw Jackfruit

Raw jackfruit is consumed in Kerala during season mainly as 'avial', 'koottu' and 'olath'. They are traditional Kerala preparations. In 'avial' cooked long slices of jackfruit are blended with coconut and related spices and served along with rice. In preparation of 'olath' cooked slices of jackfruit are blended with onion and seasoned in oil. In 'koottu' otherwise known as 'puzhukku' raw jackfruit cut in small rounds are cooked and blended with coconut based paste. In all three preparations jack seeds are added to enhance the taste.

Jack seed are also used separately to prepare fries and curries.

'Avial', 'koottu' and 'olath' are the typical dishes of Kerala, so they were selected for processing into RTC mixes for this study.

Materials and methods

3. MATERIALS AND METHODS

The methodology of the present study entitled " Development of jackfruit based Ready To Cook (RTC) instant mixes", is presented under the following heads:-

3.1. Selection and collection of jackfruit

3.2. Standardization and product development

3.3. Packaging and storage

3.4. Quality assessment of dehydrated jackfruit

3.1. SELECTION AND COLLECTION OF JACKFRUIT

Jackfruit koozha type was selected for the study. Raw mature jackfruits were harvested from trees grown in the Instructional farm based on external visible maturity indices such as distance between spines, number of spines per unit area, colour of spines and the number of days elapsed from fruit set (95-110 days).

3.2 . STANDARDIZATION AND PRODUCT DEVELOPMENT

A standardized recipe is one that has been tried, adopted and retried several times for use by a given food service and which has been found to produce the same acceptable results and yield, each time when the exact procedures are used with the same type of equipment and the same quantity and quality of ingredients (USDA, 2001). Standardization of recipes is an essential strive for high quality products. According to Tolute (2000), the procedure for recipe standardization begins with the process of recipe modification or adjustment.

Three popular raw jackfruit based dishes of Kerala were identified for standardization namely, *Avial, Koottu* and *Olath*.

3.2.1. Preliminary Processing of Jackfruit Bulbs and Seeds

Freshly harvested jackfruits were washed under clean water and cut into large slices. The bulbs and seeds were separated. The fresh weight of bulbs and seeds were recorded in order to determine the final yield of the processed product after dehydration.

3.2.1.1. *Standardization of Width of Slices*

Selection of appropriate width of slices of the vegetables to be dried is very important, as thicker slices will dry at a slower rate or may not dry fully and it may subsequently deteriorate after packing than thinner pieces. But in the case of very thin pieces there is a tendency to stick to the drying trays and will also be difficult to remove. So the size and thickness of the jackfruit slices and seeds were standardized. The bulbs and seeds were sliced into required size for the 3 products, *Avial, Kootu* and *Olath*. The best of these variations were identified by evaluating the Overall visual quality (OVQ) using a 1 -9 point scale where, 9 refers to excellent and fresh appearance, 7 to good, 5 to fair (limit of marketability), 3 to fair useable but not saleable and 1 to unusable (Yuan *et al.,* 2010), by a panel comprising of 10 members. The variations in width of jackfruit bulb and seed slices that were evaluated are given in Table 1.

Table 1. Variations in width of bulbs and seeds

Sl No	Treatments	Width (cm)
1.	T_1	0.5
2.	T_2	1
3.	T_3	1.5
4.	T_4	2

3.2.1.2. *Standardization of Blanching Time*

Blanching is a unit operation prior to freezing, canning or drying in which fruits or vegetables are heated for the purpose of inactivating enzymes; modifying texture; preserving color, flavor, and nutritional value; and removing trapped air. Hot water is used as heating media for blanching in industry (Corcuera *et al.,* 2004).

The best identified width of jackfruit bulbs and seeds for the three preparations was subjected to blanching. The optimum blanching time was thus identified by analyzing the scores of OVQ as rated by the sensory panel after blanching. The different periods of time studied are depicted in Table 2.

Table 2. Variation in blanching time of raw material

Sl.No.	Treatments	Time (min)
1.	T_1	3
2.	T_2	5
3.	T_3	7
4.	T_4	10
5.	T_5	15

3.2.1.3. *Standardization of Pre-Treatment Media*

Pretreating fruits and vegetables for storage is an important step in preserving the produce. It retains the natural colour of the food produce and inactivates enzymes that can cause food spoilage. Torreggiani (1993) reported that pretreatment with chemicals (SO_2), or blanching prior to drying of fruits and vegetables effected the prevention of discolouration.The pre-treatment media giving the best product with respect to appearance and colour was identified. The various treatments applied to the blanched slices are given in the Table 3.

Table 3. Composition of various pre-treatment media

Sl No	Treatments	Particulars
1.	T_1	Salt (0.5%)
2.	T_2	KMS (0.2%)
3.	T_3	Ascorbic acid (0.1%)
4.	T_4	Citric acid (0.2%)
5.	T_5	Salt (0.5%) + KMS (0.2%)
6.	T_6	Salt (0.5%) + Ascorbic acid (0.1%)
7.	T_7	Salt (0.5%) + Citric acid (0.2%)
8.	T_8	KMS (0.2%) + Ascorbic acid (0.1%)
9.	T_9	KMS (0.2%) + Citric acid (0.2%)
10.	T_{10}	Ascorbic acid (0.1%) + Citric acid (0.2%)

Table 3 Continued

Sl No	Treatments	Particulars
11.	T_{11}	KMS (0.2%) + Ascorbic acid (0.1%) + Citric acid (0.2%)
12.	T_{12}	KMS (0.2%) + Ascorbic acid (0.1%) + Citric acid (0.2%) + Salt(0.5%)

Hundred grams of blanched slices were immersed in one litre water with the respective additives. The best of these variations were again identified by analyzing the scores of OVQ, as rated by the sensory panel.

3.2.1.4. ***Standardization of Immersion Time***

Immersion of various vegetables in alkaline or acid solutions prior to drying affected the prevention of discolouration (Sunkja and Raghavan, 2004).

The blanched bulbs and seeds were immersed in the selected media. Most suitable immersion time in the selected media for retaining maximum sensory qualities was identified on the basis of scores obtained on hedonic scale for OVQ. Table 4 presents the various time periods chosen for the studies.

Table 4. Variations in immersion time

Sl No	Treatments	Time (min)
1.	T_1	10
2.	T_2	15
3.	T_3	20
4.	T_4	30
5.	T_5	45
6.	T_6	60

3.2.2. Formulation Of Ready To Cook (RTC) Dehydrated Product from Jackfruit

3.2.2.1. *Avial Mix*

The adjuncts in *Avial* namely jackfruit bulbs, seeds, green chilly, crushed red chilly, red chilly powder, pepper, garlic, turmeric, jeera and curry leaves were mixed in different combinations and proportions (g) as given in Table 5.

Table 5. Proportion of adjuncts in RTC *Avial* mix

Sl No	RTC product	Ingredients	Proportion of ingredients(g)
1.	AP_1	Jackfruit bulbs and seeds + Crushed Red chilly + Garlic + Jeera + Turmeric powder + Curry leaves	100*: 3:5: 1: 2:5
2.	AP_2	Jackfruit bulbs and seeds+ Red chilly powder + Garlic + Jeera + Turmeric powder + Curry leaves	100*: 3:5: 1: 2:5
3.	AP_3	Jackfruit bulbs and seeds + Greenchilly + Garlic + Jeera + Turmeric powder + Curry leaves	100*: 3: 5:1: 2: 5
4.	AP_4	Jackfruit bulbs and seeds + Pepper + Garlic + Jeera + Turmeric powder + Curry leaves	100*: 3: 5: 1: 2: 5
5.	AP_5	Jackfruit bulbs and seeds + Pepper + Greenchilly + Garlic+ Jeera + Turmeric powder + Curry leaves	100*: 1.5: 1.5: 5: 1: 2: 5

* The ratio of jackfruit bulbs to seeds was 60:40

3.2.2.2. *Koottu Mix*

The adjuncts in *Koottu* namely jackfruit bulbs, seeds, green chilly, red chilly, red chilly powder, pepper, turmeric, cumin and curry leaves were mixed in following different combinations and proportions as depicted in Table 6.

Table 6. Proportion of adjuncts in RTC *Koottu* mix

Sl No	RTC product	Ingredients	Proportion of ingredients (g)
1.	KP_1	Jackfruit bulb and seeds + Red chilly + Turmeric powder + Cumin + Curry leaves	100*: 3:1: 3: 5
2.	KP_2	Jackfruit bulbs and seeds+Red chilly powder + Turmeric powder + Cumin + Curry leaves	100*: 3: 1: 3: 5
3.	KP_3	Jackfruit bulbs and seeds + Greenchilly + Turmeric powder + Cumin + Curry leaves	100*: 3: 1: 3: 5
4.	KP_4	Jackfruit bulbs and seeds+ Pepper + Turmeric powder + Cumin + Curry leaves	100*: 3: 1: 3: 5

* The ratio of jackfruit bulbs to seeds was 60:40

3.2.2.3. *Olath Mix*

The adjuncts in *Olath* namely jackfruit bulbs, seeds, greenchilly, red chilly crushed, red chilly powder, pepper, turmeric, onion, garlic and curryleaves were mixed in different combinations and proportions (Table 7).

Table 7. Proportion of adjuncts in RTC *Olath* mix

Sl No	RTC product	Ingredients	Proportion of ingredients (g)
1.	OP_1	Jackfruit bulbs and seeds+ Crushed Red chilly + Onion+ Garlic + Turmeric powder + + Curry leaves	100*: 2: 10: 5:1: 5
2.	OP_2	Jackfruit bulbs and seeds+Red chilly powder + Onion +Garlic + Turmeric powder + Curry leaves	100*: 2:10: 5: 1:5
3.	OP_3	Jackfruit bulbs and seeds + Green chilly + Onion + Garlic + Turmeric powder + Curry leaves	100*: 2: 10:5: 1: 5
4.	OP_4	Jackfruit bulbs and seeds + Pepper + Onion + Garlic + Turmeric powder + Curry leaves	100*: 2: 10: 5: 1: 5
5.	OP_5	Jackfruit bulbs and seeds + Pepper + Green chilly + Onion + Garlic + Turmeric powder + Curry leaves	100*:1.5:1.5: 10: 5: 1: 5

* The ratio of jackfruit bulbs to seeds was 60:40

All the formulations were dehydrated at 65°C till crisp. These dehydrated formulations were cooked and subjected to organoleptic evaluation.

Organoleptic evaluation or sensory analysis is a scientific discipline that applies principles of experimental design and statistical analysis to the use of

human senses *viz*., sight, smell, taste, touch and hearing for the purpose of evaluating consumer products (IFT, 2005).

3.2.3. Standardization of Cooking Methods of Ready To Cook Dehydrated Products from Jackfruit

Dehydrated products are in an acceptable stage for cooking, only if they are reconstituted with water. Besides the details of reconstitution is essential to be conveyed to the consumer. Here the reconstitution time and media were standardized.

3.2.3.1. *Optimization of Reconstitution Time of RTC Products*

The dehydrated *Avial, Olath* and *Kootu* mixes were reconstituted in different time durations. For this the formulated ready to cook mixes were soaked in cold water and evaluated for sensory qualities after cooking till done.

Table 8. Variations in reconstitution time of formulations

Sl No	Treatments	Time (min)
1.	R_1	10
2.	R_2	15
3.	R_3	20
4.	R_4	30
5.	R_5	45

3.2.3.2. *Optimization of Cooking Procedures and Cooking Time*

For optimizing cooking procedures proportion of RTC mixes and water were in the ratio of 1:5. Water was strained out from the reconstituted mixes and subjected to different cooking methods. Cooking time was also evaluated for all the three mixes by the members of the panel. The variations studied are presented in Table 9 and 10.

Table 9. Variations in cooking procedures

Sl.No.	Treatments	Particulars
1.	CP_1	Cooking in plain hot water
2.	CP_2	Cooking in strained hot water*
3.	CP_3	Cooking in plain cold water
4.	CP_4	Cooking in strained cold water*

* Strained water is the excess water after rehydration of the product

Table 10. Variations in cooking time

Sl.No.	Treatments	Time (min)
1.	C_1	6
2.	C_2	8
3.	C_3	10
4.	C_4	15

3.2.3.3. *Optimization of Additional Ingredients to be Added During Cooking*

Grated coconut and coconut oil are essential ingredients in Kerala dishes. Since they are perishable ingredients they were not included in the RTC mixes. Instead grated coconut and oil were added into *Avial, Koottu* and *Olath* mixes in different proportions while cooking as given Table 11 and 12

Table 11. Proportion of coconut in 50g of *Avial* and *Koottu* dry mixes

***Avial* Mix**			***Koottu* Mix**	
Sl.No.	**Treatments**	**Amount (g)**	**Treatments**	**Amount (g)**
1.	C_1	10	P_1	15
2.	C_2	20	P_2	25
3.	C_3	30	P_3	35
4.	C_4	40	P_4	45
5.	C_5	50	P_5	50

Table 12. Proportion of oil in 50g of *Avial* and *Olath* dry mix

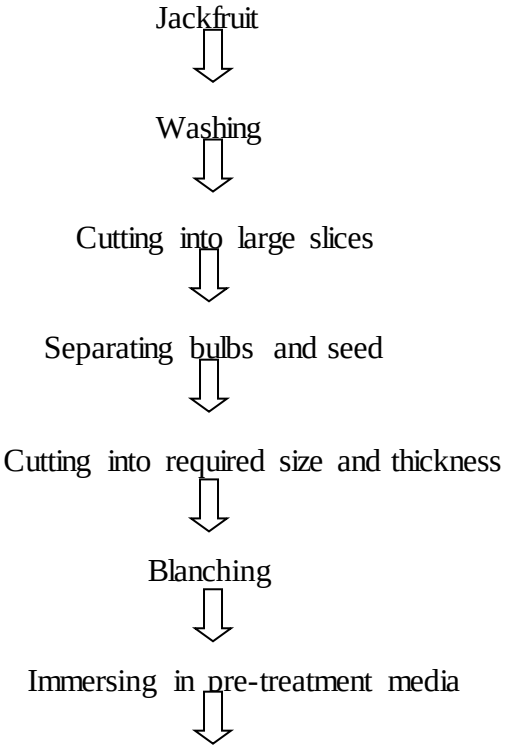
***Avial* Mix**			***Olath* Mix**	
Sl.No.	**Treatments**	**Amount (ml)**	**Treatments**	**Amount (ml)**
1.	T_1	1.5	R_1	1.5
2.	T_2	2.5	R_2	2.5
3.	T_3	3.5	R_3	3.0
4.	T_4	4.5	R_4	4.0
5.	T_5	5.0	R_5	5.0

The different treatments were evaluated by the sensory panel and the scores were analysed to identify the best treatment.

3.3. PACKAGING AND STORAGE

The standardized dehydrated *Avial, Kootu* and *Olath* were stored in PE and laminated pouches in ambient conditions and shelf life was assessed in periodic intervals (monthly) for 3 months.

The standardized preparation of jackfruit RTC mixes developed is presented in the following flow diagram (Figure 1).



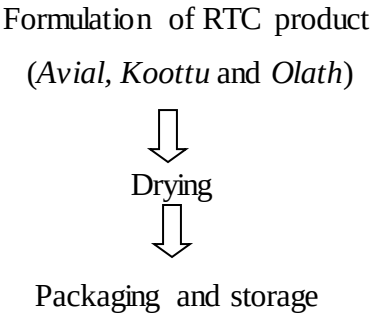


Fig. 1. Flow diagram for preparation of RTC product.

3.4. QUALITY EVALUATION OF THE RTC JACKFRUIT *AVIAL, KOOTU* AND *OLATH* MIXES

Quality parameters with respect to physical and chemical characteristics were analyzed. Besides parameters like cost, sensory attributes and shelf life were also evaluated to ascertain consumer acceptance.

3.4.1 Cost of the Developed Products

Cost of the developed products of the mixes were analyzed based on input cost i.e. cost of different ingredients used for the preparation of the product, cost of packaging materials and output cost (10 per cent of the cost of products were added as overhead charges for fuel and labour to the total input cost added).

3.4.2. Physical Characteristics of Dehydrated Mixes

Appearance, moisture, yield, weight loss, rehydration ratio and bulk density of the developed RTC products were studied.

3.4.2.1. *Appearance*

Appearance is the criteria for the desirability of any food product. Appearance of the dehydrated mixes was evaluated by the OVQ, as rated by a sensory panel.

3.4.2.2.*Moisture*

Five grams of sample was weighed into a previously weighed moisture cup and dried in an oven at 130°C till a constant weight was attained.

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

(Airani, 2007)

3.4.2.3. *Yield*

The weight of the product in relation to raw material used was calculated using the formula.

$$\text{Yield \%} = \frac{\text{Weight of dried jackfruit mixes}}{\text{Weight of fresh jackfruit}} \times 100$$

3.4.2.4. *Weight Loss of Jackfruit*

For determining of weight loss of jackfruit ,the weight of the jackfruit was recorded before treatment and after dehydration and the total loss of weight was then calculated by subtracting the final weight of the vegetable from the initial weight. The results were then expressed in percentage using following formula.

$$\text{Weight loss \%} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

3.4.2.5. *Rehydration Ratio*

Rehydration ratio of RTC *Avial, Olath* and *Kootu* mixes were recorded. About 10gm of sample was mixed with 100ml of distilled water and stirred for 5 minutes. The contents were filtered using a filter paper. The rehydrated sample was weighed and rehydration ratio was calculated using the formula.

$$\text{Rehydration ratio} = \frac{\text{Initial weight of the sample}}{\text{Drained weight of the sample}}$$

3.4.2.6. *Bulk Density*

Bulk density is an indicator of drying retention and accurate weighing repeatability. It also helps in deciding the type of packing. Bulk density is the ratio of the weight of the sample to the weight of an equal volume of water. The sample was taken in a measuring cylinder. It was leveled without compressing. The weight of the sample with the beaker was recorded. The sample was then removed from the beaker and water was filled to the same level. The weight of the water with beaker was recorded and calculated using the formula.

$$\text{Bulk density} = \frac{\text{Weight of the sample}}{\text{Weight of equal volume of water}}$$

3.4.3. Assessment of Consumer Preference

Preference tests allow consumers to express a choice between samples, one sample is preferred and chosen over other samples (Watt *et al.*, 1989). A preference test was conducted among the consumers (both semi trained and untrained) by ranking the products served in the sequence of their liking. The preference evaluation was made in order to select the most promising product for large scale production.

3.4.4. Shelf Life Study

The shelf life of the three developed products were evaluated at monthly intervals up to three months in terms of sensory attributes, moisture and microbial profile (T_0, T_1, T_2 and T_3).

3.4.4.1. *Sensory Attributes*

Sensory quality evaluation plays an important role in acceptability of a new product. Sensory characteristics like appearance, colour, flavor, texture, taste and overall acceptability of the RTC *Avial, Koottu* and *Olath* mixes were assessed by a panel of judges using a five point scale.

3.4.4.2. *Moisture*

Moisture content of the dehydrated food material is an important factor which affect the stability of the food. So it is necessary to control the moisture to a level where micoorganisms may not be able to grow and spoil the product.

3.4.4.3. *Microbial Profile*

The stored product samples were assessed for the presence of various micro-organisms *viz.*, bacteria, fungi and yeast at monthly intervals up to three months. The serial dilution of the samples followed by pour plating was employed to estimate the population of viable micro-organisms in developed products.

3.4.5. Proximate Composition

Proximate composition of the developed products were analysed using the standard procedures.

Table 13. Proximate Composition

Constituents	Method adopted
Carbohydrate (g)	Sadasivam and Manikkam (1992)
Protein(g)	Bradford (1976)
Fat(g)	Sadasivam and Manikkam (1992)
Calories(Kcal)	Gopalan *et al* (2009)
Fibre (g)	Sadasivam and Manikkam (1992)
Total minerals(mg)	Thimmiah (1999)
βcarotene (mg)	Sadasivam and Manikkam (1992)

3.4.6. Statistical Analysis

In order to obtain suitable interpretation, the generated data was subjected to statistical analysis – Measures of central tendency and Anova test were the main tools adopted. Graphical interpretation of analyzed data is also presented.

As for sensory quality evaluation the different preferences given by the 10 judges in the sensory panel were analysed using the Kruskal – Wallis test to get the mean rank values for all the treatments.

Results

4. RESULTS

The results of the present study entitled " Development of jackfruit based Ready – To - Cook (RTC) instant mixes" is presented under the following heads:-

4.1. Standardization and product development

4.2. Packaging and storage

4.3. Quality assessment of dehydrated jackfruit

4.1. STANDARDIZATION AND PRODUCT DEVELOPMENT

According to Ranjini *et al.* (2000) food consumption pattern have witnessed a major change in the past few decades with the flooding of market with a large number of convenience foods.

Standardisation plays a key role in product development, which facilitates the growth of food industries. According to Poduval (2002), one of the fore most purpose of standardisation is to facilitate the smooth movement of materials and products through all stages of production in any industrial activity, starting from the raw material to the finished products, then to the dealer and finally to the retailers and consumers.

4.1.1. Preliminary Processing

Preliminary processing of vegetables is necessary to preserve a product's quality, appearance and acceptability by suppressing adverse oxidative changes and microbial contamination during processing, storage and consumption.

The various treatments were evaluated by a panel of 10 members to screen out the best treatment. Since the attribute to be assessed was only appearance ' Overall visual quality' (OVQ) scores were ascertained.

4.1.1.1.*Standardization of Width of Slices*

Width of slices were varied keeping in mind that water loss increases with increase in the surface area of fruit pieces. It is important that all of the pieces are about the same size, so that they would dry at the same rate (James and Kuipers, 2003).

The mean values of scores allotted by the panel members for Overall visual quality was worked out. Overall visual quality (OVQ) scores for three mixes revealed that T_3 with 1.5cm scored the highest value (8.35) for the preparation of *Avial* mix. For *Koottu* the best treatment was T_1 (0.5cm) with the highest value (8.40) and for *Olath* the option was T_2 (1cm) which scored highest value (8.35). The values were found to be significantly different as revealed by the CD value (Table 14).

Table 14. OVQ scores of jack fruit slices width

Treatments	***Avial* mix**	***Koottu* mix**	***Olath* mix**
T_1 (0.50 cm)	6.15	8.40	7.00
T_2 (1.00 cm)	7.00	7.70	8.35
T_3 (1.50 cm)	8.35	6.50	6.85
T_5 (2.00 cm)	6.30	5.90	6.10
CD(0.05) - 0.40 SE ± 0.14			

4.1.1.2. *Standardization of Blanching Time*

Table 15 indicates OVQ scores of blanched jackfruit slices prior to drying. Blanching helps to slow or stop the enzyme activity that can cause undesirable changes in flavour and texture during storage. It expands the tissues, so the slices dry faster. More over it helps protect vitamins and retain colour and also reduces the time needed to refresh vegetables before cooking (Kendall *et al.*, 2005). The scores of OVQ of jackfruit slices were analysed with various time durations *viz.*, 3min, 5min, 7min, 10min and 15min in blanching.

In *Avial* mix the highest score was obtained for T_1 (8.45) being 3min. This was followed by T_2 and T_3 (5 and 7 min respectively). In *Koottu* mix highest score recorded for T_1 (8.45) and in *Olath* mix T_1 scored highest value (8.45). T_5 scored the lowest value among all the three mixes (5.50,5.50 and 5.70 respectively). This difference in values in treatments were found to be statistically significant too.

***Avial* - 1.5 cm width**

***Koottu* – 0.5 cm width**

***Olath* – 1 cm width**

Plate 1. Finalized width of dry RTC jack slices

Table 15. OVQ scores of blanched raw material

Treatments	*Avial* Mix	*Koottu* Mix	*Olath* Mix
T_1 (3 min)	8.45	8.45	8.45
T_2 (5 min)	7.35	7.35	7.40
T_3 (7 min)	6.40	6.45	6.50
T_4 (10 min)	6.05	6.15	6.10
T_5 (15 min)	5.50	5.50	5.70
CD(0.05) – 0.37 SE ± 0.13			

4.1.1.3.*Standardization of Pre-Treatment Media*

In order to prevent browning and to preserve colour of the dehydrated mixes different pre- treatment media comprising of salt(0.5%), KMS (0.2%), ascorbic acid (0.1%), citric acid (0.2%) and their combinations were used.

On analysing the OVQ scores, the treatment T_5 with salt (0.5%) and KMS(0.2%) was observed to have the highest scores: 8.45 for *Avial*, 8.50 for *Koottu* and 8.55 for *Olath* from amongst the 12 treatments, followed by T_2 with KMS(0.2%). The treatment T_6 (salt 0.5 and Ascorbic acid 0.1%) and T_{10} (ascorbic acid and citric acid) showed the lowest scores. Hence T_5 was selected from among the 12 treatments as best pre-treatment media for jackfruit slices (Table 16).

Table 16. OVQ scores of pre-treated jackfruit slices

Treatments	*Avial* Mix	*Koottu* Mix	*Olath* Mix
T_1 (Salt (0.5%))	6.10	6.40	6.25
T_2 (KMS (0.2%))	8.10	8.15	8.15
T_3 (Ascorbic acid (0.1%))	1.70	1.65	1.65
T_4 (Citric acid (0.2%))	6.35	6.60	6.65
T_5 (Salt (0.5%) + KMS (0.2%))	8.45	8.50	8.55

Table 16 Continued

Treatments	***Avial* Mix**	***Koottu* Mix**	***Olath* Mix**
T_6 (Salt (0.5%) + Ascorbic acid (0.1%))	1.60	1.65	1.65
T_7 (Salt (0.5%) + Citric acid (0.2%))	6.45	6.55	6.35
T_8 (KMS (0.2%) + Ascorbic acid (0.1%))	3.20	3.35	3.45
T_9 (KMS (0.2%) + Citric acid (0.2%))	7.20	7.25	7.45
T_{10} (Ascorbic acid (0.1%) + Citric acid (0.2%))	1.60	1.70	1.66
T_{11} (KMS (0.2%) + Ascorbic acid (0.1%) + Citric acid (0.2%))	1.65	1.70	1.66
T_{12} (KMS (0.2%) + Ascorbic acid (0.1%) + Citric acid (0.2%) + Salt(0.5%))	1.7	1.70	1.68
CD(0.05) - 0.33 SE ± 0.12			

4.1.1.4. *Standardisation of Immersion Time*

The immersion time of jackfruit slices in pre-treated media were set in different time durations such as 10min, 15min, 20min, 30min, 45min and 60min. Analysis of OVQ showed similar results in all the three mixes.

Table 17. OVQ scores of jack fruit slices pre-treated in different timings

Treatments	***Avial* Mix**	***Koottu* Mix**	***Olath* Mix**
T_1 (10 min)	5.60	5.40	5.50
T_2 (15 min)	6.20	6.25	6.35
T_3 (20 min)	6.45	6.55	6.55
T_4 (30 min)	8.40	8.50	8.45
T_5 (45 min)	7.15	7.25	7.20
T_6 (60 min)	7.10	7.00	7.15
CD(0.05) - 0.13 SE ± 0.36			

(Olath in Salt)

(Olath in KMS)

(Koottu in Ascorbic acid)

(Olath in Citric Acid)

(Olath in KMS + Salt)

(Koottu in Ascorbic acid+ Salt)

(Avial in Citric acid +Salt)

(Avial in KMS+Ascorbic acid)

(Avial in KMS+Citric acid)

(Koottu in Ascorbic acid+ Citric acid)

(Olath in KMS + Ascorbic acid+ Citric acid)

(Avial in KMS + Ascorbic acid+ Citric acid + Salt)

Plate 2. Pretreated dried jackfruit bulbs and seeds

Treatment T_4 (30min) gave the highest scores for OVQ in all the three mixes 8.40 for *Avial*, 8.50 for *Koottu* and 8.45 for *Olath*. While T_1 (10min) gave the lowest scores. The value of T_4 was significantly higher than the other treatments Table 17.

4.1.2. Formulation of Ready To Cook (RTC) Dehydrated Products from Jackfruit

Ready To Cook products are primarily targeted for persons with busy life style, convenience seekers and mobile women. The newly emerging era of fast foods, convenience foods and instant foods are becoming increasingly popular among Indian households (Rajpur, 2007). According to Solanki (2000) there is an urgent need to develop low cost ready to cook mix to improve the nutritional status of our population along with saving time.

In the present study, different combinations of dehydrated RTC products were formulated keeping the jackfruit bulb and seeds as the major ingredients and varying the amounts and proportion of adjuncts used. A sensory panel evaluated the various formulations with respect to the five parameters namely, appearance , colour, texture, flavour, taste and overall acceptability.

According to FAO (2003), sensory evaluation is a common and very useful tool in quality assessment of processed products. It makes use of the senses to evaluate the general acceptability and quality attributes of the products, which is what finally leads to demand of a product.

When food is assessed by human sensory organs, the evaluation is said to be sensory analysis (Simi, 2002). Sensory evaluation is defined as “A scientific discipline used to evoke, measure, analyze, and interpret those responses to products that are perceived by the senses of sight, smell, touch, taste, and hearing" (Stonel and Sidel, 1993). Although sensory evaluation of food is the most important for quality assessment, taste evaluations are not practical for routine quality control. But to have quantitative methods too, rejection points are established by sensory means (Jonnalagadda *et al.,* 2001). The discipline requires panels of human assessors, on whom the products are tested, followed by recording the responses made by them. Numerical scoring is used to evaluate

particular characteristics of one or more samples indicating the rating as excellent, very good, fair and poor (Manay and Swamy, 2000).

4.1.2.1. *Formulation of Avial Mix from Jackfruit*

Five combinations were formulated for *Avial* mix. The organoleptic evaluation of formulated RTC *Avial* mix was done by panel of 10 judges and the data is presented in the Table 18.

Appearance

The first impression of food depends on its appearance. The mean rank values for appearance of the five formulations of *Avial* ranged from 12.15 – 45.50. The highest mean rank value (45.50) for appearance was observed in AP_3 which was a combination of jackfruit bulbs and seeds, red chilly powder, garlic, jeera, turmeric powder and curry leaves. Analysis of scores revealed that the formulation AP_3 was significantly superior in appearance than the other formulations.

Colour

Colour is one of the important visual attributes that has been used to judge the overall quality of foods for a very long time. Among the formulations AP_3 was noted to get the highest mean rank value (45.50) while AP_5 recorded the least mean rank value (13.50) for this parameter. There was significant difference in these scores of the formulations.

Texture

Texture constitutes physical property of a food stuff as apprehended by the eye, skin and muscle senses located in the mouth. The highest mean rank value (45.50) in texture was obtained for the formulation AP_3. The formulations AP_5 with constituents pepper, garlic, jeera, turmeric powder and curry leaves got the least mean rank value (12.55) among the treatments.

Flavour

Odour preference is generated by stimulation of sensory cells by specific volatile compounds present in foods. The flavour of different formulated *Avial* mixes differed in mean rank values, which ranged from 13.75 – 45.15. The

highest mean rank value was recorded by AP_3 (45.15) and least value was scored by AP_5 (13.75). This differences were statistically significant too.

Taste

Taste is the major attribute which determines the acceptability of a food. Taste is the sensation produced when a substance in the mouth reacts chemically with receptors of taste buds. Superior taste was found in AP_3 with the highest score of 45.20 and least was noted in AP_5 (11.25) The difference in these scores were also found to be significant.

Overall Acceptability

Overall acceptability also clearly depicted that among the 5 formulations AP_3 obtained maximum mean rank value (45.50) and highest preference in overall acceptability. Least mean rank value (19.70) and less preference was recorded for AP_5. The kruskal values indicated that there was significant difference in the scores obtained for the parameters of five formulations for AP_5. and AP_3. On the basis of this AP_3 was selected as best combination.

Table 18. Sensory quality of various formulations of *Avial* mix

Formulations	Mean rank values					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Overall acceptability**
AP_1	25.95	22.30	25.80	20.95	18.60	18.60
AP_2	24.50	23.90	26.20	26.70	23.25	22.40
AP_3	45.50	45.50	45.50	45.15	45.20	45.50
AP_4	19.40	22.30	17.45	20.95	29.20	21.30
AP_5	12.15	13.50	12.55	13.75	11.25	19.70
χ^2	30.78	28.69	31.47	28.58	33.37	25.85
CV	12.77					

4.1.2.2. *Formulation of Koottu Mix from Jackfruit*

Four combinations were formulated for *Koottu* mix. The organoleptic evaluation of formulated RTC *Koottu* mix was done by panel of 10 judges and the data is presented in the Table 19.

Appearance

The appearance parameter increases the appeal of a product. In *Koottu* mix the formulation KP_1 obtained significantly higher mean rank value (33.10) for appearance compared to the other 3 formulations. This formulation comprised of jackfruit bulb along with seeds, red chilly, turmeric powder, cumin and curry leaves. The mean rank values obtained were significantly different. KP_3 got the lowest mean rank value (7.00) which is a combination of Jackfruit bulbs and seeds, green chilly, turmeric powder, cumin and curry leaves.

Colour

Colour is another important parameter for the consumer acceptance of any food product. The kruskal values revealed that there was significant difference in the mean rank values of formulations in this attribute which ranged from 12.00 – 34.25. The maximum mean rank value (34.25) was noted for KP_1 and KP_3 scored the least mean rank value (12.00) for this parameter colour.

Texture

Texture is an overall assessment of the sensations of the mouth and hand or it is the sense of touch by hand and mouth, KP_1 got the highest mean rank value (34.50) for this attribute and KP_3 has got lowest mean rank value (15.00). The difference in these scores were found to be significant. The scores obtained by KP_3 and KP_4 were on par with regard to this parameter.

Flavour

Flavour distinguishes one food from another, therefore it is considered an important parameter in the acceptance of any food product. The maximum mean rank value for flavour was noted for KP_1 (34.60) while least mean rank value (13.95) was obtained for KP_3.

Taste

Consumers generally value food for its taste. In this case kruskal values revealed that there was a significant difference in the taste of the formulated *Koottu* mixes. The obtained mean rank values ranged from 12.20 – 35.16. KP_1 gained the highest mean rank value (35.16) and KP_3 got the lowest mean rank value (12.20) for this attribute.

Overall Acceptability

The statistical analysis revealed that there was significant difference in this parameter between the formulations developed (between KP_1 and KP_3). It is noted from the kruskal values that KP_1 obtained the highest mean rank value (34.00) in overall acceptability than other formulations, second position was obtained by KP_2 (17.75) and least mean rank value was noted for KP_3 (14.75). On the basis of analysis of values, KP_1 was selected for the further study.

Table 19. Sensory quality of various formulations of *Koottu* mix

Formulations	Mean rank values					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Overall acceptability**
KP_1	33.10	34.25	34.50	34.60	35.16	34.00
KP_2	25.65	18.40	17.00	17.00	18.85	17.75
KP_3	7.00	12.00	15.00	13.95	12.20	14.75
KP_4	16.25	17.35	15.50	16.45	15.80	15.50
χ^2	28.84	20.88	20.11	20.39	23.35	18.64
CV	10.24					

4.1.2.3. *Formulations of Olath Mix from Jackfruit*

Five combinations were formulated for *Olath* mix. The organoleptic evaluation of formulated RTC *Olath* mixes were done by panel of 10 judges and the data in the form of mean rank values are presented in the Table 20.

Appearance

Surface characteristics of the food products contribute to the appearance. The scores obtained for the appearance of the formulated *Olath* mixes developed from jack fruit ranged from 14.95 – 45.30. The statistical data showed that, there was significant difference in the mean rank values of appearance of the formulated *Olath* mixes (between OP_1 and OP_5). OP_1 combination comprised of jackfruit bulbs and seeds, crushed red chilly, onion, garlic, turmeric powder and curry leaves which got the highest mean rank value (45.30). OP_5 formulation developed using the adjuncts such as jackfruit bulbs and seeds, pepper, green

chilly, onion, garlic, turmeric powder and curry leaves obtained the lowest mean rank value. But it was on par with the mean rank values for appearance in OP_2, OP_3 and OP_4.

Colour

Table 20 reveals the mean rank values of colour of the formulated *Olath* mixes. Among the five combinations OP_1 got maximum mean rank value (45.50) and OP_5 scored least mean rank value (14.10).

Texture

Table 20 depicts the mean rank values obtained for the formulated *Olath* mixes. Statistical analysis of the data showed that, there was significant difference in the scores. It ranged from13.20 – 45.30. OP_1 received the highest mean rank value (45.30) in this attribute, followed by OP_2 with the mean rank value (28.65). OP_5 received least mean rank value (13.20).

Flavour

The mean rank values obtained for the parameter flavour of the formulated *Olath* mixes is shown in Table 20. The kruskal values revealed that there was significant difference in the flavour of the *Olath* mixes. OP_1 obtained highest mean rank value (45.25) and OP_5 got the lowest mean rank value (14.95).

Taste

The difference in the scores were found to be significant. It ranged from 15.35 – 45.50. Maximum mean rank value was noticed for formulation OP_1. OP_5 obtained the least mean rank value (15.35).

Overall Acceptability

Table 20 reveals the overall acceptability of the formulated *Olath* mix from the jackfruit. The kruskal values revealed that there was significant difference in the mean rank values obtained, it is ranged from 17 – 45.25. OP_1 scored maximum mean rank value (45.25), followed by OP_2 with the mean rank value (24.65) and OP_5 got the least score (17.00).

On the basis of kruskal values OP_1 was selected as best formulation of *Olath* mix developed from the jackfruit.

***Avial* mix**

***Koottu* mix**

***Olath* mix**

Plate. 3. Finalized RTC mixes

Table 20. Sensory quality of various formulations of *Olath* Mix

Formulations	Mean rank values					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Overall acceptability**
OP_1	45.30	45.50	45.30	45.25	45.50	45.25
OP_2	21.65	25.60	28.65	26.30	26.90	24.65
OP_3	22.80	23.80	22.75	23.65	21.70	22.55
OP_4	22.80	18.50	17.60	17.35	18.05	18.05
OP_5	14.95	14.10	13.20	14.95	15.35	17.00
χ^2	27.25	29.74	32.15	28.49	29.28	26.86
CV	12.77					

The identified treatments namely, AP_3, KP_1 and OP_1 were dehydrated till crisp at 65°C. After cooling they were packed in airtight containers.

4.1.3. Standardization of Cooking Methods of the Ready To Cook Mixes

The cooking methods to be adopted by the customer were standardized. The reconstitution time and methods were standardized systematically.

4.1.3.1. *Optimization of Reconstitution Time of RTC Products*

Drying is one of the oldest and most widely used methods of food preservation, however, its success largely depends on the rehydration quality (reconstitution) of dried products. The dried products will be acceptable as a food only if the color, texture, flavor, taste and nutritive value are retained to the maximum when they are reconstituted with water. If pre-drying treatment and drying itself would not induce any changes in the material, rehydration could be treated as a reversible process of dehydration. In practice most of the changes are irreversible and rehydration cannot be considered simply as a process reversible to dehydration (Krokida and Marinos, 2003). Rehydration can be considered as a remedy to the injury in the material caused by drying and treatments preceding dehydration (Minn and Magee, 2003).

The formulated RTC mixes were reconstituted by various treatments. Initially the measured quantity of mixes were soaked in plain water for 10min, 15min, 20min, 30min and 45min.

Tables 21, 22 and 23 presents the data of evaluation of reconstitution time of formulated mixes of *Avial, Koottu* and *Olath*.

4.1.3.1.1. *Optimization of Reconstitution Time of RTC Avial Mix*

The dried product was immersed in various time durations in cold water. The reconstitution time was evaluated with respect to sensory parameters of the products *viz*., appearance, colour, texture, flavour, taste and overall acceptability.

Appearance

When the scores for appearance were analysed, treatment R_4 (30 min) was found to be give the highest mean rank value (45.30) and R_1 (10 min) got lowest score (7.80). The difference among the scores was found to be significant. It ranged from 7.80-45.30.

Colour

The mean rank values for colour ranged from 8.10 – 45.50. The highest mean rank value (45.50) for the parameter colour was obtained for the treatment R_4. Mean rank value of R_5 (45min) was 32.95 and R_1 (10min) scored the lowest mean rank value (8.10).

Texture

The statistical analysis of the observations related to texture revealed that, treatment R_4 got highest mean rank value (45.10) and lowest mean rank value (7.80) was observed for R_1. There was significant difference in these scores obtained for this parameter.

Flavour

Kruskal values revealed that, the maximum mean rank value (45.30) for flavour was noted in the treatment R_4 while minimum mean rank value was scored by R_1. The statistical analysis of data depicted that the difference was significant.

Taste

The scores ranged from 8.70 – 45.10. The highest mean rank value (45.10) for taste was secured for the treatment R_4. R_5 (45 min) scored the mean rank value of (34.20) and R_1 (10 min) obtained lowest mean rank value (8.70). There was significant difference among R_1, R_3, R_4 and R_5.

Overall Acceptability

When the kruskal values for overall acceptability scores were analysed, it revealed that R_4 (30 min) was found to be superior with the highest mean rank value (45.10), followed by R_5 (45min) with the mean rank value of 33.80 and R_1 scored the least value (9.00).

As inferred from the Kruskal values depicted in Table 21. It can be concluded that, R_4 (30min) was found to be superior in all the sensory parameters. So R_4 (30min) was selected as the best reconstitution time of the formulated *Avial* Mix.

Table 21. Sensory quality of RTC *Avial* mix with varying reconstitution time

Formulations	Mean rank values					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Overall acceptability**
R_1 (10 min)	7.80	8.10	7.80	8.75	8.70	9.00
R_2 (15 min)	16.40	16.45	16.85	16.25	17.35	16.85
R_3 (20 min)	23.30	24.50	24.15	23.60	22.15	22.75
R_4 (30 min)	45.30	45.50	45.10	45.30	45.10	45.10
R_5 (45 min)	34.70	32.95	33.60	33.60	34.20	33.80
χ^2	42.15	40.62	40.36	39.87	39.61	39.01
CV	12.77					

4.1.3.1.2. *Optimization of Reconstitution Time of RTC Koottu Mix*

The variations in reconstitution time of the formulated *Koottu* mix was assessed on the basis of sensory evaluation. The scores of sensory parameters are presented herewith-

Appearance

The obtained mean rank values for appearance ranged from 7.50 – 44.40. It was noted that, R_4 (30min) gained the highest mean rank value (44.40); R_5 got second position with the mean rank value (35.25) while R_1 (10 min) got lowest mean rank value (7.50). The difference among the extreme scores were found to be significant.

Colour

As for this sensory attribute, the results showed that, the scores ranged from 6.45 – 44.55. There was significantly difference among these scores. The statistical analysis depicted that treatment R_4 got the maximum mean rank value (44.55) and R_1 got the lowest mean rank value (6.45).

Texture

Table 22 points out that there was significant difference in the scores obtained for this parameter. R_4 (30min) got highest mean rank value (44.55), followed by R_5 (45min) the score was 34.35, whereas the treatment R_3 (20min) and R_2 (15 min) obtained 24.70 and 16.70 respectively. R_1 was noted to have the lowest score (7.20). The difference between these scores were statistically significant.

Flavour

Analysis of kruskal values revealed that, among the five treatments R_4 scored the maximum mean rank value of (44.60) while R_1 recorded the least mean rank value (6.10). The statistical analysis of data depicted that this difference was significant.

Taste

The results indicated that, the obtained scores for this parameter ranged from 6.00 – 44.15. The treatment R_4 (30 min) scored the highest mean rank value (44.15), R_5 (45 min) was placed second with the mean rank value (34.15) and R_1 (10 min) obtained the lowest mean rank value (6.00).

Overall Acceptability

The overall acceptability scores revealed that R_4 with the reconstitution time of 30 min obtained highest score (43.30), followed by R_5 with the mean rank value of 37.00 and R_1 scored the least mean rank value (6.25). The difference among the extreme scores was found to be significant.

It is thus observed that highest mean rank values for sensory attributes was noted for the treatment R_4 followed by R_5. So R_4 has selected as the best treatment for reconstitution of the formulated *Koottu* mix.

Table 22. Sensory quality of RTC *Koottu* mix with varying reconstitution time

Formulations	Mean rank values					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Overall acceptability**
R_1 (10 min)	7.50	6.45	7.20	6.10	6.00	6.25
R_2 (15 min)	14.80	16.55	16.70	19.10	18.15	20.15
R_3 (20 min)	25.55	24.90	24.70	23.00	25.05	20.80
R_4 (30 min)	44.40	44.55	44.55	44.60	44.15	43.30
R_5 (45 min)	35.25	35.05	34.35	34.70	34.15	37.00
χ^2	42.75	42.99	41.01	41.94	41.19	41.77
CV	12.77					

4.1.3.1.3. *Optimization of Reconstitution Time of RTC Olath Mix*

Olath mix was evaluated after reconstitution for sensory qualities (Table 23).

Appearance

The analysis of data revealed that the treatment R_4 scored the maximum mean rank value (43.50) whereas R_1 gained the minimum mean rank value (7.35). The data also revealed that this difference was statistically significant.

Colour

Regarding the sensory evaluation of colour of the product, the results revealed that, there was significant difference in the scores obtained. R_4 got the highest mean rank value (44.05) and R_1 obtained the lowest mean rank value (7.20).

Texture

The results in the Table 23 indicated that, the scores obtained for this parameter ranged from 7.10 – 43.70. The kruskal values indicated that, maximum mean rank value 43.70 was obtained for the treatment R_4, which was on par with R_5 with mean rank value (35.90) and lowest mean rank value value (7.10) was obtained by R_1.

Flavour

The analysis of results reveal that, R_4 (30 min) was found to be give the highest mean rank value (44.60) for flavour. The mean rank values obtained ranged from 6.65 – 44.60. R_1 (10 min) got the lowest mean rank value (6.65). The difference among these scores was also found to be significant.

Taste

The highest mean rank value of (43.25) for this attribute was secured by the treatment R_4 (30 min), which was on par with R_5 (45 min) with the mean rank value (37.10) and R_5 (10 min) received the lowest rank with the score of 5.95. The scores ranged from 5.95 – 43.25. It was also observed that the obtained scores were significantly different.

Overall Acceptability

The overall acceptability scores revealed that R_4 with reconstitution time of 30 min obtained the highest mean rank value (44.70), which was on par with R_5 with the mean rank value (34.80) while R_3 and R_2 secured 23.60 and 17.75 respectively. R_1 scored the lowest value 6.65.

As the highest score of sensory parameters namely, appearance, colour, texture, flavour, taste and overall acceptability was obtained for the treatment R_4, it was selected as the best treatment for reconstitution of the formulated *Olath* Mix.

***Avial* mix**

***Koottu* mix**

***Olath* mix**

Plate 4. Reconstituted RTC mixes

Table 23. Sensory quality of RTC *Olath* mix with varying reconstitution time

Formulations	Mean rank values					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Overall acceptability**
R_1 (10 min)	7.35	7.20	7.10	6.65	5.95	6.65
R_2 (15 min)	15.25	16.35	17.00	17.05	18.20	17.75
R_3 (20 min)	24.55	23.80	23.80	25.30	23.00	23.60
R_4 (30 min)	43.50	44.05	43.70	44.60	43.25	44.70
R_5 (45 min)	36.85	36.10	35.90	33.90	37.10	34.80
χ^2	42.62	42.19	40.86	41.42	42.88	41.97
CV	12.77					

4.1.3.2. *Optimization of Cooking Procedures and Cooking Time*

4.1.3.2.1. *Cooking Procedures*

Directions regarding using a packed commodity is needed at the consumer level. This adds to the acceptance of the products. Optimization of cooking procedures of dehydrated mixes were conducted after various treatments. Treatments were again evaluated on the basis of organoleptic evaluation by a panel of 10 members.

Tables 24, 25 and 26 presents the evaluation of the cooking procedures *viz*., cooking in plain hot water (CP_1), cooking in strained (strained water is the excess water after rehydration of the products) hot water (CP_2), cooking in plain cold water(CP_3), and cooking in strained cold water (CP_4).

4.1.3.2.1.1. *Cooking Procedures for RTC Avial Mix*

The sensory evaluation of *Avial* mix cooked by the 4 methods were analysed and the results are shown in Table 24.

Appearance

When the kruskal values for appearance was analysed. CP_2 (cooking in hot strained water) obtained significantly higher mean rank value (35.20) as compared to other formulations and CP_3 ie, cooking in plain cold water got the least mean rank value.

Colour

The maximum mean rank value was noted for CP_2 (35.15), while CP_3 scored the least mean rank value (8.39) for this parameter. There was significant difference in these scores for this cooking procedure.

Texture

Analysis of scores revealed that CP_2 ranked first with the mean rank value of 35.25 and CP_3 got the least mean rank value (12.80) among the treatments. The difference in these scores were also significant.

Table 24. Sensory Quality of RTC *Avial* mix with variations in cooking procedure

Formulations	Mean rank values					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Overall acceptability**
CP_1	18.95	19.20	16.45	19.35	15.70	16.35
CP_2	35.20	35.15	35.25	35.35	34.90	35.50
CP_3	6.25	8.39	12.80	11.25	13.05	14.50
CP_4	21.60	19.25	17.50	16.05	18.35	15.65
χ^2	31.80	27.67	23.28	25.67	22.37	23.12
CV	10.24					

CP_1 = Cooking in plain hot water CP_2 = Cooking in strained hot water

CP_3 = Cooking in plain cold water CP_4 = Cooking in strained cold water

Flavour

The scores for flavour varied greatly. It is ranged from11.25 – 35.35. CP_2 scored the highest mean rank value (35.35) and CP_3 got least value 11.25.

Taste

The difference in the scores obtained for this attribute was found to be significant. Maximum mean rank value was noticed for CP_2 (34.90), followed by CP_4 (cooking in strained cold water) with a mean rank value of 18.35 and least mean rank value was obtained for CP_3 (13.05).

Overall Acceptability

Among the four cooking procedures CP_2 obtained maximum mean rank value (35.50) for overall acceptability. The scores ranged between 14.50 – 35.50. The kruskal values indicates that there was significant difference in the scores obtained for the parameters.

On the basis of scores of sensory evaluation, CP_2 (cooking in strained hot water) was selected as best cooking method.

4.1.3.2.1.2. ***Cooking Procedures for RTC Koottu Mix from Jackfruit***

The organoleptic evaluation of various cooking methods on the formulated RTC *Koottu* mix was done by a panel of 10 judges to find out the best cooking procedures and the scores of sensory evaluation is presented in the Table 25.

Appearance

Among the various cooking procedures CP_2 (cooking in hot strained water) obtained a significantly higher mean rank value (35.25) for appearance compared to the other treatments. The extreme scores obtained were significantly different. CP_3 (cooking in plain cold water). got least mean rank value 13.55

Colour

The kruskal values revealed that there was significant difference in the scores obtained for this parameter. The mean rank values ranged from 13.90 -35.25. The highest mean rank value was noted for CP_2 (35.25) and CP_3 scored the least mean rank value (13.90).

Texture

CP_2 ranked first with the mean rank value (35.50) and CP_3 got the lowest mean rank value (10.80) for this parameter. The difference in these scores were also significant.

Flavour

Maximum score was noted for CP_2 (35.30) ie., cooking in strained hot water. CP_4 ie., cooking in strained cold water recorded the least score 14.75.

Taste

In this case, significant difference in the extreme values was revealed from the kruskal values. It ranged from 12.10 – 35.50. CP_2 gained highest mean rank value (35.50) and CP_3 got the lowest mean rank value (12.10). CP_1, CP_3 and CP_4 were on par.

Overall Acceptability

The data revealed that there was significant difference between the extreme values of cooking procedures. It was observed that based on kruskal values CP_2 obtained the highest mean rank values (35.50) the other scores were on par with CP_4 (19.35) and least mean rank value was obtained by CP_3 (10.20).

As inferred from the result CP_2 was selected as best treatment for the further study.

Table 25. Sensory quality of RTC *Koottu* mix with variations in cooking procedures

Formulations	Mean rank values					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Overall acceptability**
CP_1	16.85	18.20	18.50	15.70	19.80	16.95
CP_2	35.25	35.25	35.50	35.30	35.50	35.50
CP_3	13.55	13.90	10.80	16.25	12.10	10.20
CP_4	16.35	14.65	17.20	14.75	14.60	19.35
χ^2	22.72	22.71	25.3	22.44	24.94	26.08
CV	10.24					

CP_1 = Cooking in plain hot water CP_2 = Cooking in strained hot water

CP_3 = Cooking in plain cold water CP_4 = Cooking in strained cold water

4.1.3.2.1.3. *Cooking Procedures for RTC Olath Mix from Jackfruit*

The reconstituted mixes were cooked using different methods- namely cooking in plain hot water, cooking in strained (strained water is the excess water after rehydration of the products) hot water, cooking in plain cold water, and

cooking in strained cold water. The organoleptic evaluation of formulated RTC *Olath* mix was done by panel of 10 judges to find out the best cooking procedures and the parameter wise analysis is presented in the Table 26.

Appearance

The scores obtained for the appearance of the *Olath* mix with 4 different cooking procedures ranged from 7.20 – 35.30. The statistical analysis revealed that there was significant difference in the scores of appearance of *Olath* mix. CP_2 (cooking in strained hot water) got the highest mean rank value (35.30). CP_3 cooking in plain cold water obtained the least mean rank value (7.20). CP_1 and CP_4 were found to be on par.

Colour

The table explains the scores obtained for colour of the *Olath* mix after the 4 cooking procedures. Among the four treatments CP_2 got the maximum mean rank value (35.50) and CP_3 scored minimum mean rank value (7.00).

Texture

Table 26 depicts the scores obtained for texture in *Olath* mix. Analysis of the data showed that, there was significant difference among the scores. It ranged from 6.80 – 35.25. CP_2 received the highest mean rank value (35.25) for this parameter, followed by CP_4 with the mean rank value (20.00). CP_3 gained least mean rank value 6.80, which was significantly different with all treatments.

Flavour

Analysis of the scores obtained for this parameter of *Olath* mix revealed that, the ranked means were significantly different in the three cooking methods. CP_2 obtained the highest mean rank value (35.50) and CP_3 got least mean rank value (8.85).

Taste

The difference in the scores of taste were found to be significant among most of the cooking methods, (CP_1 and CP_4 were found to be on par). It ranged from 8.50 – 34.50. Maximum mean rank value was noticed for CP_2 (34.50). CP_3 obtained the least mean rank value (8.50).

Overall Acceptability

Table 26 explains the overall acceptability of the *Olath* mix from the jackfruit after the four cooking procedures. The kruskal values revealed that there was significant difference in the scores obtained, for CP_1, CP_2 and CP_3, it ranged from 7.75 – 35.30. CP_2 ranked first with maximum mean rank value 35.30, CP_1 was placed second with the mean rank value of 21.40 and CP_3 got the least mean rank value 7.75.

On the basis of kruskal values CP_2 (cooking in strained hot water) was selected as the best cooking procedure for *Olath* mix developed from raw jackfruit.

Table 26. Sensory quality of RTC *Olath* mix with variations in cooking procedures

Formulations	Mean rank values					
	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
CP_1	20.60	22.30	19.95	20.75	21.80	21.40
CP_2	35.30	35.50	35.25	35.50	34.50	35.30
CP_3	7.20	7.00	6.80	8.85	8.50	7.75
CP_4	18.90	17.20	20.00	16.90	17.20	17.55
χ^2	30.11	31.66	30.64	28.2	26.54	29.55
CV	10.24					

CP_1 = Cooking in plain hot water CP_2 = Cooking in strained hot water

CP_3 = Cooking in plain cold water CP_4 = Cooking in strained cold water

4.1.3.2.2. *Optimization of Cooking Time of Dehydrated RTC Mixes*

Optimization of cooking time of dehydrated mixes is also important at the consumer level. It was evaluated on the basis of organoleptic evaluation judged by 10 panel members.

Table 27, 28 and 29 reveals the kruskal values of the RTC mixes cooked in different time durations 6min, 8min, 10min and 15min.

4.1.3.2.2.1. *Optimization of Cooking Time of Avial Mix*

The variations in duration of cooking time of the *Avial* mix was evaluated (6 min – 15 min). The organoleptic evaluation was conducted in the formulated RTC *Avial* mixes by a panel of 10 judges to find out the optimum cooking time. The results of sensory evaluation are presented in the Table 27.

Appearance

The mean rank values for appearance ranged from 6.20 – 35.30. C_4 (15min cooking time) was found to be give the highest mean rank value (35.30) and C_1 (6min cooking time) got lowest mean rank value (6.20). These score were found to be significantly different.

Colour

The mean rank values obtained for the colour parameter ranged from 6.80 – 35.50. The obtained scores were significantly different. Statistical analysis depicted that treatment C_4 received maximum mean rank value (35.50), C_3 was placed second with a mean rank value of 25.25 which was on par with C_2 and C_1 scored the least mean rank value (6.80).

Texture

It is noticed from the Table 27 that there was significant difference in the extreme mean rank values obtained for texture which ranged from 6.80 – 35.50. C_4 got the highest mean rank value (35.50) and C_1 obtained the least mean rank value (6.80).

Flavour

It was observed that, maximum mean rank value (35.50) was secured by the treatment C_4, which was on par with C_3 (10min cooking time) with a mean rank value of 25.90 and C_1 obtained a minimum mean rank value of 6.65. The statistical analysis of data depicted that the scores were significantly different.

Taste

Table 27 further shows that the mean rank value obtained for taste ranged from 6.70 – 35.50. It was observed that C_4 (15min-cooking time) got the highest mean rank value (35.50), followed by C_3 (10 min-cooking time) with the mean

rank value of 25.90 and C_1 (6min-cooking time) received the least mean rank value (6.70).

Overall Acceptability

As per the results depicted in the Table 27, the obtained mean rank values ranged from 6.00 – 35.50. C_4 with 15 min cooking time of *Avial* mix obtained the highest mean rank value (35.50), followed by C_3 with the mean rank value (23.10) and C_1 scored the least mean rank value (6.00).

Table 27 represents the various parameters such as appearance, colour, texture, flavour, taste and overall acceptability which were assessed separately to find out the best treatment in varying time duration. The statistical data presented that C_4 (15min-cooking time) secured the highest mean rank value for all the sensory parameters. It indicates that C_4 (15min) was the best treatment to satisfy all the organoleptic qualities during cooking of *Avial* mix. So C_4 (15min-cooking time) has selected as best for further study.

Table 27. Sensory quality of RTC *Avial* mix with varying cooking time

Formulations	Mean rank values					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Overall acceptability**
C_1 (6 min)	6.20	6.80	6.80	6.65	6.70	6.00
C_2 (8 min)	16.05	15.45	15.60	15.95	15.90	17.40
C_3 (10 min)	24.45	25.25	25.10	25.90	25.90	23.10
C_4 (15 min)	35.30	35.50	35.50	35.50	35.50	35.50
χ^2	34.40	34.38	34.35	34.32	34.33	34.01
CV	10.24					

4.1.3.2.2.2. *Optimization of Cooking Time of RTC Koottu Mix*

The *Koottu* mix formulated was reconstituted and subjected to cooking for various time durations (6 min – 15 min). The sensory evaluation of formulated RTC *Koottu* mix was done by a panel of 10 judges and the scores are presented in the Table 28.

Appearance

The exact time duration for cooking of the dehydrated *Koottu* mix was evaluated, the obtained mean rank values ranged from 6.40 – 34.90. C_4 (15 min- cooking time) was found to be give the highest mean rank value (34.90) and C_1 (10 min-cooking time) got the least score (6.40). The difference among these scores was found to be significant.

Colour

The mean rank value obtained for the colour parameter ranged from 7.40 – 34.70. The statistical analysis depicted that treatment C_4 received the maximum mean rank value (34.70), C_3 which was on par with mean rank value of 24.70 and least mean rank value was obtained by C_1 (7.40). This difference was seen to be significant.

Texture

The data in Table 28 reveals that there was significant difference in the extreme scores obtained for texture. C_4 got highest mean rank value (33.90) and C_1 obtained least mean rank value (6.70).

Flavour

The obtained result points out that, C_4 secured maximum mean rank value (33.90), followed by C_3 (10min-cooking time) with the mean rank value (26.10) and C_1 (6min-cooking time), obtained the minimum mean rank value of 7.05. The statistical analysis of data depicted that their difference was significant.

Taste

Table 28 shows the mean rank value obtained for the attribute taste. The values ranged from 6.30 – 34.45. It was observed that C_4 (15min-cooking time) was superior with respect to taste with the mean rank value of 34.45, C_3 (10 min- cooking time) was placed second with the mean rank value of 22.50 and C_1 (6min-cooking time) got the least mean rank value of 6.30.

Overall Acceptability

The overall acceptability scores presented in Table 28 reveals that C_4 (15 min cooking time) obtained the highest mean rank value (34.10), which was on

par with C_3 with the score of 23.40. C_1 scored lowest value (6.70). There was significant difference in the extreme values.

Table 28 presents the scores received for various parameters such as appearance, colour, texture, flavour, taste and overall acceptability. The statistical data presented reveals that C_4 (15min-cooking time) secured highest mean rank value for all the sensory parameters. Therefore it is concluded that C_4 (15min- cooking time) was identified as the best treatment giving the best product after cooking.

Table 28. Sensory quality of RTC *Koottu* mix with varying cooking time

Formulations	Mean rank values					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Overall acceptability**
C_1 (6 min)	6.40	7.40	6.70	7.05	6.30	6.70
C_2 (8 min)	16.50	15.20	16.05	14.95	18.75	17.80
C_3 (10 min)	24.20	24.70	25.35	26.10	22.50	23.40
C_4 (15 min)	34.90	34.70	33.90	33.90	34.45	34.10
χ^2	32.63	31.64	30.97	31.59	34.45	29.57
CV	10.24					

4.1.3.2.2.3. *Optimization of Cooking Time of RTC Olath Mix*

The best cooking time was selected from the four timings namely 6 min, 8 min, 10 min and 15 min. The organoleptic evaluation of formulated RTC mixes was done by a panel of 10 judges and the scores are presented in the Table 29.

Appearance

The mean rank values obtained ranged from 7.70 – 35.50. It was observed that C_3 (10min-cooking time) scored the maximum mean rank value (35.50), followed by C_4 (15min-cooking time) with the mean rank value (25.05). C_1 (10min-cooking time) obtained the minimum mean rank value (7.70). The statistical analysis of data depicted that the difference in scores were significant.

Colour

The data in Table 29 reveals that there was significant difference in the mean rank values obtained for colour which ranged from 5.65 – 35.35. C_3 (10min-cooking time) got the highest mean rank value (35.35) and C_1 (6min- cooking time) obtained least mean rank value (5.65).

Texture

The result points out that, the mean rank values for this parameter ranged from 5.60 – 35.50. The statistical analysis depicts that treatment C_3 ranked first with maximum the mean rank value (35.50), C_4 ranked second with the mean rank value (23.30) and C_1 scored least mean rank value (5.60).

Flavour

The variations in cooking time of *Olath* mix was evaluated, the obtained mean rank values ranged from 5.60 – 35.50. C_3 (10 min-cooking time) was found to be give the highest mean rank value (35.50) and C_1 (6 min-cooking time) got the least mean rank value (5.60). The difference among these scores were found to be significant.

Taste

Table 29 reveals the mean rank values obtained for the attribute taste. It was found to range from 6.90 – 33.30. It was observed that C_3 (15 min-cooking time) got the highest mean rank value (33.30), treatment C_4 (15 min-cooking time) was placed in the second position with the mean rank value of 25.20 which was on par with C_3 and C_1 6 min-cooking time received the least mean rank value (6.90).

Overall Acceptability

The scores portrayed in the Table 29 reveals that the treatment C_3 (10 min- cooking time) obtained the highest mean rank value (33.90), followed by C_4 with the mean rank value (25.35) and C_1 scored the least value (6.70).

The sensory evaluation depicted in Table 29, presents the scores received for the various parameters such as appearance, colour, texture, flavour, taste and overall acceptability. The data shows that C_3 (10min-cooking time) secured the highest mean rank values for all the sensory parameters, followed by C_4 (15min-

cooking time). It is thus concluded that C_3 (10min-cooking time) was best treatment to get best quality during cooking of *Olath* mix. So C_3 (10min-cooking time) was assessed as the best treatment for further study.

Table 29. Sensory quality of RTC *Olath* mix with varying cooking time

Formulations	Mean rank values					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Overall acceptability**
C_1 (6 min)	7.70	5.65	5.60	5.60	6.90	6.70
C_2 (8 min)	13.75	18.50	17.60	17.90	16.60	16.05
C_3 (10 min)	35.50	35.35	35.50	35.50	33.30	33.90
C_4 (15 min)	25.05	22.50	23.30	23.00	25.20	25.35
χ^2	34.19	33.83	34.8	34.35	29.17	30.97
CV	10.24					

4.1.3.3. *Optimization of Additional Ingredients to be Added*

To give useful hints to the consumers as to the additional perishable ingredients to be added before serving, the amount of coconut to be added was standardized.

Coconut is an indispensible ingredient in these traditional recipes. The amount of coconut , to be added, was standardised after trials in different levels. The amount ranged from 10-50g per 50g of dry RTC mixes.

4.1.3.3.1. *Addition Of Coconut into Avial Mix*

Coconut forms one of the major ingredients in *Avial*. In order to assess the optimum amount of coconut, five variations were tried and evaluated by a sensory panel.

Appearance

The variations in the amount of coconut added into the *Avial* mix was evaluated. The obtained mean rank values ranged from 5.95 – 43.10. C_3 (30g) was found to be give the highest mean rank value (43.10) and C_1 (10g) got the

least mean rank value (5.95). The difference among these scores were found to be significant.

Colour

The mean rank values obtained for the colour ranged from 5.65 – 44.20. The statistical analysis revealed that treatment C_3 (30g of coconut) received the maximum mean rank value (44.20). C_4 (45g of coconut) ranked second with the mean rank value (31.60) and C_1 scored mean rank value of 5.65).

Texture

The data in Table 30 reveals that there was significant difference in the scores obtained for the attribute texture. C_3 got the highest mean rank value (44.80) and C_1 obtained the least mean rank value (5.50).

Flavour

It is noted from the Table 30 that C_3 (30g of coconut) scored the maximum mean rank value (43.60) followed by C_5 with a mean rank value of (32.10) while C_1 obtained a minimum mean rank value (5.95). The statistical analysis of data depicted that the difference was significant. The mean rank values ranged from 5.95 – 43.60.

Taste

Table 30 shows the mean rank value obtained for taste. It ranged from 5.60 – 44.20. Superior taste was noticed in C_3 (30g of coconut) with mean rank value of 44.20. C_5 (50g of coconut) was placed second with mean rank value (32.85) and least mean rank value was noted for C_1 (10g of coconut).

Overall Acceptability

The overall acceptability scores depicted on the Table 30 reveals that C_3 (addition of 30g coconut) obtained the highest mean rank value (44.10), followed by C_5 with the score (30.80) and C_1 scored least mean rank value (5.70).

When the sensory evaluation as assessed by parameters such as appearance, colour, texture, flavour, taste and overall acceptability were analysed (Table 30) it was observed that C_3 (30g of coconut) secured the highest mean rank values for all the sensory parameters, followed by C_5 (50g of coconut). It is

thus concluded that C_3 (30g of coconut) was the best treatment to get the best qualities during cooking of *Avial* mix.

Table 30. Sensory quality of RTC *Avial* mix with varying proportions of coconut

Formulations	Mean rank values					
	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
C_1 (10 g)	5.95	5.65	5.50	5.95	5.60	5.70
C_2 (20 g)	15.65	16.95	16.70	17.60	18.55	19.10
C_3 (30 g)	43.10	44.20	44.80	43.60	44.20	44.10
C_4 (40 g)	30.10	31.60	27.50	28.25	26.30	27.80
C_5 (50 g)	32.70	29.10	33.00	32.10	32.85	30.80
χ^2	41.86	41.98	44.53	40.02	41.10	39.53
CV	12.77					

4.1.3.3.2. *Addition of Coconut into RTC Koottu Mix*

Coconut imparts the characteristic flavour, taste and appearance of *Koottu* Mix. Coconut in various amounts was added into the cooked *Koottu* Mix and assessed for sensory qualities by a panel of 10 judges and the results are shown in Table 31.

Appearance

The addition of the quantity of coconut to be added into *Koottu* mix was evaluated. The obtained mean rank values ranged from 5.75 – 42.90. P_3 (35g of coconut) was found to give the highest mean rank value (42.90) and P_1 (15g of coconut) got the least mean rank value (5.75). The difference among these scores were found to be significant.

Colour

The mean rank value obtained for the attribute colour ranged from 5.70 – 43.10. The statistical analysis revealed that treatment P_3 received maximum

mean rank value (43.10), followed by P_5 which ranked second with the mean value of 33.10 (on par with P_3) and P_1 scored mean rank value of 5.70 only.

Texture

Analysis of the data (Table 31) reveals that there was significant difference in the scores obtained for the texture. The scores ranged from 5.50 – 43.65. P_3 (35g of coconut) got the highest mean rank value (43.65) and P_1 (15g of coconut) obtained least mean rank value (5.50).

Flavour

As revealed in Table 31 maximum mean rank value (42.60) was secured by P_3, followed by P_5 with the mean rank value (31.35) and P_1 obtained the minimum mean rank value (5.50). The statistical analysis revealed that the difference in the extreme values were significant.

Taste

Table 31 also shows the scores obtained for taste. It was seen to range from 5.50 – 42.75. It was observed that P_3 (35g) got the highest mean rank value (42.75), P_5 (50g) was placed second with the mean rank value (32.55) and least mean rank value was scored by P_1 (15g) with the score (5.50).

Overall Acceptability

The scores depicted in Table 31 revealed that P_3 (addition of 35g coconut) obtained the highest mean rank value (38.60), followed by P_4 with the mean rank value (36.55) and the least mean rank value (6.95) was obtained for the treatment P_1.

The result shown in Table 31 on sensory evaluation indicated that, the scores received for various parameters such as appearance, colour, texture, flavour, taste and overall acceptability were significantly different. The statistical data noted that P_3 (35g) secured the highest mean rank value for all the sensory parameters, followed by P_5 (50g). It is thus concluded that P_3 (35g) is the best treatment to get superior qualities during cooking of *Avial* mix.

Table 31. Sensory quality of RTC *Koottu* mix with varying proportions of coconut

Formulations	Mean rank values					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Overall acceptability**
P_1 (15 g)	5.75	5.70	5.50	5.50	5.50	6.95
P_2 (25 g)	16.65	15.30	15.50	17.15	15.65	14.50
P_3 (35 g)	42.90	43.10	43.65	42.60	42.75	38.60
P_4 (45 g)	30.10	30.30	31.75	30.60	31.05	36.55
P_5 (50 g)	32.10	33.10	31.10	31.35	32.55	30.90
χ^2	41.41	43.2	31.65	40.56	42.84	37.76
CV	12.77					

4.1.3.3.3. *Addition of Coconut Oil into Avial Mix*

Like coconut scrapings, coconut oil too is added to enhance the taste and flavour of these traditional dishes. The amount of oil added into *Avial* and *Olath* mixes ranged from 1.5ml-5.0ml in five different treatments for 50g of dry mix. The results of sensory evaluation is discussed herewith.

Appearance

In the case of *Avial* mix, the mean rank value of appearance ranged from 5.95 – 40.30. The highest mean rank value (40.30) of appearance was obtained for T_3 (3.5ml). T_1 (1.5ml) was found to be give the least mean rank value (5.95). The difference among these scores were found to be significant.

Colour

The mean rank value obtained for the colour parameter ranged from 5.95 – 41.05. The statistical analysis depicted that treatment T_3 received maximum mean rank value (41.05), followed by T_4, mean rank value being 33.00 and T_1 scored the least mean rank value 5.95.

Texture

The statistical data in Table 32 reveals that there was significant difference in the scores obtained for texture. T_3 got highest mean rank value (40.45) and the least mean rank value (5.95) was obtained by T_1 .

Flavour

The results further point out that, the difference in the extreme scores was significant. T_3 scored the maximum mean rank value (39.55), followed by T_5 and T_1 secured minimum mean rank value (6.05).

Taste

Table 32 shows the mean rank value obtained for the parameter taste, it ranged from 6.50 – 38.10. It was observed that T_3 (3.5ml) got the highest mean rank value (38.10), T_5 (5.0ml) was placed second with a mean rank value of 34.35 and T_1 (1.5ml) received the least mean rank value (6.50).

Overall Acceptability

The scores depicted in Table 32 reveals that T_3 with an addition of 3.5ml of oil into the *Avial* mix obtained highest mean rank value (42.70), followed by T_5 with the mean rank value (34.40) and T_1 has scored least mean rank value (9.00).

Results of sensory evaluation are depicted as scores for various parameters such as appearance, colour, texture, flavour, taste and overall acceptability as shown in Table 32. The statistical data reveals that T_3 (3.5ml) secured the highest mean rank value for all the sensory parameters, followed by T_5 (5.0ml). It can thus be concluded that T_3 (3.5ml) was the best treatment to get superior qualities during cooking of *Avial* mix. So T_3 (addition of 3.5ml) was assessed as best treatment for further study.

Table 32. Sensory quality of RTC *Avial* mix with varying proportions of oil

Formulations	Mean rank values					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Overall acceptability**
T_1 (1.5 ml)	5.95	5.95	5.95	6.05	6.50	9.00
T_2 (2.5 ml)	16.55	15.20	15.50	15.45	15.90	15.25
T_3 (3.5 ml)	40.30	41.05	40.45	39.55	38.10	42.70
T_4 (4.5 ml)	35.90	33.00	31.80	31.80	32.65	25.30
T_5 (5.0 ml)	28.80	32.30	37.65	37.65	34.35	34.40
χ^2	38.87	40.31	40.03	38.59	35.95	34.78
CV	12.77					

4.1.3.3.4. *Addition of Coconut Oil into Olath Mix*

Coconut oil was added into the *Olath* mix for seasoning to impart the characteristic flavour, taste and appearance. The scores of sensory evaluation are presented in the Table 33.

Table 33. Sensory quality of RTC *Olath mix* with varying proportions of oil

Formulations	Mean rank values					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Overall acceptability**
R_1 (1.5 ml)	6.05	6.25	6.10	6.05	6.05	5.90
R_2 (2.5 ml)	15.05	16.40	16.40	15.05	15.70	17.15
R_3 (3.0 ml)	40.75	41.55	40.70	40.75	40.65	36.60
R_4 (4.0 ml)	32.55	29.60	29.30	32.55	31.70	34.75
R_5 (5.0 ml)	33.10	33.70	35.00	33.10	33.40	33.10
χ^2	40.67	38.48	38.47	40.67	39.15	35.10
CV	12.77					

Appearance

It can be noticed from the Table 33 that R_3 scored the highest mean rank value (40.75). R_1 obtained the least mean rank value (6.05). The statistical analysis of data depicted that the difference was significant.

Colour

The data in Table 32 further reveals that there was significant difference in the mean rank values obtained for colour. It is ranged from 6.25 – 41.55. R_3 got highest mean rank value (41.55) and R_1 obtained least mean rank value (6.25).

Texture

The mean rank value obtained for texture ranged from 6.10 – 40.70. The statistical analysis revealed that treatment R_3 received the highest mean rank value (40.70), followed by R_5 which scored the mean rank value of (35.00) and R_1 scored the least mean rank value (6.10).

Flavour

The addition of different amounts of oil into *Olath* mix was evaluated for flavour also. The mean rank values ranged from 6.05 – 40.75. R_3 (3.0ml) was found to be give the highest mean rank value (40.75) and R_1 (1.5ml) got the least mean rank value (6.05). The difference between these scores was found to be significant.

Taste

Table 33 shows the scores obtained for the taste, the values ranged from 6.05 – 40.65. It was observed that R_3 (3.0ml) got the highest mean rank value (40.65), R_5 (5.0ml) was placed second with the mean rank value (33.40) and R_1 (1.5ml) received the least mean rank value (6.05).

Overall Acceptability

The scores shown in the Table 33 reveals that R_3 (with the addition of 3.0ml of oil) obtained the highest mean rank value (36.60), followed by R_4 (4.0ml) with the mean rank value of 34.75 and R_1 (1.5ml) scored the least mean rank value (5.90).

***Avial* mix**

***Koottu* mix**

***Olath* mix**

Plate 5. Cooked RTC mixes

The results of sensory evaluation as shown in Table 33 indicates that, the scores received for the various parameters such as appearance, colour, texture, flavour, taste and overall acceptability were significantly different. The data reveals that R_3 (3.0ml) secured the highest scores for all the sensory parameters and the least mean rank value was obtained by R_1 (1.5ml). It can thus be concluded that R_3 (3.0ml) was the best treatment to get superior qualities for cooking of *Olath* mix.

4.2. PACKAGING AND STORAGE

Food packaging plays a vital role in preserving food throughout the distribution chain. Without packaging, the processing of food can become compromised as it gets contaminated by direct contact with physical, chemical, and biological contaminants. In recent years, the development of novel food packaging (modified atmosphere and active packaging) has not only increased the shelf life of foods, but also their safety and quality - thus bringing more convenience to consumers. Directly related, and interlinked, with food packaging is the concept of shelf life - the length of time foods, beverages, pharmaceutical drugs, chemicals, and many other perishable items take before they are considered unsuitable for sale, use, or consumption (Langowski and Wani, 2013).

The standardized dehydrated *Avial, Kootu* and *Olath* mixes were packed in PE and laminated pouches and stored in ambient conditions for studying their shelf life at monthly intervals up to three months.

The results of storage analysis are presented in the section on quality analysis (4.3.4)

4.3. QUALITY EVALUATION OF DEHYDRATED JACKFRUIT *AVIAL, KOOTU* AND *OLATH* MIXES

Quality is the ultimate criteria of the desirability of any food product to the consumers. The quality of the food is a combination of the attributes that determines the degree of acceptability of the product. Food quality is a complex concept that is frequently measured using objective indices related to the

***Avial* mix**

***Koottu* mix**

***Olath* mix**

Plate 6. RTC mixes packed in PE and laminated pouches

nutritional, microbiological or physicochemical characteristics of food, in terms of the opinion of designated experts (Cardello, 1995). According to Sharma (2006), quality is a very important parameter for judging the edible nature of any food product. These include cost, consumer preference, physical characteristics, sensory attributes, consumer preference, shelf life study and proximate composition.

4.3.1 Cost of the Developed Products

In order to realize the economic feasibility of the developed RTC mixes the cost was calculated by taking individual cost of the ingredients used with 10 per cent over head. The cost of 1Kg packets of RTC mixes were thus calculated.

Table 34. Cost of the jack fruit mixes developed

Name of the product	Cost of the finished product/ kg(Rs)
Avial mix	30.00
Koottu mix	24.00
Olath mix	32.00

4.3.2. Physical Characteristics of Dehydrated Mixes

Physical characteristics are associated with the overall quality of the developed food product. It helps in the quality assessment and acceptability of any food product. The physical characteristics namely appearance, moisture, yield, loss of weight, rehydration ratio and bulk density were studied.

4.3.2.1. *Appearance*

Visual appeal creates the first impression and is a major factor for acceptance of a food. Appearance is the criteria for the desirability of any food product. The results are presented in the Table 35. The scores for appearance ranged from 4.34 – 4.88. Highest score 4.88 was recorded for *Avial* mix, whereas lowest score was noted for *Koottu* mix and *Olath* mix scored 4.54. Appearance or surface characteristics of *Avial* mix was found to be better than *Koottu* and *Olath* mix.

4.3.2.2. *Moisture*

Moisture content is one of the important parameters which interferes with the quality of the RTC mixes during the storage. This affects the physical and nutritional composition of the developed products. The total moisture content of the developed RTC mixes are shown in Table 35.

The moisture level of RTC mixes ranged from 5.38-6.18 per cent. The ANOVA table indicated that there was significant difference in moisture content of the three RTC mixes *viz. Avial*, *Koottu* and *Olath* mixes. However these values were in the safe range with respect to shelf life

The highest moisture content was noted for *Avial* mix (6.18%) and the lowest moisture content was observed for *Koottu* mix (5.38%), whereas for *Olath* mix moisture content was 5.54 per cent.

4.3.2.3. *Yield*

Drying removes moisture, the food shrinks and decreases in size and weight, thus requiring less space for storage. Yield of dried products are directly related to how much water is in the original product. The yield of the developed RTC mixes are given in Table 35.

It was noted that when 100g of sliced pre-treated jackfruit mixes were dried, the yield of RTC mixes ranged from 35.90 – 37.32 per cent. The data further revealed that the yield of *Avial* mix (37. 22) was on par with the yield of *Olath* mix (37.32). However yield of *Koottu* mix was significantly lower to *Avial* and *Olath* mixes.

Table 35. Appearance, moisture and yield of dehydrated mixes

Samples	Appearance	Moisture	Yield
Avial mix	4.88	6.18	37.22
Koottu mix	4.34	5.38	35.9
Olath mix	4.54	5.54	37.32
SE	0.02	0.02	0.28
CD(0.05)	0.062	0.062	0.87

4.3.2.4. *Weight Loss*

For determining weight loss of the cut vegetables, the weight of the vegetables before and after dehydration were recorded and the total loss of weight was then calculated. The results are presented in Table 35.

Loss of weight of developed RTC mixes ranged from 62.68 – 64.10. There was no significant difference in the weight loss of developed RTC *Avial* and *Olath* mixes, but *Kootu* mix showed significantly higher levels.

4.3.2.5. *Rehydration ratio*

Although drying is one of the oldest and most widely used methods of food preservation, its success largely depends on the rehydration (reconstitution) of dried products. The dried products will be acceptable for food uses only if good color, texture, flavor and nutritive value are restored when these are reconstituted or rehydrated in water (Pervin *et al.*, 2008). Rehydration ratio is the weight of dehydrated sample to drained weight of rehydrated sample. The rehydration ratio of the developed RTC mixes are presented in the Table 36.

Rehydration ratio ranged from 0.34 – 0.42. The rehydration ratio of *Koottu* mix was found to be higher (0.42%) while *Olath* and *Avial* mixes were on par.

Table 36. Weight loss, rehydration ratio and bulk density of dehydrated mixes

Samples	Weight loss	Rehydration ratio	Bulk density
Avial	62.78	0.34	0.97
Koottu	64.1	0.42	0.96
Olath	62.68	0.35	0.95
SE ±	0.28	0.0039	0.0034
CD(0.05)	0.87	0.012	0.010

4.3.2.6. *Bulk density*

Bulk density is a property of flours. It is defined as the mass of many particles of the material divided by the total volume they occupy. The total

volume includes particle volume, inter-particle void volume and internal pore volume. The bulk density of developed RTC mixes is given in the Table 36.

Bulk density was higher in *Avial* mix followed by *Koottu* and *Olath* mixes.

4.3.3. Assessment of Consumer Preference

Today consumers are more conscious of the large range of food products available in the market. Novel foods are rapidly increasing in number in the markets. Consumer acceptance of a new product is based largely on its convenience, appearance, sensory value and economic value and health benefits. Here *Avial, Koottu* and *Olath* mixes were developed from jackfruit. Fifty adult females were selected randomly from neighbourhood houses and College of Agriculture Vellayani.

Consumer preference was assessed using five point Hedonic rating scale. The results of Hedonic rating is depicted in Table 37.

Table 37. Consumer preference of RTC mixes (N=50)

Parameters	Products		
	***Avial* mix**	***Koottu* mix**	***Olath* mix**
Like extremely	32(64)	8(16)	29(58)
Like very much	11(22)	30(60)	10(20)
Like moderately	3(6)	8(16)	7(14)
Like slightly	4(8)	2(4)	3(6)
Neither like nor dislike		2(4)	1(2)

* Figures in parenthesis indicate Percentage score.

When 64 per cent of the respondents liked RTC *Avial* mix extremely, only 16 per cent liked the *Koottu* mix to that extent. But RTC *Olath* mix was liked extremely by 58 per cent.

4.3.4. Shelf Life Stability

Assessment of shelf life quality is important since it determines the suitability of a particular ingredient for the product development. Shelf life is the

recommendation of time that products can be stored, during which the defined quality of a specified proportion of the goods remains acceptable under expected conditions of distribution, storage and display (Azanha and Faria, 2005). Changes brought about in food by way of breakdown of protein, carbohydrate, fat and amino acids are called microbial spoilage (Saimon, 2000). The factors like raw material quality, storage temperature, storage containers, procedures employed and the environment in which it is processed affects the shelf life quality (Shankar, 1993).

The shelf life quality of the developed RTC mixes were analysed by assessing the sensory parameters, moisture content and microbial profile for three months at monthly intervals.

4.3.4.1. Sensory Evaluation of Developed RTC Mixes

Organoleptic evaluation plays an important role in determining the acceptability and shelf stability of food products. Table 38 and 39. shows the sensory evaluation of developed RTC mixes before packing and after three months of packaging.

Appearance of Mixes

In the initial analysis of the two types packaging the mean rank values for appearance were found to be on par.

After one month the scores were higher for laminate pouches 21.55,21.60 and 21.55 for *Avial, Koottu* and *Olath* mixes respectively. The scores for mixes were however on par among the mixes. Similar trends were seen after two months. The scores for mixes in PE pouches were lower (19.45,19.10 and 19.20 for *Avial, Koottu* and *Olath* mixes respectively).

After three months the scores were again higher for mixes packed in laminate pouches but there was no significant difference among the mixes among the treatments (CV = 10.24).

Colour of The RTC Mixes

Initially the scores for colour in the two types of packagings were found to be on par, as evident in the table 38 and 39. After a month the scores were higher for mixes in laminate pouches. When the mean rank value of *Avial* mix in

Table 38. Sensory evaluation of developed RTC mixes packed in Laminated pouches

Products	**Mean Rank Values**											
	Appearance				**Colour**				**Texture**			
	T_0	**T_1**	**T_2**	**T_3**	**T_0**	**T_1**	**T_2**	**T_3**	**T_0**	**T_1**	**T_2**	**T_3**
***Avial* mix**	22.50	21.55	21.95	20.35	22.50	22.50	21.40	20.60	22.55	22.10	21.95	20.55
***Koottu* mix**	22.40	21.60	21.80	20.00	22.60	20.50	21.30	20.55	22.55	22.10	21.80	20.40
***Olath* mix**	22.50	21.55	21.90	20.10	22.50	20.55	21.20	20.65	22.50	20.40	21.90	20.40
CV	10.24											

T_0 – Initial month, **T_1 -** First month, **T_2 –** Second month and **T_3** – Third month

Products	**Mean Rank Values**											
	Flavour				**Taste**				**Overall acceptability**			
	T_0	**T_1**	**T_2**	**T_3**	**T_0**	**T_1**	**T_2**	**T_3**	**T_0**	**T_1**	**T_2**	**T_3**
***Avial* mix**	22.5	22.25	21.90	20.80	22.50	22.10	21.60	20.90	22.50	22.20	21.40	20.40
***Koottu* mix**	22.0	22.00	21.80	20.90	22.50	22.12	21.50	20.85	22.45	22.15	21.10	20.35
***Olath* mix**	22.0	22.10	21.90	20.70	22.45	22.10	21.55	20.95	22.50	22.15	21.20	20.30
CV	10.24											

T_0 – Initial month, **T_1 -** First month, **T_2 –** Second month and **T_3** – Third month

Table 39. Sensory evaluation of developed RTC mixes packed in PE pouches

Products	Mean Rank Values											
	Appearance				Colour				Texture			
	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3
***Avial* mix**	22.50	20.10	19.45	18.10	22.50	20.50	19.30	17.60	22.50	19.95	19.10	18.95
***Koottu* mix**	22.40	20.20	19.10	18.20	22.60	20.40	19.35	17.80	22.50	20.10	19.00	17.95
***Olath* mix**	22.50	20.16	19.20	18.35	22.50	20.35	19.30	17.90	22.50	19.90	19.15	17.90
CV	10.24											

T_0 – Initial month, T_1 - First month, T_2 – Second month and T_3 – Third month

Products	Mean Rank Values											
	Flavour				Taste				Overall acceptability			
	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3
***Avial* mix**	22.30	20.15	18.95	18.30	22.50	20.20	18.70	17.50	22.50	20.00	19.20	18.45
***Koottu* mix**	22.30	20.10	19.00	18.40	22.50	20.35	18.65	17.50	22.45	20.10	19.15	18.65
***Olath* mix**	22.40	20.10	19.20	18.50	22.45	20.25	18.60	17.55	22.50	20.20	19.20	18.40
CV	10.24											

T_0 – Initial month, T_1 - First month, T_2 – Second month and T_3 – Third month

laminate pouches was 22.50, the value was 20.50 for the mix in PE pouches. However this difference was not marked in *Koottu* and *Olath* mixes. After second month the difference in scores for colour were markedly higher for mixes packed in laminate pouches, being 21.40, 21.30 and 21.20 for *Avial, Koottu* and *Olath* mixes respectively. After the third month, the scores remained higher for RTC mixes in laminate pouches. When the mean rank value for the *Avial* mix was 20.60, it was only 17.60 for those packed in PE pouches. For *Koottu* mix, mean rank value was 20.55 for laminated packed mixes while it was 17.80 for those in PE pouches. Similarly for *Olath* mix, the mean rank values were 20.65 and 17.90 respectively for mixes in laminate and PE pouches.

Texture of The RTC Mixes

Change in texture through out the storage period was observed at monthly interval in the two types of packagings. Initial mean rank values were on par in both types of packagings for all the three types of mixes. However the scores were high after one month of storage for mixes in laminate pouches 22.10, 22.10 and 22.40 for *Avial, Koottu* and *Olath* mixes respectively. Similar was the case after two months and three months. The difference in scores increased by three months. However the values were on par among the mixes.

Flavour of the RTC Mixes

Flavour changes along the storage period were analysed. The values were on par initially in both treatments. But higher values were found for mixes in laminate pouches after one month. This difference continued in the second and third months analyses. When the mean rank values for *Avial* mix after third month was 20.80 (in laminate pouches) it was found to be 18.30 for those in PE pouches. For *Koottu* mix the respective values were 20.90 and 18.40 respectively, while for *Olath* mixes, the values were 20.70 and 18.50 respectively.

Taste of the RTC Mixes

Taste of the mixes were also evaluated after cooking in periodic intervals. This parameter too showed similar tends. The values did not vary initially among the treatments, but started varying from the first month. The difference in mean rank values increased over time. For instance, the difference in values among

treatments for *Avial* mix was 2.8 in PE pouches, while it was only 1.6 in laminate pouches by third month. Similar was the trend in other mixes also.

Overall Acceptability of the RTC Mixes

As for the major parameters namely overall acceptability, the values were on par among treatments initially, but the difference increased in favour of laminate pouches by the third month. The difference in values more marked in PE packing than laminate pouches. For *Koottu* mix the difference in values were 2.10 in laminate packing, while it was 2.80 in PE packing. The same difference was noted in the other mixes also.

4.4.4.2. Moisture Content of Stored Products

Moisture content is one of the most commonly measured properties of food materials. Knowledge of the moisture content is often necessary to predict the behaviour of foods during processing. The moisture content of the developed products packed in laminate and PE pouches were analysed. The comparison of products from both types of packaging were conducted periodically for three months and the data is shown in Table 40.

The data reveals that initially the moisture content of developed products packed in PE pouches varied from 5.44 – 6.08 per cent. The highest moisture content was recorded for *Avial* mix (6.08 per cent) and the lowest was observed for *Koottu* mix (5.28 per cent) packed in PE pouches, whereas the moisture content of the developed RTC mixes packed in laminate pouches ranged from 5.38 – 6.18 per cent during the initial period of storage. The highest moisture content was observed for *Avial* mix (6.18 per cent) and the lowest was recorded for *Koottu* mix (5.38 per cent). Initially the moisture content of developed RTC mixes packed in PE pouches were on par with RTC mixes packed in laminate pouches.

Table 40 further indicates the moisture content of developed RTC mixes during storage periods. At the end of first month the moisture content of developed RTC mixes packed in PE pouches and stored at ambient condition ranged from 5.41 – 6.22 per cent. The highest moisture content was noted for *Avial* mix (6.22 per cent) and lowest was noted for *Koottu* mix (5.41 per cent).

The moisture content of developed RTC mixes packed in laminate pouches varied from 5.40 – 6.20 per cent. *Avial* mix recorded highest moisture content (6.20 per cent) followed by *Olath* mix (5.56 per cent) and the lowest was noted for *Koottu* mix (5.40 per cent). Higher moisture content was recorded in the RTC mixes packed in PE pouches.

During the end of second month in PE packaging the moisture content ranged from 5.46 – 6.24 per cent. The highest moisture content was observed in *Avial* mix (6.24 per cent) and lowest was recorded for Koottu mix (5.46 per cent) packed in PE pouches. The RTC mixes packed in laminate pouches varied from 5.41 – 6.22 per cent. The lower moisture content was recorded in RTC mixes packed in laminate pouches.

At the end of the third month the moisture content ranged between 5.53 – 6.44 per cent packed in PE pouches. Highest moisture content was noted for *Avial* mix (6.44 per cent) and lowest was recorded for *Koottu* mix (5.53 per cent). The moisture content of RTC mixes packed in laminate pouches ranged from 5.45 – 6.25 per cent.

When the mixes packed in PE pouches were analysed, the moisture content of *Avial* mix was 6.08 per cent at the time of packing and increased up to 6.44 per cent after three months. In the case of laminate pouches the moisture content of *Avial* increased from 6.18-6.25 per cent within a period of 3 months.

In the case of *Koottu* mix packed in PE pouches the moisture content increased from 5.28 to 5.53 per cent. While in *Koottu* mix packed in laminate pouches the moisture content increased from 5.38-5.45 per cent.

As for *Olath* mix, the moisture content increased from 5.44-5.67 per cent packed in PE pouches and for *Olath* mix packed in laminate pouches ranged from 5.54-5.63 per cent. The data shows that the moisture content was higher in RTC mixes packed in PE pouches as compared to laminate pouches, although the difference was not statistically significant.

Table 40. Moisture content (%) of RTC mixes packed in laminate and PE pouches

RTC mixes	PE package				Laminate pouches			
	Initial	First month	Second month	Third month	Initial	First month	Second month	Third month
Avial	6.08	6.22	6.24	6.44	6.18	6.20	6.22	6.25
Koottu	5.28	5.41	5.46	5.53	5.38	5.40	5.41	5.45
Olath	5.44	5.57	5.61	5.67	5.54	5.56	5.57	5.63
SE	0.020	0.024	0.025	0.098	0.020	0.021	0.023	0.019
CD (0.05)	0.062	0.074	0.078	0.303	0.062	0.065	0.072	0.061

4.3.4.2. *Microbial Profile of RTC Mixes*

Analysis of microbial population in developed food products is important as it determines the quality and safety of food products. The microbiological safety of food is achieved by ensuring the absence of pathogenic microorganisms and as far as possible through preventing their multiplication by all possible means (Beckers, 1988). Food products that have been subjected to an adequate heat-treatment during processing are free of vegetative pathogens. Thus initially it is regarded as safe. Microbial analyses of stored products were done to ascertain the shelf life of the products. The products were stored in ambient conditions for three months. The microbial evaluation was done initially and at 30 days intervals up to 3 months. The growth of bacteria, fungi, actinomycetes and E-coli were determined using Nutrient Agar (NA), Potato Dextrose Agar with Rose Bengal (PDARB), Ken Knight's Agar (KEN) and Eosin Methylene Blue (EMB). The evaluation was done by serial dilution of the samples followed by pour plating techniques suggested by Johnson and Curl (1972).

Processed foods which are stored and consumed after a period of storage require certain microbial criteria to be employed to ensure their quality and safety. Many organisms causing food borne illness may grow and cause significant effect

on the quality of final product. A high microbial load and storage temperature higher than recommended for a particular food can reduce the shelf life of a product. According to Shankar (2000) several factors such as quality of raw material, storage temperature, storage containers, processing methods and the environment in which it is processed will always affect the microbiological quality of processed foods. Since ready to cook foods provide ample scope for contamination with spoilage and pathogenic microorganisms, the microbial quality was assessed.

During the storage period no bacterial colonies were found to appear in the developed RTC mixes packed in PE and laminated pouches. But Yeast colonies were seen in negligible amounts in PE packaging. Even though yeast was detected in *Koottu* mix packed in PE pouches during third month, it was within permissible limits (FSSAI limit for dehydrated products is not more than 40,000 cfu/g). No other pathogenic organisms could be detected in the developed products.

4.3.5. Proximate Composition

Saxena (2003) reported that laboratory analyses is one of the best methods to assess the quality of different constituents present in the products. Proximate composition of the mixes were ascertained with respect to carbohydrate(g), protein(g), fat(g), calories(Kcal), fibre(g), total minerals(mg) and β carotene(mg).

4.3.5.1. *Carbohydrate*

Being the major source of calorie after fat, carbohydrate is the nutrient of concern in all food products. Hence an awareness of the nutrient will be valuable to consumers.

Table 41 gives the carbohydrate content of developed RTC mixes. The statistical analysis of data reveals that there was significant difference between carbohydrate content of the developed RTC mixes.

The maximum carbohydrate content was noted for *Avial* mix (38.37g/100g) and minimum was recorded for *Koottu* mix (33.16g/100g) whereas for *Olath* mix carbohydrate content was 37.19g/100g.

Table 41. Proximate composition in 100 g of mix

Samples	Carbohydrate (g)	Protein (g)	Fat (g)	Calories (Kcal)	Fibre (g)	β carotene (mg)
Avial Mix	38.37	13.32	0.71	223	8.31	0.072
Koottu Mix	33.16	12.93	0.52	189	6.54	0.46
Olath Mix	37.19	13.10	0.62	214	7.35	0.17
SE	0.36	0.012	0.012	1.29	0.16	0.004
CD(0.05)	1.13	0.037	0.037	3.98	0.49	0.012

4.3.5.2. *Protein*

Protein is one of the most important nutrients required by the body to carry out a wide range of functions essential for the maintenance of life. Proteins are essential components of tissues and cells of the body (Gopalan *et al.*, 2009). An assessment of the nutrient will again be useful to consumers.

The protein content of the developed RTC mixes are depicted in Table 41. From the table it is observed that there was no significant difference in the protein content of the RTC mixes. Protein content ranged from 12.93- 13.32g. The protein content was found to be higher for *Avial* mix (13.32g/100g) and lower protein content was noted for *Koottu* mix (12.93g/100g).

4.3.5.3. *Fat*

Fat is an essential nutrient as it provides energy, absorbs certain nutrients and maintains core body temperature.

The fat content of the developed RTC mixes are shown in Table 41. Their levels ranged from 0.52-0.71g. The higher fat content was recorded for *Avia*l mix (0.71g/100g) followed by *Olath* mix (0.62g/100g) and lower levels are noted for 0.52g/100g.

4.3.5.4. *Calories*

Energy is essential for rest, activity, growth and maintenance of sound health. Its content is of concern to health conscious consumers.

The energy content of the products developed from jackfruit *viz.*, *Avial*, *Koottu* and *Olath* is presented in Table 41.

The statistical analysis reveals that there was significant difference in the calorie content of developed RTC mixes. The energy content was found to be highest for *Avial* mix (223kcal/100g) and minimum for *Koottu* mix (189kcal/100g). The calorific value of *Olath* mix was 214kcal/100g.

4.3.5.5 *Fibre*

Fibre is the indigestible portion of food derived from plants. Fibres can act by altering the nature of the contents of the gastrointestinal tract and by changing the rate of absorption of nutrients and chemicals.

The total fibre content of the developed mixes are shown in the Table 41. Fibre content of the mixes ranged from 6.54-8.31g. The maximum fibre content was noted for *Avial* mix (8.31g/100g) and the least fibre was recorded for *Koottu* mix (6.54g/100g).

The ANOVA results reveal that there was significant difference between the fibre content of the developed RTC mixes.

4.3.5.6. *β carotene*

β carotene is the main safe dietary source of vitamin A. It is essential for normal growth and development, immune system functioning and vision.

The β carotene content of the developed RTC mixes are depicted in Table 41. β carotene content ranged from 0.072mg- 0.46mg/100g. *Koottu* mix had comparatively higher levels (0.46mg/100g) and *Avial* mix had the lowest (0.072mg/100g) levels of β carotene. The differences were statistically significant.

4.3.5.7. *Total Minerals*

Total mineral is a measure of the total amount of minerals present within a food, and it is also a measure of the amount of specific inorganic components present within a food.

The total mineral content of the developed RTC mixes are depicted in Table 42. The data revealed that the total mineral content was highest for *Olath* mix (5.61g/100g) and lowest for *Koottu* mix (4.58g/100g).

It is evident from table that there was significant difference in the total mineral content of the developed RTC mixes.

Table 42. Mineral content of dehydrated mixes (per 100g)

Samples	Total mineral (g)	Calcium (mg)	Iron (mg)	K (mg)	Mg (mg)	Na (mg)	Mn (mg)
Avial Mix	5.47	118.53	121.93	516.80	108.48	51.10	2.01
Koottu Mix	4.58	116.82	121.18	514.80	108.35	51.20	3.47
Olath Mix	5.61	112.13	121.37	516.20	108.46	51.80	3.91
SE	0.16	0.76	0.32	0.19	0.36	0.68	0.34
CD(0.05)	0.50	2.36	0.10	0.61	0.11	0.21	1.05

4.3.5.8. *Calcium*

Calcium is essential for all living organisms, in particular for the cell physiology. As a major material used in mineralization of bone, teeth and shells, Calcium is the most abundant mineral by mass in most animals.

The calcium content of the developed RTC mixes are depicted in Table 42. From the table it may be noted that the calcium content ranged from 112.13-118.53 mg. There was significant difference between the calcium content of the developed RTC mixes. The maximum calcium content was noted for *Avial* mix (118.53mg/100g) and minimum was recorded for *Olath* mix (112.13mg/100g).

4.3.5.9. *Iron*

Iron is an essential trace element found in nearly all living organisms. Iron is essential for the proper growth and development of the human body. It helps to metabolize proteins and plays a role in the production of haemoglobin and red blood cells. Iron deficiency can lead to conditions like iron deficiency anaemia.

The iron content of the developed RTC mixes are recorded in the Table 42. The statistical data reveals that there was significant difference in the iron content of the RTC mixes. Iron content was higher in *Avial* mix (121.93mg/100g) and lowest in *Koottu* mix (121.18mg/100g).

4.3.5.10. *Potassium*

Potassium is an essential macro-mineral in human nutrition; it is the major cation inside animal cells, and it is thus important in maintaining fluid and

electrolyte balance in the body. Potassium is also important in conducting muscle contraction and in the sending of all nerve impulses in animals through action potential.

The potassium content of the developed RTC mixes are depicted in Table 42. The data reveals that the potassium content was highest for *Olath* mix (516.20mg/100g). The level of potassium in *Avial* and *Olath* mixes were on par and lowest for *Koottu* mix (514.80mg/100g).

4.3.5.11. *Magnesium*

Magnesium is highly required for cellular metabolism, essential for intracellular enzyme activity, metabolism of carbohydrate and as a structural component of DNA and RNA.

The magnesium content of the developed RTC mixes are recorded in Table 42. From the table it is noted that there was significant difference in the magnesium content of the developed RTC mixes. These levels ranged from 108.35-108.48mg/100g. Their levels in all the mixes were seen to be on par.

4.3.5.12. *Sodium*

The sodium content of the developed RTC mixes are depicted in Table 42. There was no significant difference in the sodium content of the developed RTC mixes. The values were seen to be on par.

4.3.5.13. *Manganese*

The manganese content of the developed RTC mixes are depicted in Table 42. From the table it is noted that the manganese content ranged from 2.01-3.91%. There was significant difference between the manganese content of the developed RTC mixes. The higher manganese content was noted for *Olath* mix (3.91mg/100g) and lower level was recorded for *Avial* mix (2.01mg/100g).

The results obtained are reviewed and discussed hence forth in the following chapter.

Discussion

5. DISCUSSION

The result of the present investigation entitled "Development of jackfruit based Ready To Cook (RTC) instant mixes" are discussed below.

5.1. Standardization and product development

5.2. Packaging and storage

5.3. Quality assessment of dehydrated jackfruit RTC mixes

5.1. STANDARDIZATION AND PRODUCT DEVELOPMENT

The jackfruit (*Artocarpus heterophyllus* Lam.) originated in the rain forests of the Western Ghats of India and quickly spread to other parts of India, South Asia, the East Indies and ultimately the Philippines (Anapaula *et al.*, 2013). Young jackfruit is often used for cooking in many countries like India, Nepal, Bangladesh, Srilanka, Indonesia, Cambodia, Thailand and Vietnam. The utilization of jackfruit is restricted due to its cumbersome preparation procedures .Developing a processed product with good sensory qualities and prolonged shelf life would benefit consumers by its easier preparation. This will also serve in the broader aim of promotion of intake of vegetables. Its world wide marketing will also be facilitated.

Pai (2007) reported that there is a need to make new products from indigenous raw materials having nutritional value which open up new channels for domestic and export market. Hence, research in this field should be focused to develop nutrient packed food products from locally available recourses. Ray and Athwali (2000) reported that more and more people were going in for processed foods and it is estimated that over 10 per cent of the expenditure is being spent for processed foods. Saha and Dankwal (2009) opined that instant food means, simple, fast and convenient foods, which are easy and fast to prepare. In this context RTC mixes from raw jackfruit were developed.

In the present investigation jackfruit koozha type was collected and washed. The fruits were cut open, bulbs and seeds were separated. As jackfruit bulbs are big

in size. It was sliced in varying widths for each dish. Width of 0.5cm, 1cm and 1.5cm were identified as the best from the different treatments for *Koottu*, *Olath* and *Avial* mixes respectively. Shape, size and thickness of the chips influences how fast it dries; diffusion and the rate of drying are fastest in small chips. When chips are thick the outer layer easily compresses, thereby preventing the free air movement through the mass (FIIR, 2005). Abano and Samamoah (2011) reported that the rate of drying time is also dependent on temperature of drying air and thickness of the slices. If the slices are thinner it will dry faster as compared to thicker slices. Cassava tubers were cut into chips of 2.0 cm thickness for faster dehydration (Oghenechavwuko *et al.*, 2013). Thickness affects the drying time as thickness of the sample increases the drying time to achieve a desirable moisture ratio also increases (Islam *et al.*, 2012). Mozumder *et al.* (2012) reported that tomatoes were cut into slices with thickness of 5mm for optimum drying.

Blanching is one of the most widely used pre- treatments in the drying of vegetables because of the resultant inactivation of enzymes, changes in tissue structure and short drying time (Latapi and Barrett, 2006). The sliced jackfruits were subjected to water blanching for 3min, 5min, 7min, 10 min and 15min. Three minute blanching was found to give better product in three cases. In order to prepare jack fruits chips the bulbs where cut into 4cm x 2cm, blanched in water for 10 minutes followed by immersion of jack fruit slices into 0.1% KMS for 15 minutes (Molla *et al.*, 2008). Hassini *et al.* (2002) reported that potato slices were blanched for 5 minutes in 95°C water. The sliced carrots were subjected to hot water blanching by holding them in a muslin cloth in boiling water at 100°C for 6 minutes to inactivate peroxidase (Goula and Adamopoulo, 2010).

The sliced jack fruit was pre treated with salt (0.5%), KMS (0.2%), ascorbic acid (1%), citric acid (0.2%) and in different combinations. The treatment done with KMS (0.2%) and salt (0.5%) for 30 minutes was found to give a product with better appearance and acceptability. According to Rahman *et al.*, (2012) jackfruit bulbs treated with 0.1%KMSbefore osmotic dehydration gave the most acceptable

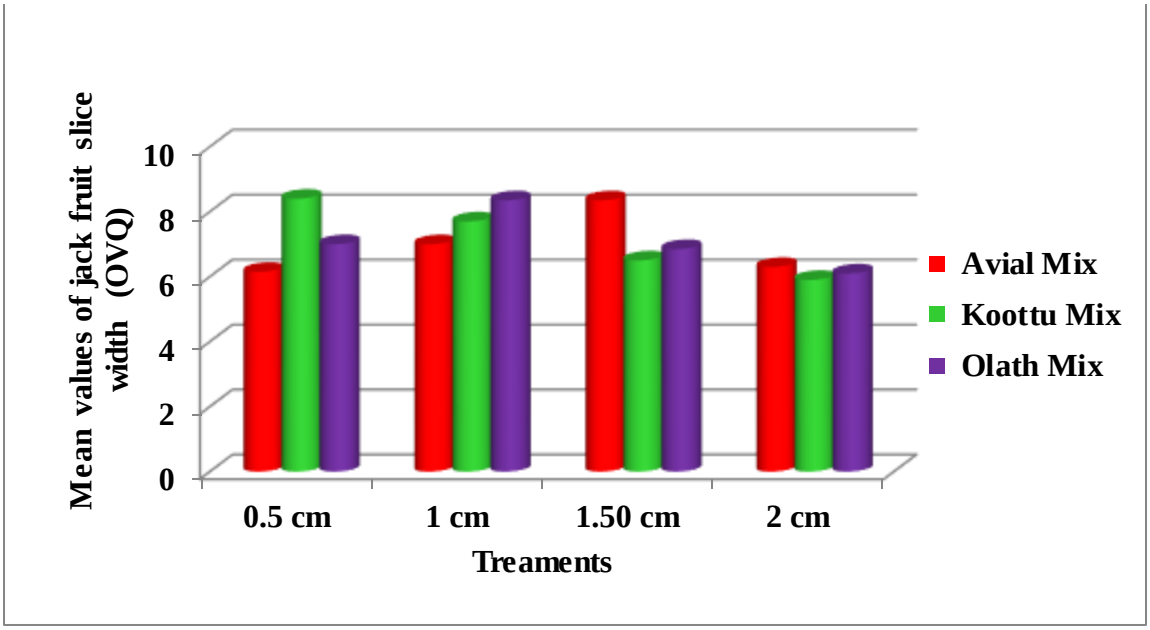


Fig. 2. OVQ scores of jack fruit slices width

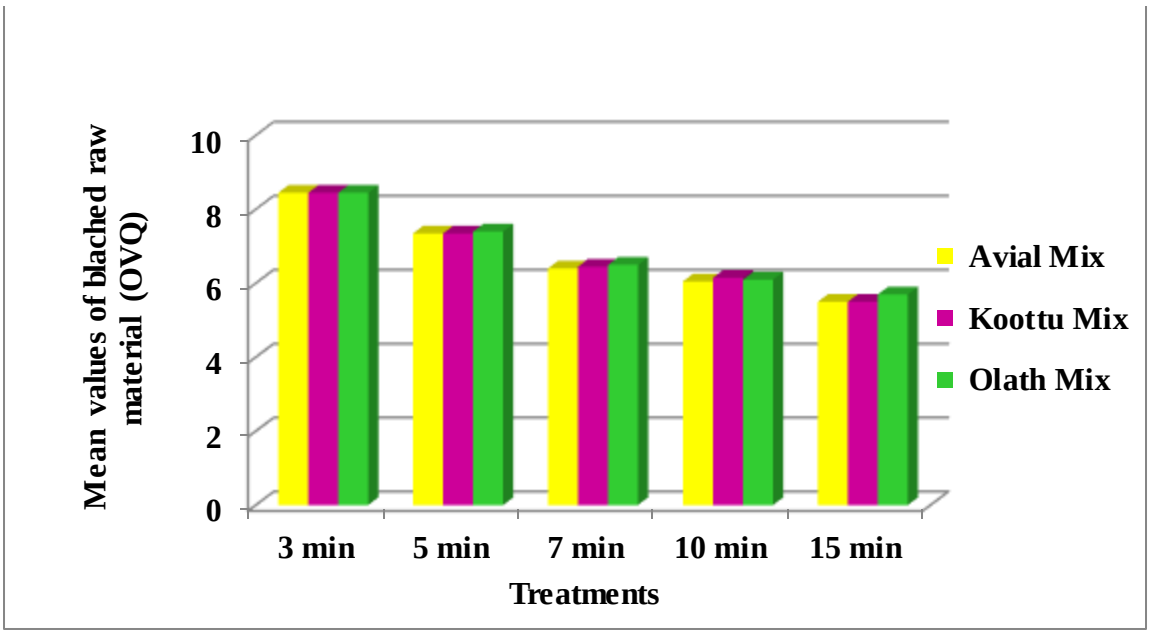


Fig. 3. OVQ scores of blanched raw material

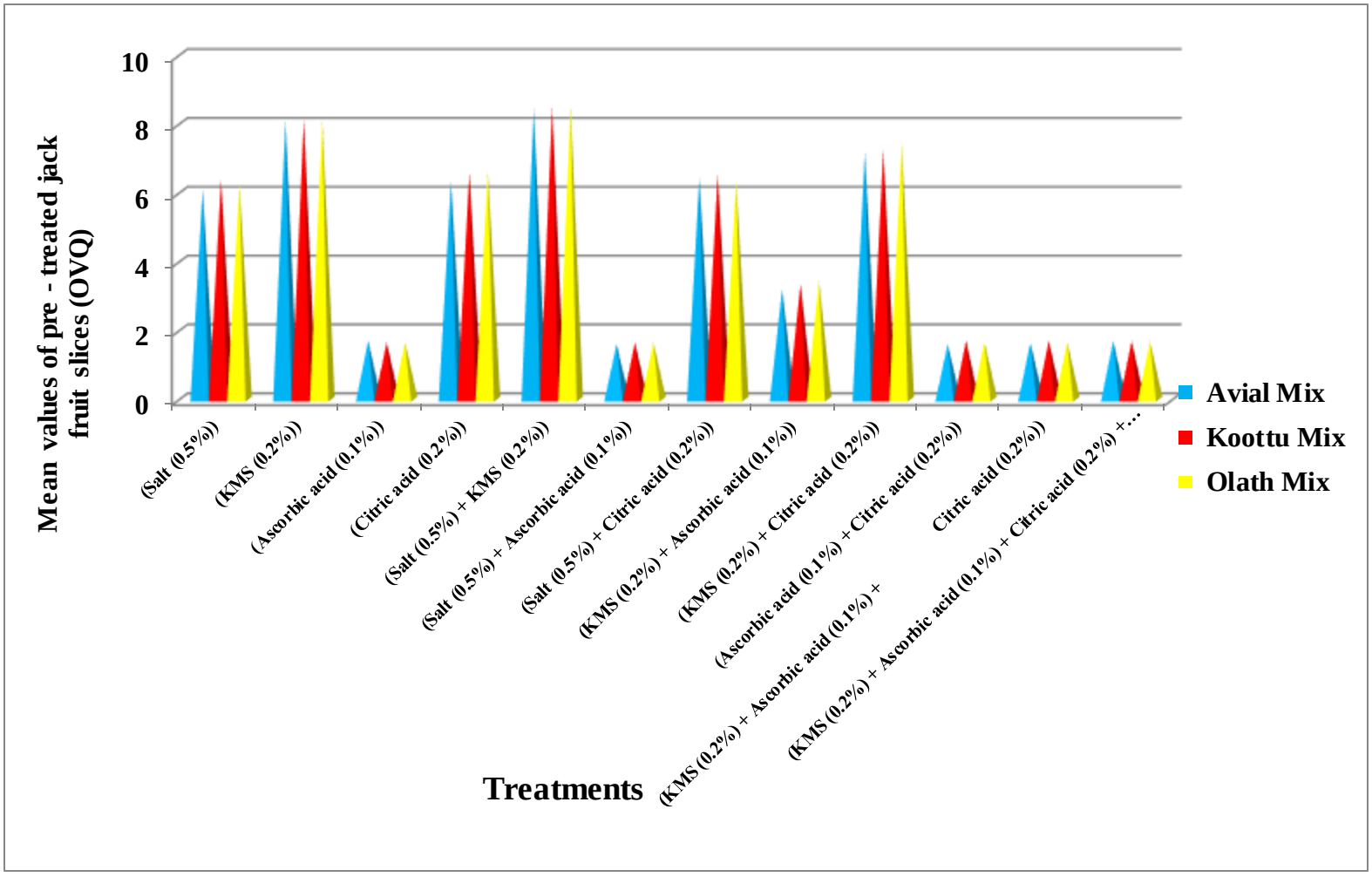


Fig. 4. OVQ scores of pre-treated jackfruit slices

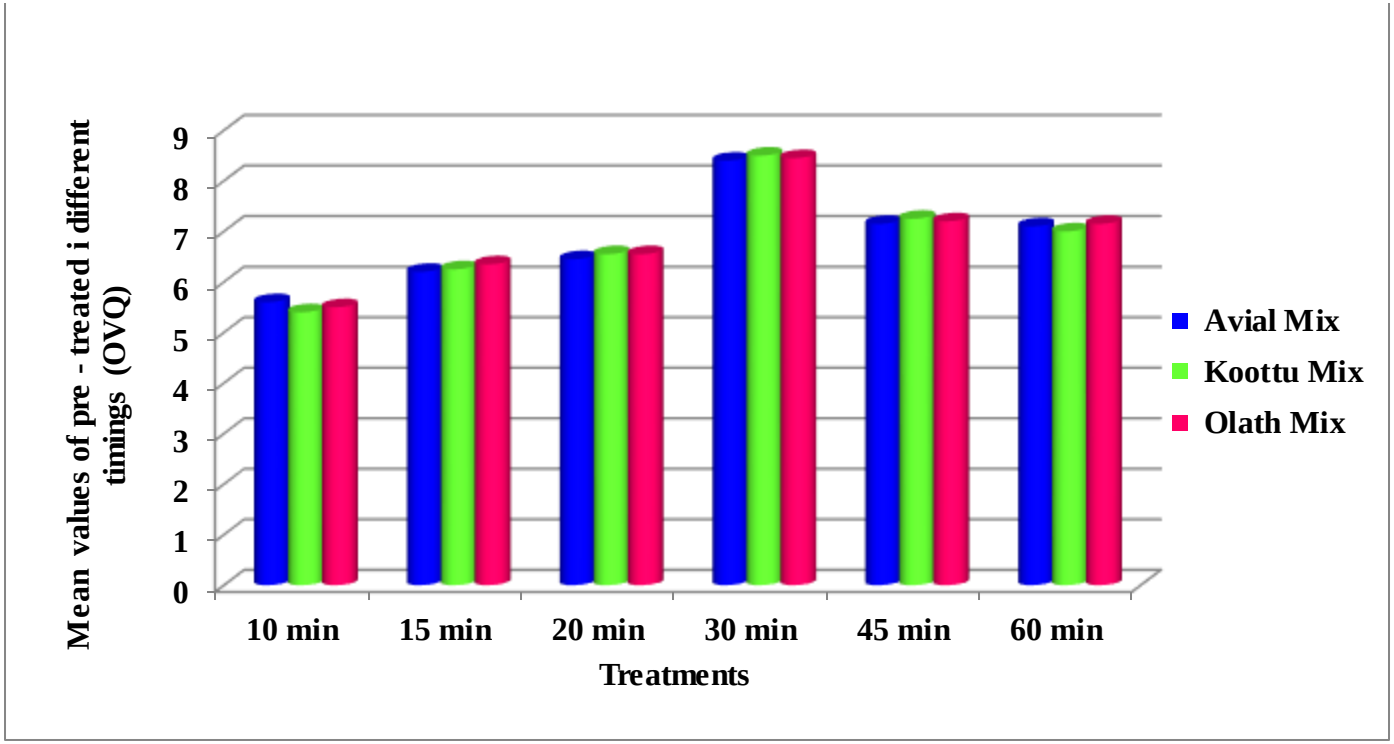


Fig. 5. OVQ scores of jack fruit slices pre-treated in different timings

product. Ioannou and Ghoul (2013) reported that appropriate chemical pre-treatment can be adopted to preserve colour and inactivate enzymatic action. Different pre-treatment methods have been developed for fruit drying, among which are lemon juice, salt solution, honey dip, ascorbic acid, sulfuring, osmotic pretreatment, and blanching (Karim, 2005). If no pre-treatment is done, the fruits will continue to darken after they are dried.

The blanched jack fruit slices were immersed in selected pre treatment media for 10 minutes, 15 minutes, 20 minutes, 30 minutes, 45 minutes and 60 minutes. Immersion time of 30 minute was found to be optimum for giving a better product. In the preparation of jack fruit candy, jack fruit bulbs were cut into 1x0.5 cm pieces, blanched in hot water for 4 minutes and immersed in 2 % calcium lactate and 0.1% KMS solution for 2 minutes. It was inferred that the immersion increases the strength of the product (Zuniga et al., 2004).

5.1.1. Formulation of Ready To Cook (RTC) Dehydrated Product from Jack Fruit.

The demand for Ready-To-Cook and Ready–To-Eat foods have captured a large amount of the food retail markets in India. There is a rise in the demand for foods based on traditional Indian recipes across different states and abroad because of its good quality, taste and convenience (Rahman, 2013). Mathur and Sabikhi (2002) opine that today's consumers are more health conscious, which is the driving force for designing newer foods. Liaqat *et al*. (2009) found that recipe standardization achieved optimal accuracy in determining the nutrient estimation. In the present investigation, *Avial*, *Olath* and *Koottu* were formulated based on standard traditional recipes. Sensory evaluation with a panel of 10 members identified the best combinations in each dish. Identified *Avial* mix comprised of jack fruit bulbs and seeds, greenchilly, garlic, jeera, turmeric powder and curry leaves (100:3:5:1:2:5). The identified *Koottu* mix comprised of jackfruit bulbs and seeds, red chilly, turmeric powder, cumin and curry leaves (100:3:1:3:5). The best treatment of *Olath* mix comprised of jack fruits bulbs and seeds, crushed red chilly, onion, garlic, turmeric

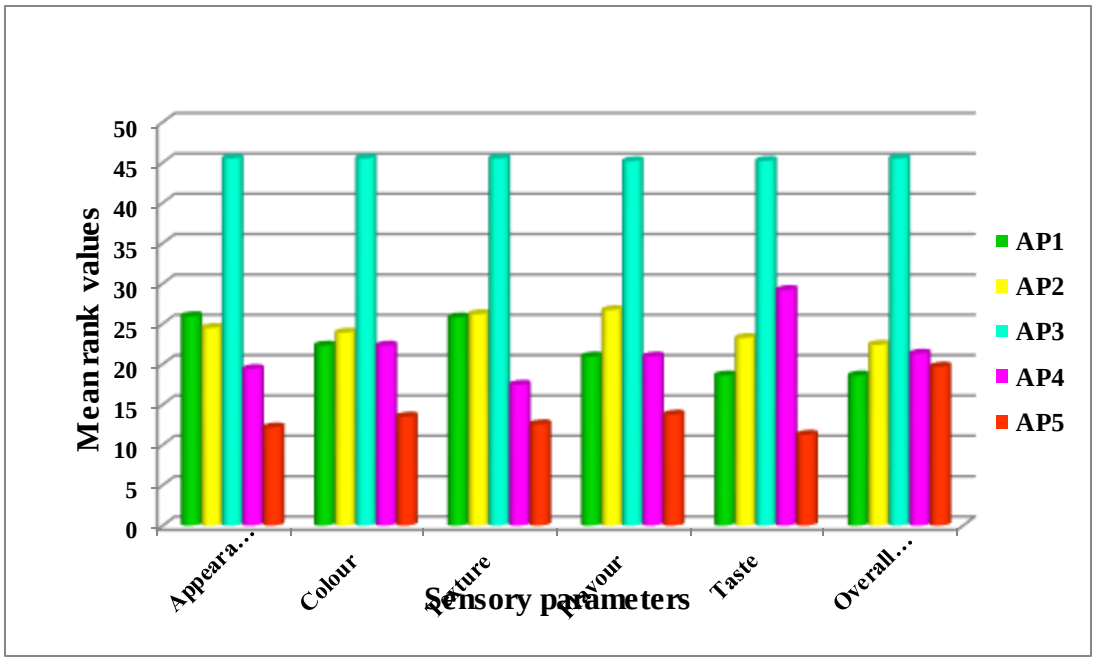


Fig. 6. Sensory quality of various formulations of *Avial* mix

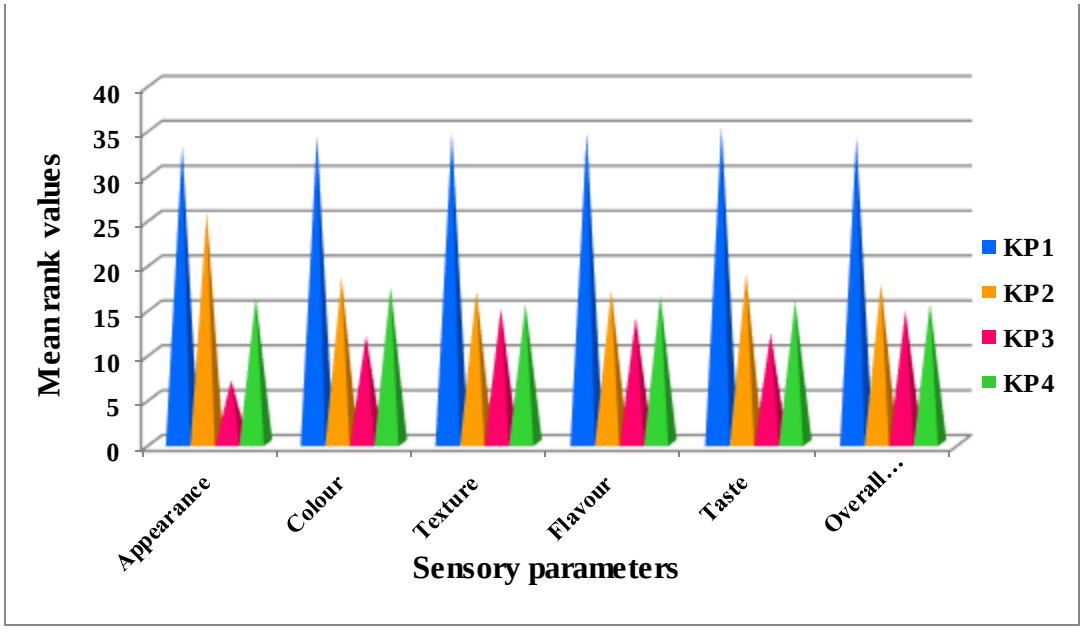


Fig. 7. Sensory quality of various formulations of *Koottu* mix

powder and curry leaves (100:2:10:5:1:5). Kaushik *et al*. (2011) reported that, India has rich heritage of food and recipes. Midhila (2013) standardized a traditional RTC product namely, 'thoran' mix from nendran banana blossom variety. The recipe comprised of adjuncts such as nendran banana blossom, coconut, cumin, garlic, red chilly, salt and turmeric powder. This product was found to be very much acceptable.

5.1.2. Standardization of Cooking Methods of RTC Dehydrated Products from Jack Fruit.

5.1.2.1. *Optimization of Reconstitution Time of RTC Product.*

Reconstitution (pre-soaking) was advantageous as this treatment gave higher rehydration, softer texture and uniform heating of the product (Pervin *et al*., 2008). The optimum amount of water required for reconstitution depends largely on the product; too little water will be expected to slow down the rate of water absorption and at the same time large quantity of surplus water should be avoided because flavoring factors and valuable nutrients such as water soluble vitamins and minerals may be lost to a large extent.

The dehydrated mixes where reconstituted for 10 minutes, 15 minutes, 20 minutes, 30 minutes and 45 minutes. The treatment of 30 minutes of reconstitution time was found to give the most acceptable product. According to Pervin *et al*. (2008) presoaking of 50 minutes was found to be more favorable for dried lablab bean without seed coat and 60 minutes presoaking gave the best product for bean with seed coat. Apati *et al*. (2010) reported that dehydrated oyster mushroom could be rehydrated at room temperature for 30 minutes for giving better product. Thus it can be inferred that rehydration time varies with the raw material.

5.1.2.2. *Optimization of Cooking Procedures and Cooking Time*

Cooking Procedure

The reconstituted RTC mixes were standardized for cooking procedures through four treatments, *viz*., cooking in plain hot water, cooking in strained hot water, cooking in plain cold water and cooking in strained cold water. Cooking in hot

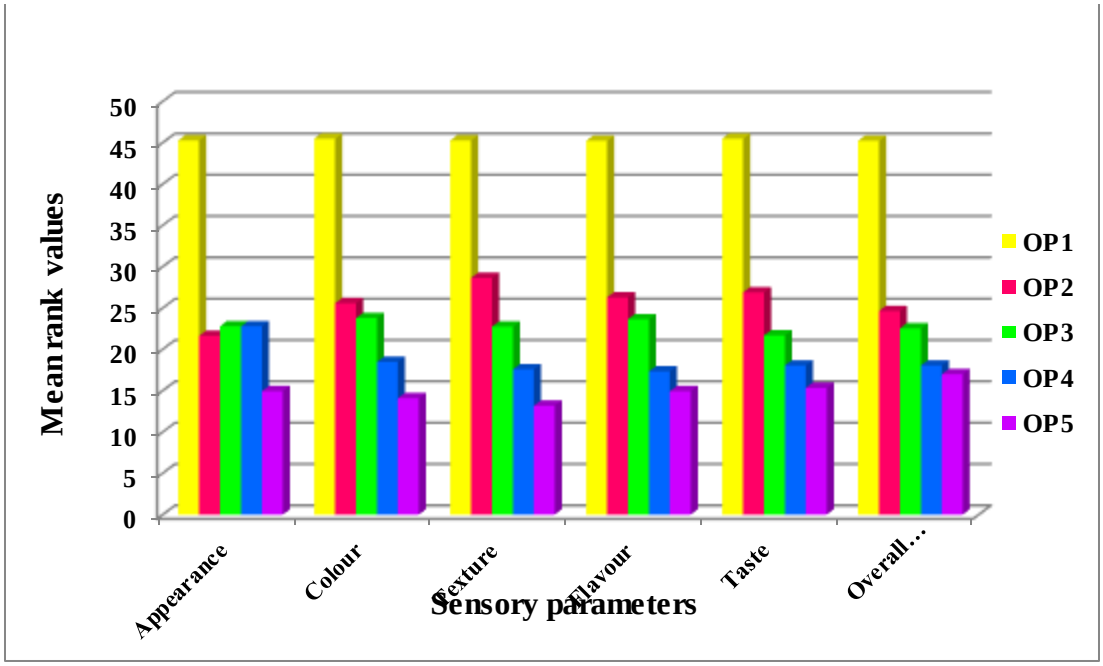


Fig. 8. Sensory quality of various formulations of *Olath* mix

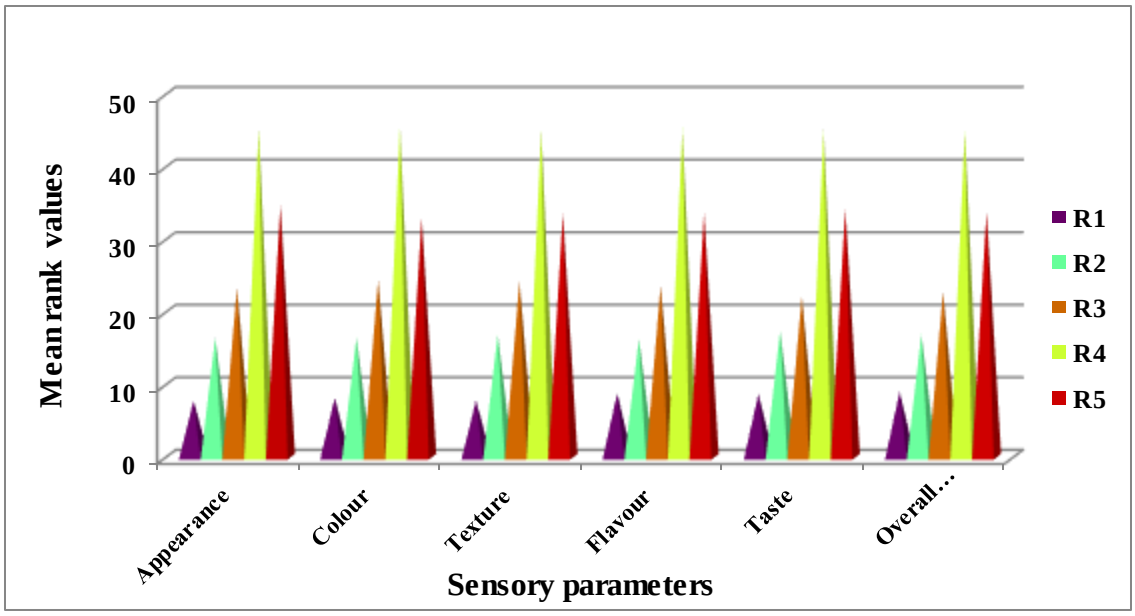


Fig. 9. Sensory quality of *Avial* mix with varying reconstitution time

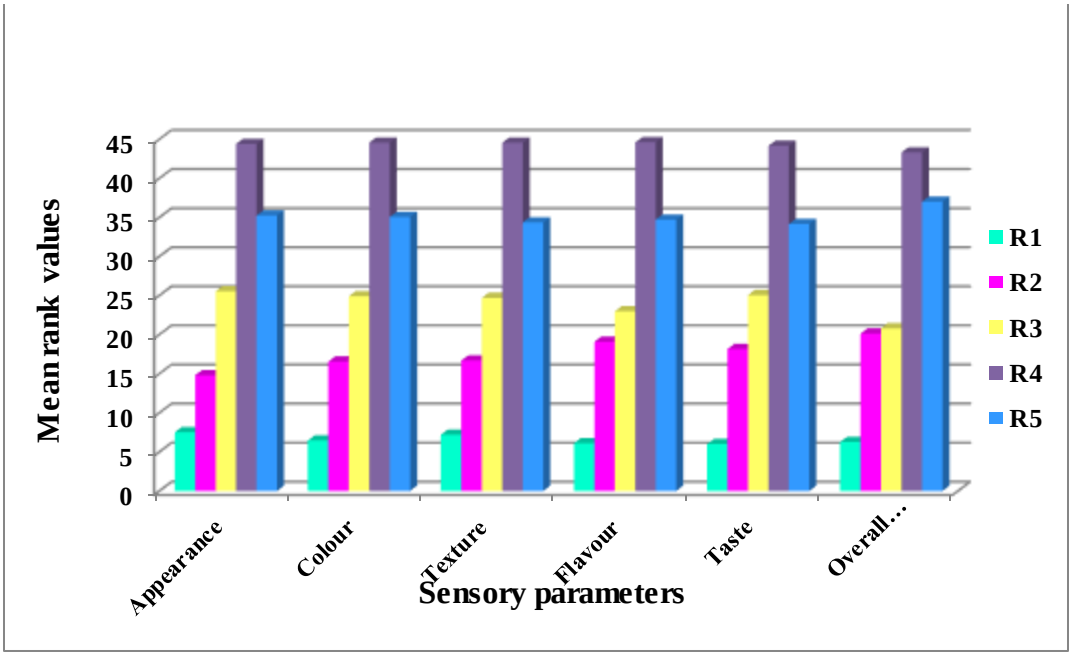


Fig. 10. Sensory quality of *Koottu* mix with varying reconstitution time

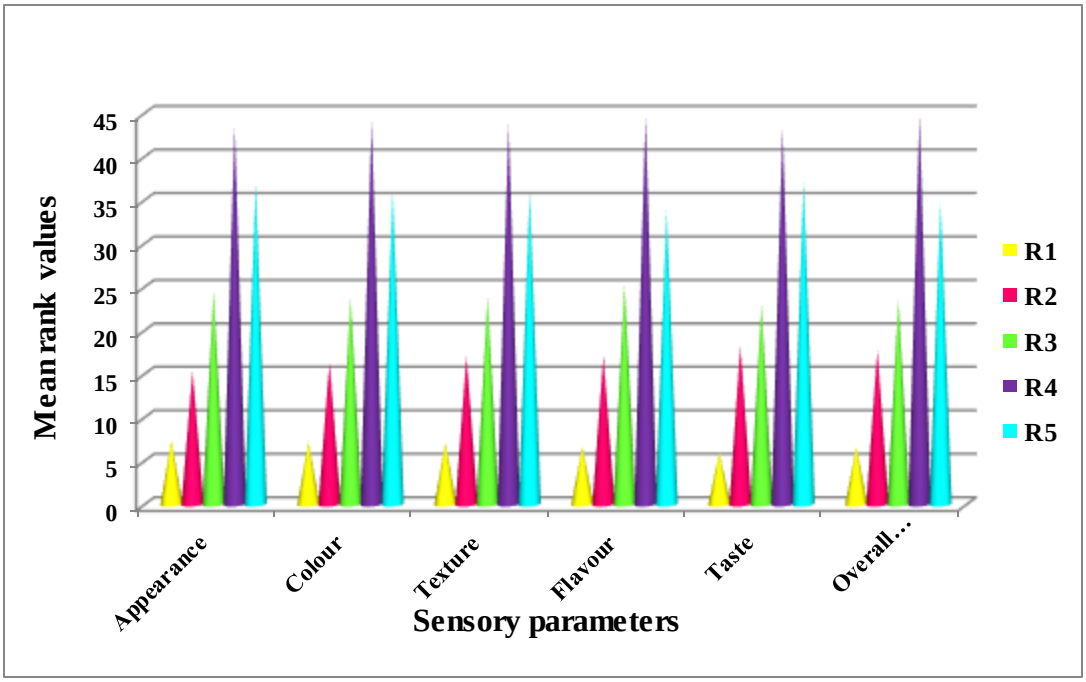


Fig. 11. Sensory quality of *Olath* mix with varying reconstitution time

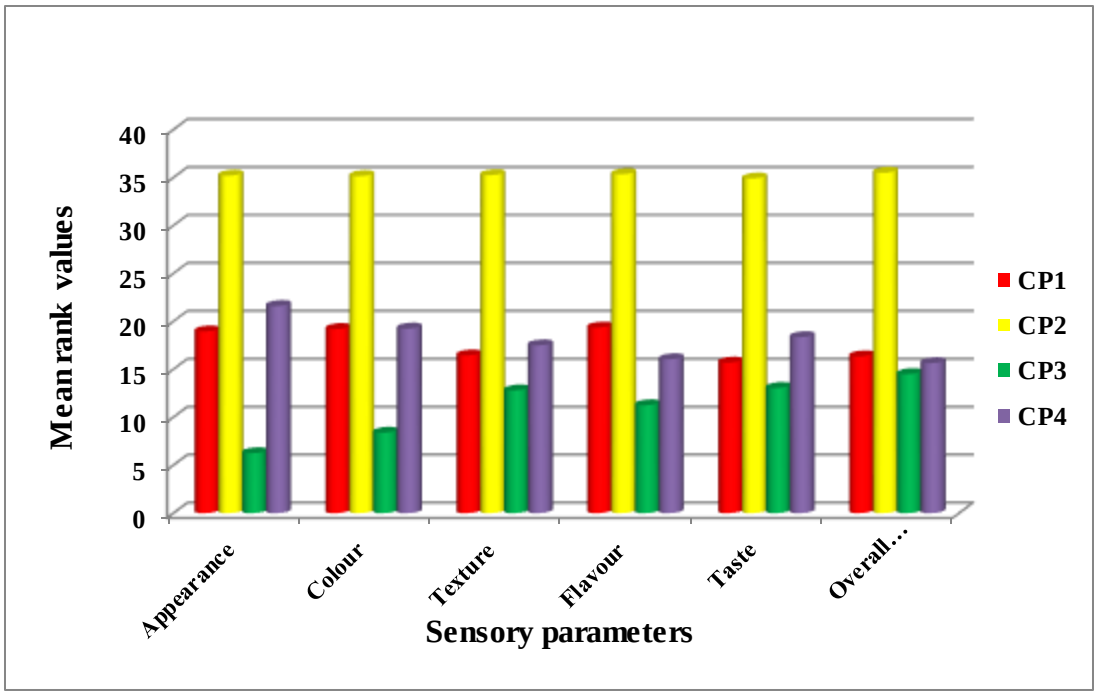


Fig. 12. Sensory quality of *Avial* mix with variations in cooking procedures

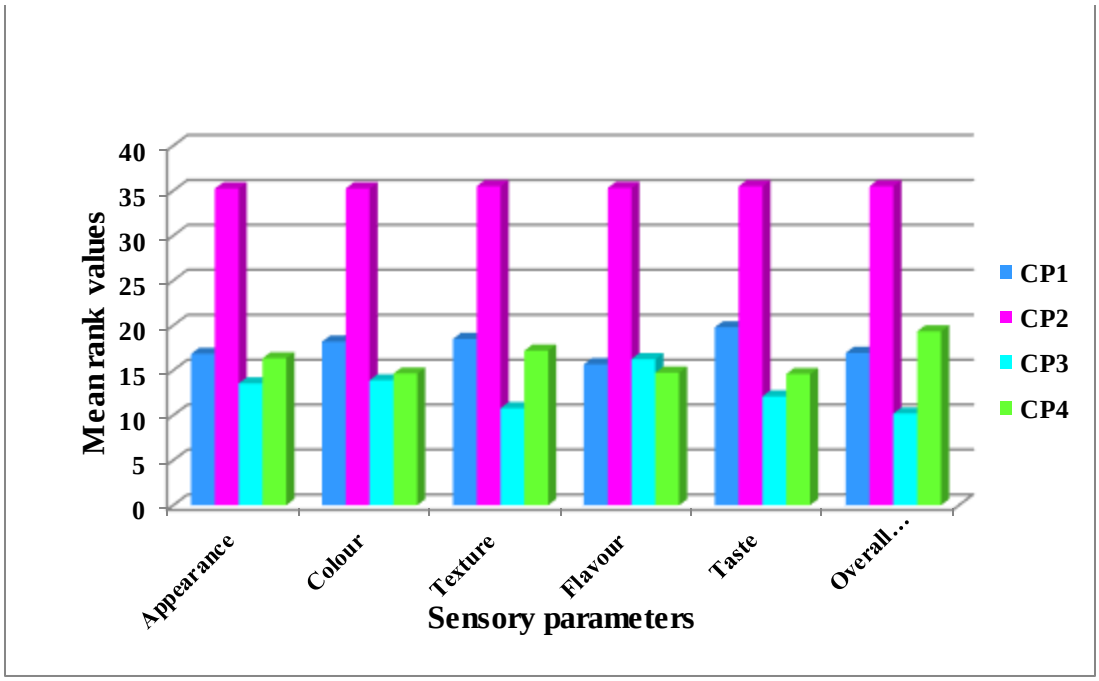


Fig. 13. Sensory quality of *Koottu* mix with variations in cooking procedure

strained water was noted to be the best treatment to improve the quality of dehydrated mixes before cooking. Roberts and Cox (1999) suggested that rehydrated or reconstituted fruits and vegetables should be cooked in the water in which they were soaked to utilize the nutrients leached. Thus it can be inferred that cooking in strained hot water is both tastier and nutritious.

Cooking Time

The developed RTC mixes were cooked at different timings such as 6 min, 8 min, 10min and 15min. It was found that 10 min was enough for the preparation of the *Olath* and the 15 min was necessary for cooking *Avial* and *Koottu*. Khetarpaul *et al*. (2004) reported that pre – soaking reduced the cooking time of products. Ghadge *et al*. (2008) also reported similar results.

5.1.2.3. *Optimization of Additional Ingredients to be Added*

Coconut and oil are the necessary adjuucts for *Avial, Koottu* And *Olath* mixes to impart the typical taste, flavor and appearance of these traditional recipes. Coconut was added into *Avial* in various proportion of 10g, 20g, 30g, 40g and 50g, among this 30g of coconut per 100gm was selected as best of treatment by the sensory panel. Similarly 15g, 25g, 35g, 45g and 50g of coconut were added into *Koottu* mix from amongst these, 35g addition of coconut was found to be best treatment. Midhila (2013) concluded that coconut forms one of the major ingredient of most of Kerala cuisines due to its delicious taste and aroma.

Krishna *et al*. (2010) reported that coconut oil is consumed in tropical countries for thousands of years. Coconut oil has shelf life and contribute nutritional and functional benefits to value added foods. In the case of *Avial* mix 3.5ml of addition of oil was found to give a better product. Oil was added to *Olath* mix at the proportion of 1.5ml, 2.5ml, 3.0ml, 4.0ml and 5.0ml, 3.0 ml addition of coconut oil in to *Olath* mix was found to be better treatment to improve the seasoning qualities of the *Olath*. Coconut and coconut oil impart characteristic flavor to food (FMRC, 2008).

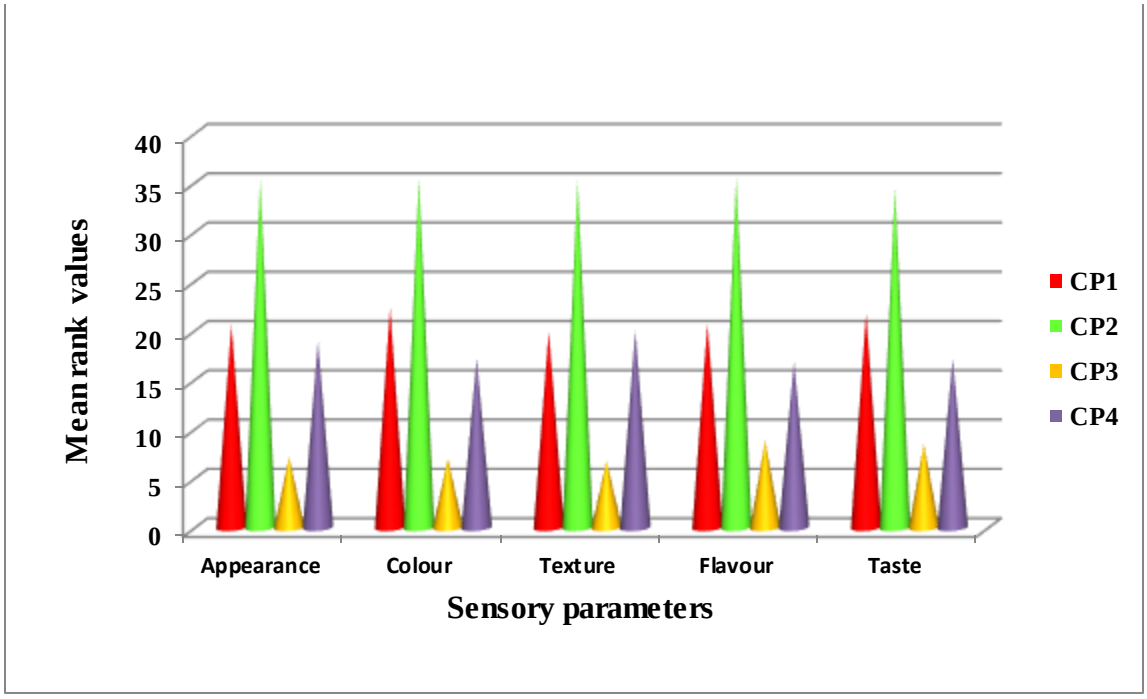


Fig. 14. Sensory quality of *Olath* mix with variations in cooking procedures

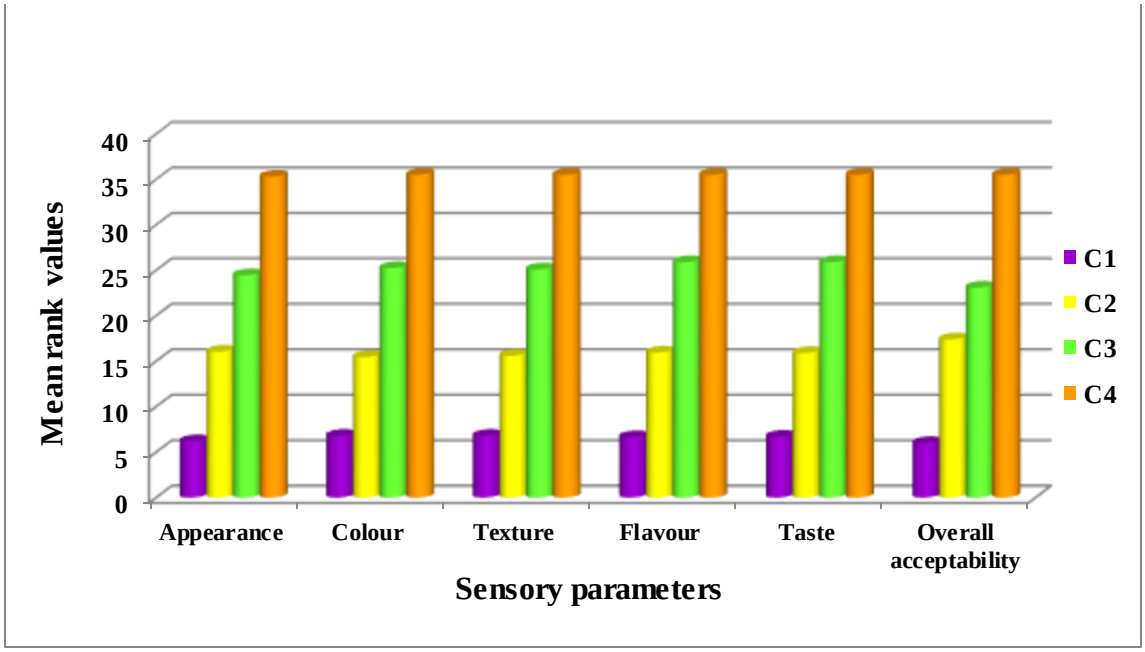


Fig.15. Sensory quality of *Avial* mix with varying cooking time

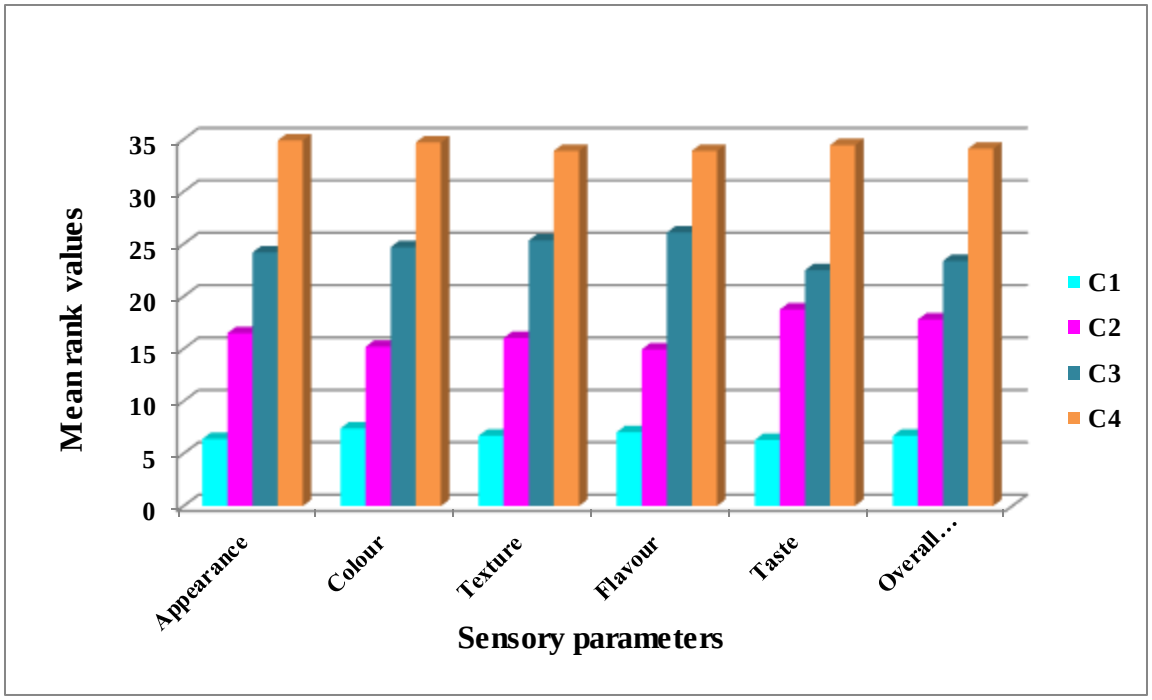


Fig. 16. Sensory quality of *Koottu* mix with varying cooking time

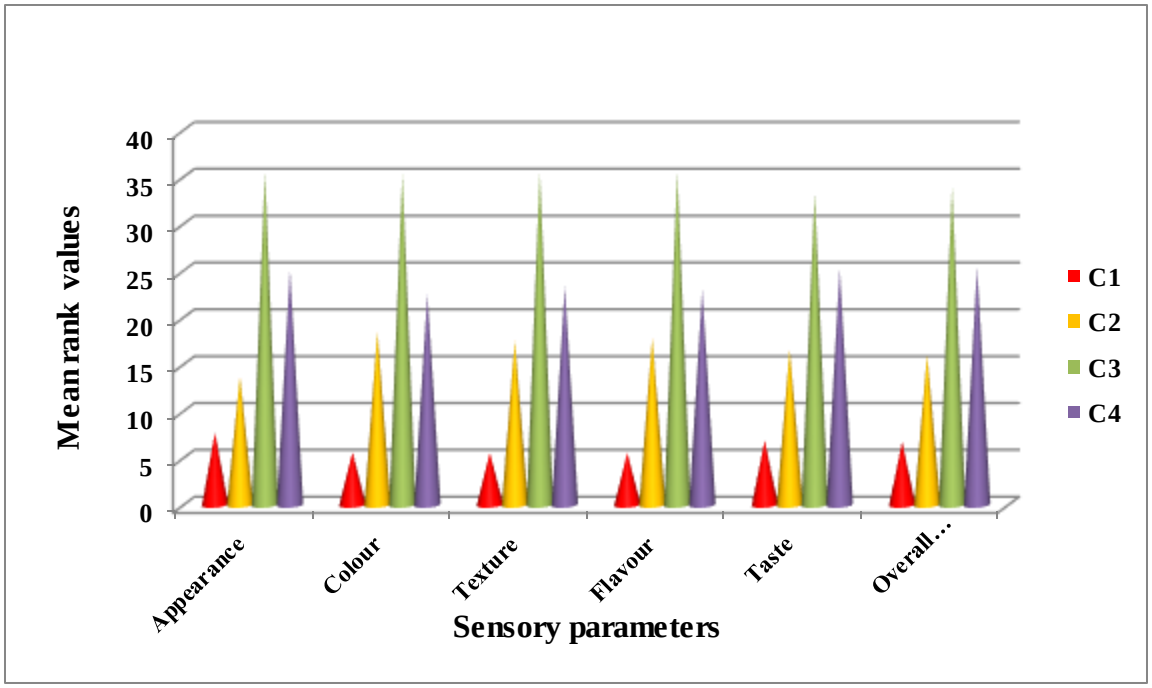


Fig. 17. Sensory quality of *Olath* mix with varying cooking time

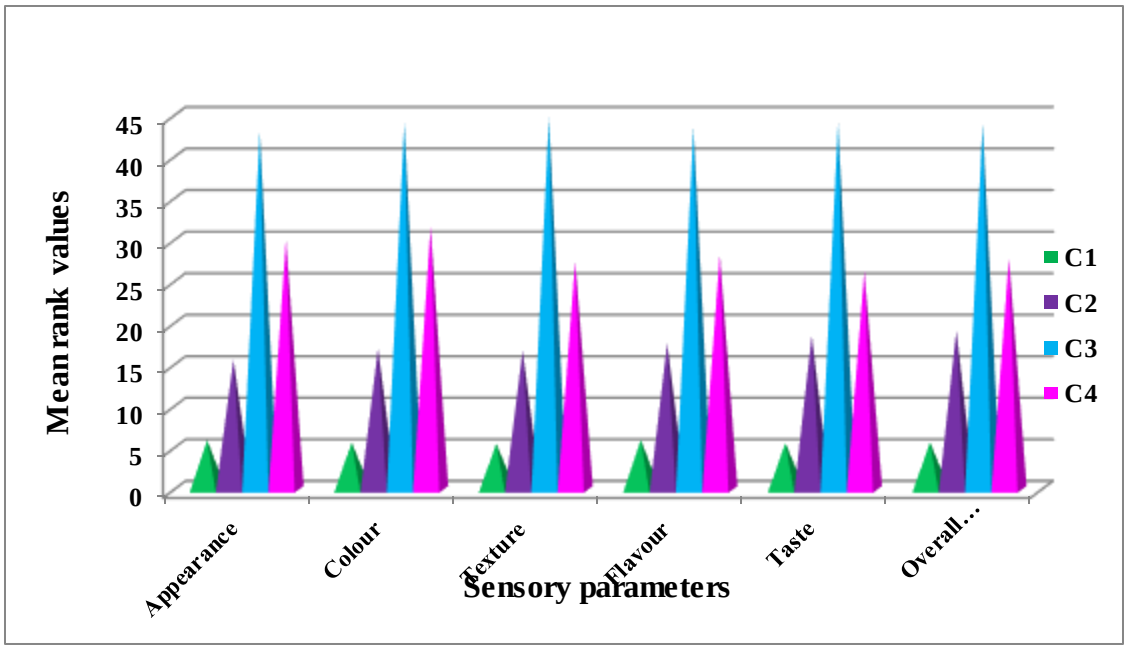


Fig. 18. Sensory quality of *Avial* mix with varying proportions of coconut

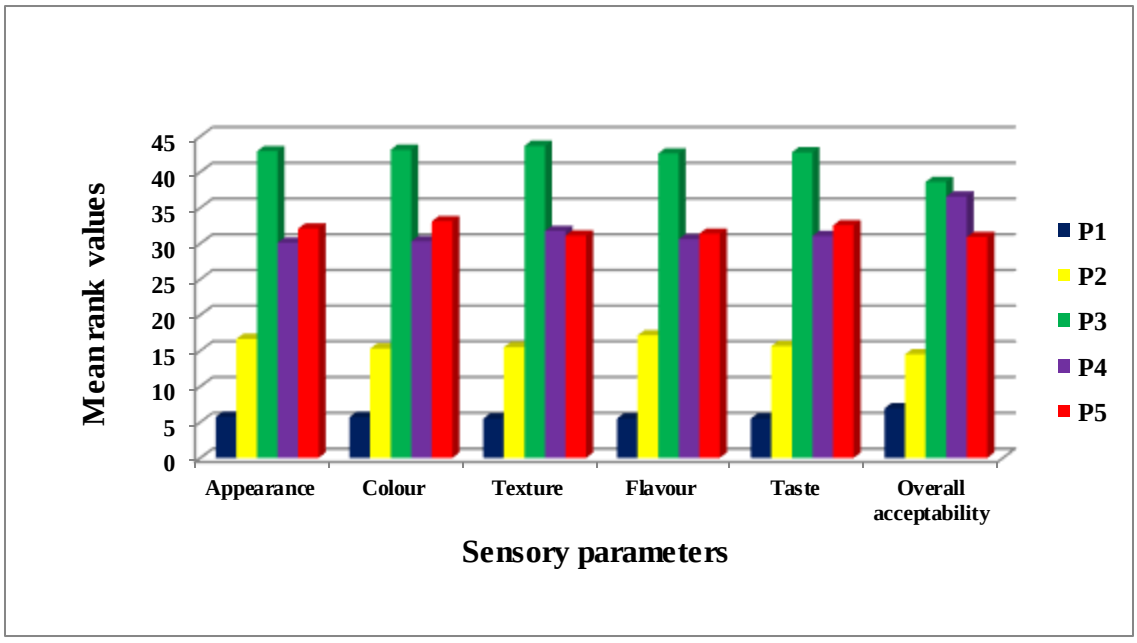


Fig.19. Sensory quality of *Koottu* mix with varying proportions of coconut

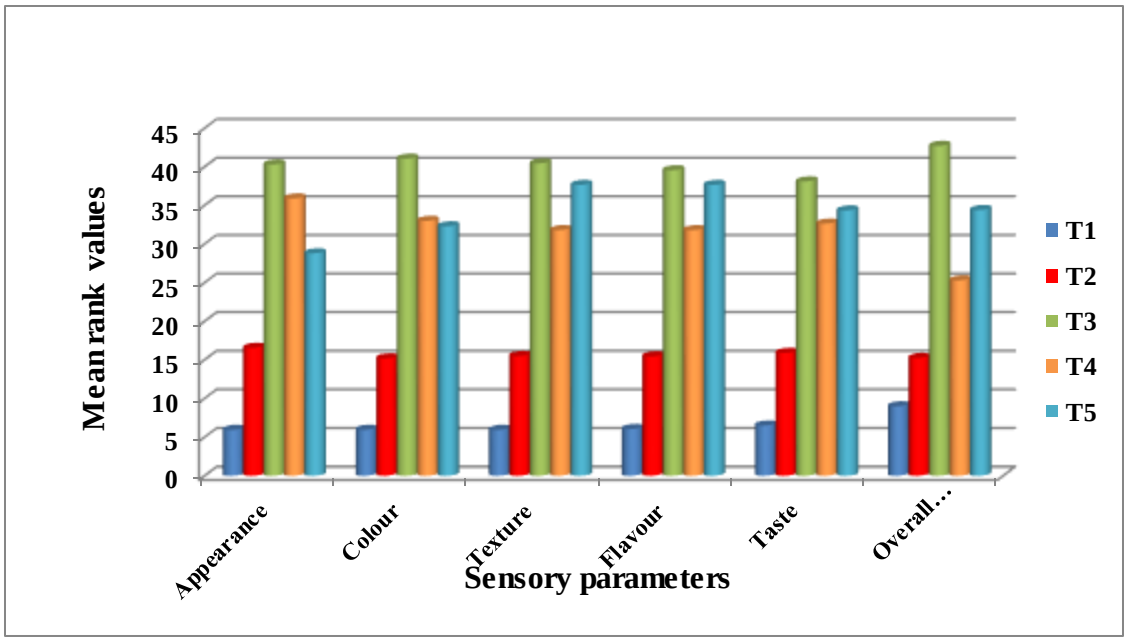


Fig. 20. Sensory quality of *Avial mix* with varying proportions of oil

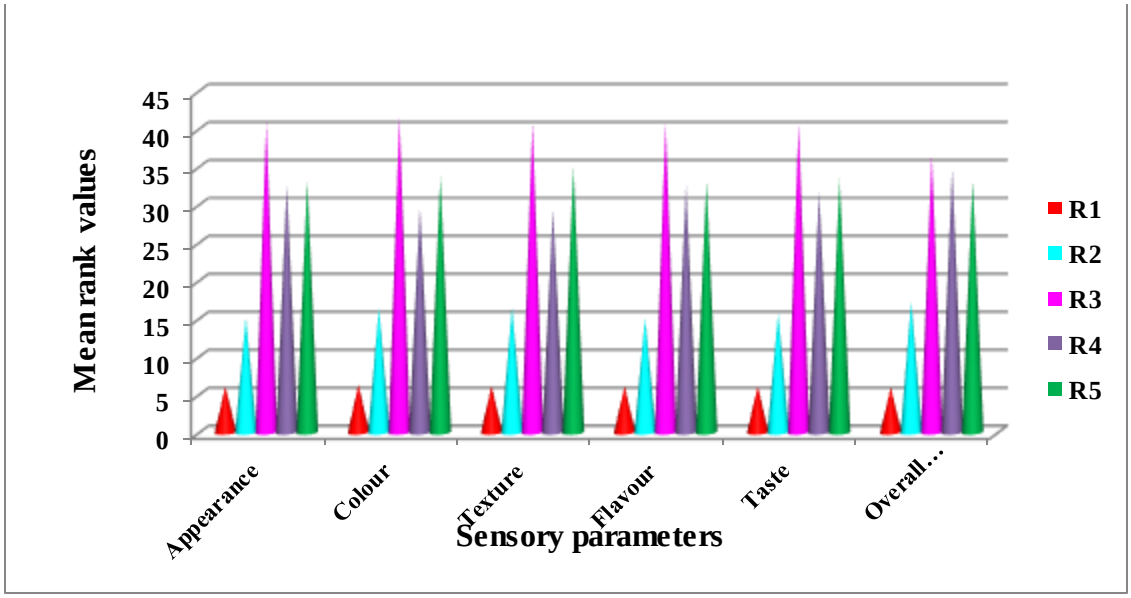


Fig. 21. Sensory quality of *Olath mix* with varying proportions of oil

5.2. PACKAGING AND STORAGE

The standardized dehydrated mixes were packed in PE and laminate pouches and stored in ambient conditions to find out the best packaging material. According to Bhattacharjee and Bhole (1999) food packaging and storage are the vital step to ensure product quality because it provides protection against deterioration and damage during storing ,transportation and distribution. In this present investigation, laminate pouches were found to be the better packaging material for *Avial*,*Olath* and *Koottu* mixes.

Molla *et.al.* (2008) indicated that the jackfruit chips packed in metalex foil pouches performed the best and those packed in polypropylene pouches could not be kept for longer periods. Similar observation was found by Rahman and Shamsuddin (2003) in papaya chips processing. The result is also in agreement with cassava chips packaging (Islam and Shemsuddin, 2003). Laminated polyethylene packages were found to be suitable in packing supplementary foods and could be kept for 90 days (Salve *et al.*, 2011). Dehydrated mushrooms packed in laminated pouches could be stored at 27±2°C and 82±3°C for 9 weeks without significant changes in moisture and appearance (Jayathurya and Illeperuma, 2013).

5.3. QUALITY ASSESSMENT OF DEHYDRATED JACKFRUIT RTC MIXES

Nambiar (2008) reported that development of nutritious and organoleptically acceptable recipes with locally available foods is a challenge for the food scientist as the benefits of food – based strategies to prevent micronutrient malnutrition are manifold.

In the present investigation products developed from jackfruit were assessed for its physical properties ,shelf life stability and proximate composition and cost of products were also assessed.

5.3.1. Cost of the Developed Products

In the present investigation the cost of the developed RTC mixes *viz*., *Avial, Koottu* and *Olath* were analysed. The cost of the *Avial, Koottu* and *Olath* RTC mixes were 30.00, 24.00 and 32.00 Rupees per kg respectively.

5.3.2. Physical Characteristic of Dehydrated Mixes

Physical characteristics help in the qualitative assessment and acceptability of any new product. The physical characteristics namely appearance, moisture, yield, weight loss, rehydration ratio and bulk density were ascertained.

According to Martins *et al*. (2001) the acceptability of the food product is very much influenced by its appearance. Sensory evaluation is an important part of the process of developing new food products. The present study indicates that the *Avial* mix had the highest score (4.88) for appearance. However the other two products also obtained a score above four, indicating that all the three products were acceptable.

Moisture can adversely affect the quality of food. It is an important parameter in dehydrated food, which directly influences the microbial activity, non enzymatic browning solubility and hygroscopicity. The moisture content of developed RTC mixes. (*Avial, Kottu* and *Olath* mixes) ranged from 5.38-6.18 per cent. SCUC (2006) reported that the moisture content of the tender and ripe jackfruits were 84.0g and 77.2g respectively. Rohitha and Amunogoda (2013) reported that the moisture (adsorption isotherms) content of solar dehydrated jackfruit ranged from 3.4-4.7 per cent. Premakumari *et al*. (2012) reported that moisture content of RTC Indian recipes such as 'dosa mixes', 'vermicelli' and 'kozhukattai' incorporated with rice bran was 7.14 - 8.97per cent. In a study on RTE extruded products made from flour blends the moisture content ranged from 1.80 -2.44 per cent Kocheria *et al*. (2013). The lower moisture content is due to the fact that this is a dehydrated product.

The yield of the developed RTC mixes on dehydration ranged from 35.90-37.32 per cent. Airani (2007) reported that the total yield of the jackfruit seed flour was recorded as 68 percent. Kumar *et al*. (2012) reported that jackfruit powder yield from hot air oven was 17.8 per cent. Udoro (2008) reported that the yield of dried

chips from cassava roots is about 20-40 per cent. The lower yield is due to the weight difference of the initial raw material which is while bulk and the products which are thin slices.

Weight loss is an indicator of the success of dehydration. Moisture content below 8 per cent extends the shelf life of a product. Loss of weight of the developed RTC mixes ranged from 62.68-64.10 percent.

Rehydration characteristics were used as a quality parameter of dried products (Vrac and Gurna,1994). Rehydration is used to express the ability of dried material to absorb water. In the present investigation the rehydration ratio of developed RTC mixes ranged from 0.34-042. The rehydration ratio of dried banana slices treated with ascorbic acid was 1.21 (Abano and Samamoah, 2011). Singh *et al*. (2009) reported that rehydration ratio of bitter gourd slices dried at 70°C was 0.78.

Ranganna (2001) states that bulk density indicates the weight of substances held in unit volume. According to Potter (1998), bulk density is one of the most common and simple measurements which can be used for the analysis of powdered food. Indura *et al*. (2009) opined that the bulk density is one of the important parameters, which indicates the quality of food products and higher the bulk density lower will be the package volume. In the present study the bulk density of the developed RTC mixes ranged from 0.95 to 0.97. Wagner (2000) reported that the appearance of the orange and grape fruit powders prepared by foam mat drying can be improved by increasing bulk density. Saranya (2012) reported that the enriched soup mix (ESM) developed from moringa pulp had a bulk density of 0.31-0.35mg/100g. Midhila (2013) reported that the bulk density of flour of Rasakadali variety was found to be highest and was observed to be 0.97mg/100g. Odoemelam (2005) reported that heat processed jack flour had a lower bulk density 0.54g/ ml^{-1} than the raw flour 0.61g/l^{-1}. Heat process reduces bulk density by 11.50 per cent. Bulk density depends on the particle size. It is a measure of heaviness of a flour sample. It is important for determining packing requirements, material handling and applying in wet processing in food industry. High volume indicates that it can be used as thickener. The value

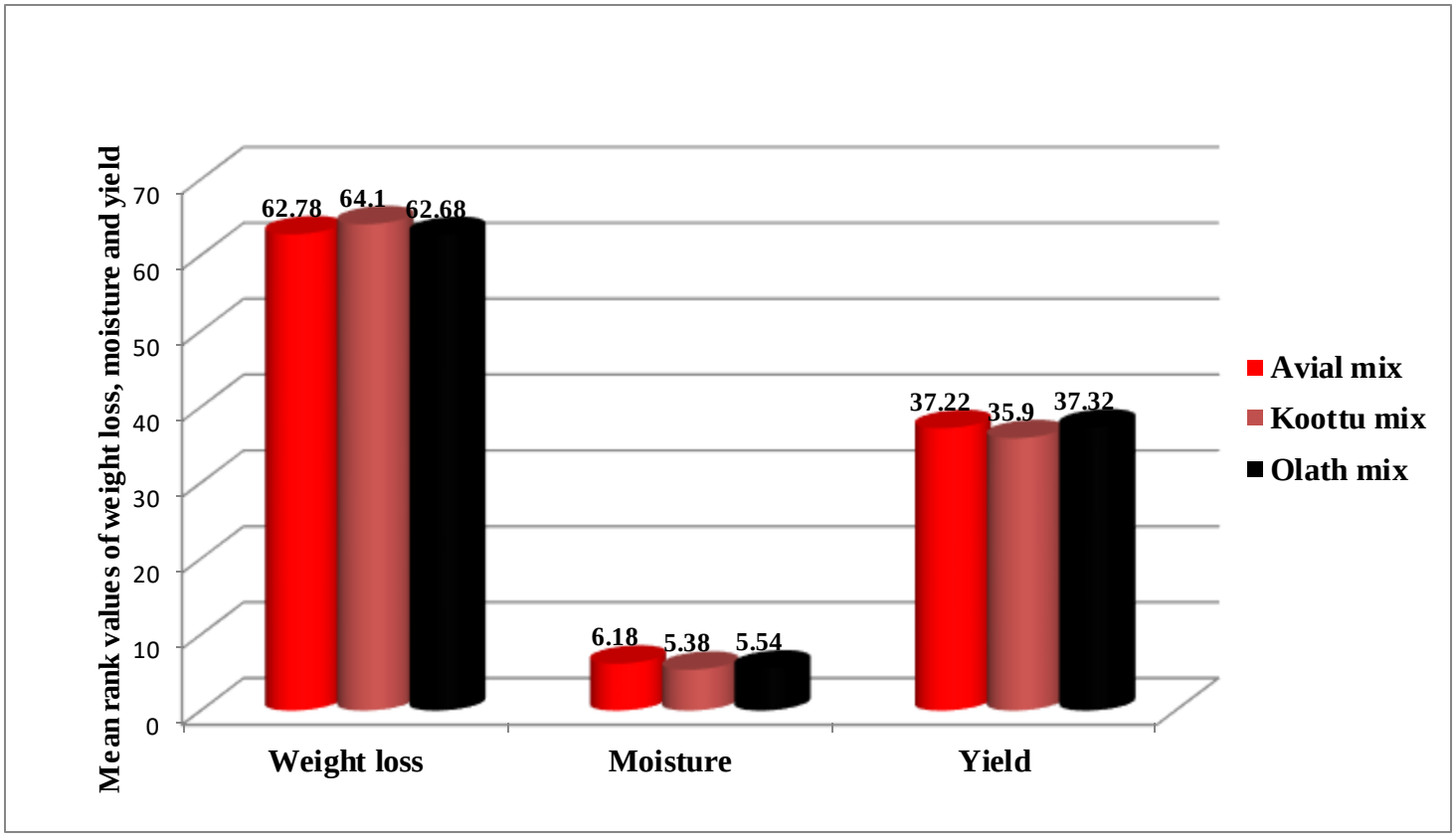


Fig. 22. Weight loss, moisture and yield of RTC products

obtained in thestudy conducted on jack fruit seed flour by Abraham and Jayamuthunrai (2014) was 0.80g/cm^{-3}.

5.3.3. Assessment of Consumer Preference

Brenner (2000) reported that hedonic quality dimensions mostly represents experience characteristics, since taste can be established only after earlier consumption. Convenience is the main factor considered from the consumer point of view. Convenience is much more than just preparing and quick consumption. It means saving time, physical and mental energy, convenience, planning, shopping, preparing and clean up (Candel, 2001). Preparation of jack fruit is a cumbersome process. Most of the consumers preferred *Avial* mix, followed by *Olath* mix.

5.3.4. Shelf Life Stability of Dehydrated RTC Mixes

The shelf life can be defined as the length of time that a package or a material in a container will remain in a saleable on acceptable condition under specified condition of storage (Kumar,2001). In the present investigation, sensory evaluation, moisture and microbial profile were conducted periodically up to a period of three months.

5.3.4.1. Sensory Evaluation

Monitoring the storage behaviour in terms of sensory analysis is an easy and important method of testing shelf life stability. The acceptability of the product was examined at monthly intervals up to three months. The sensory attributes such as appearance, colour, flavour, texture, taste and overall acceptability were found to decrease more in the RTC product packed in PE pouches than the RTC products packed in laminate pouches. Molla *et al*. (2008) reported that jack fruit chips could be stored in ambient condition by keeping them in metalex foil pouches for two months without loss of organoleptic quality. Evaluation of snack foods packed in laminated pouches and stored for 90 days was established to have acceptable colour, taste, texture, flavour and crispiness to the panel members (Shukla *et al*., 2013). Singh *et al*. (2011) reported that sensory qualities of RTE pizza was acceptable for 45 days when packed in MAP compared to conventional packaging.

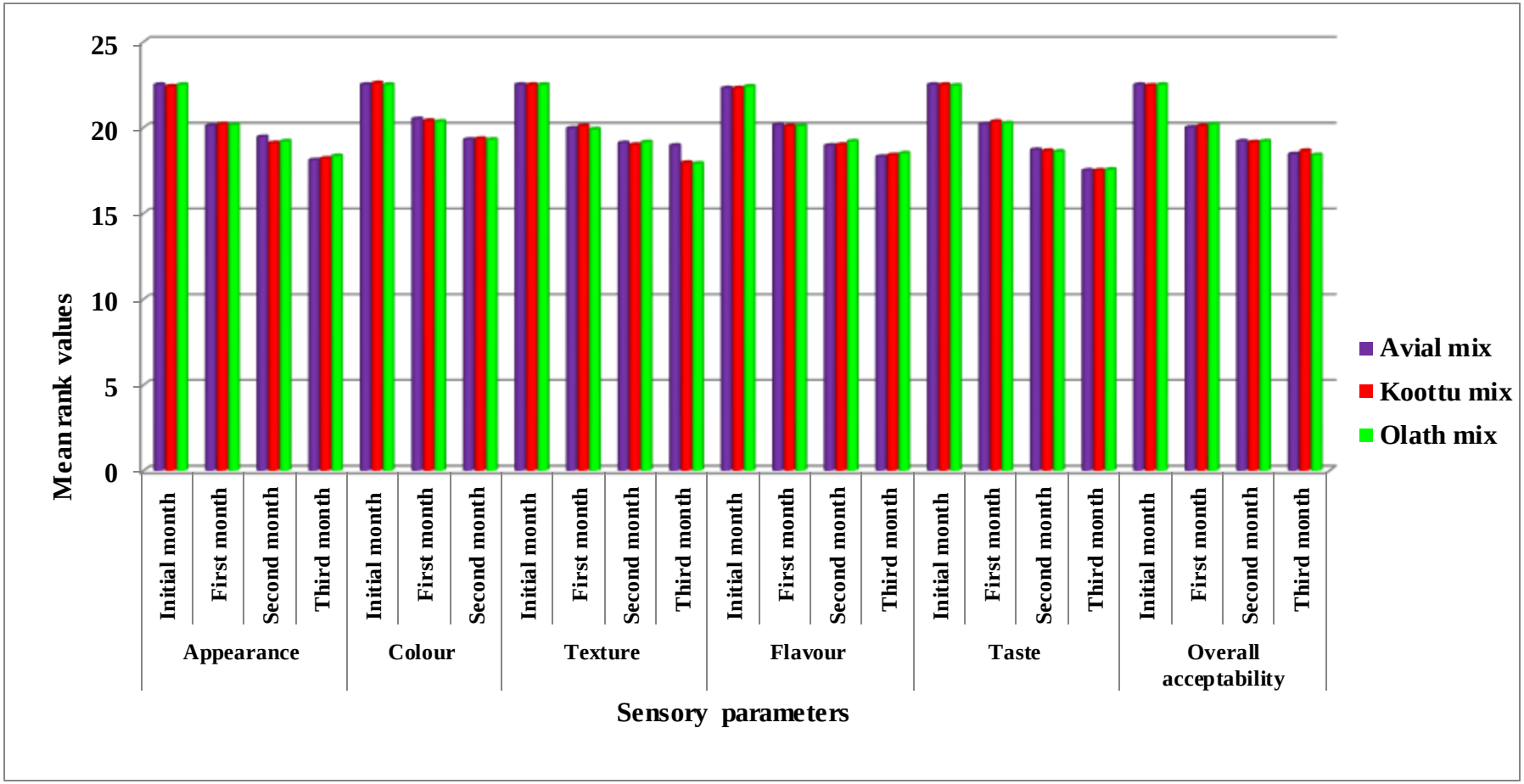


Fig. 23. Sensory evaluation of developed RTC mixes packed in PE pouches

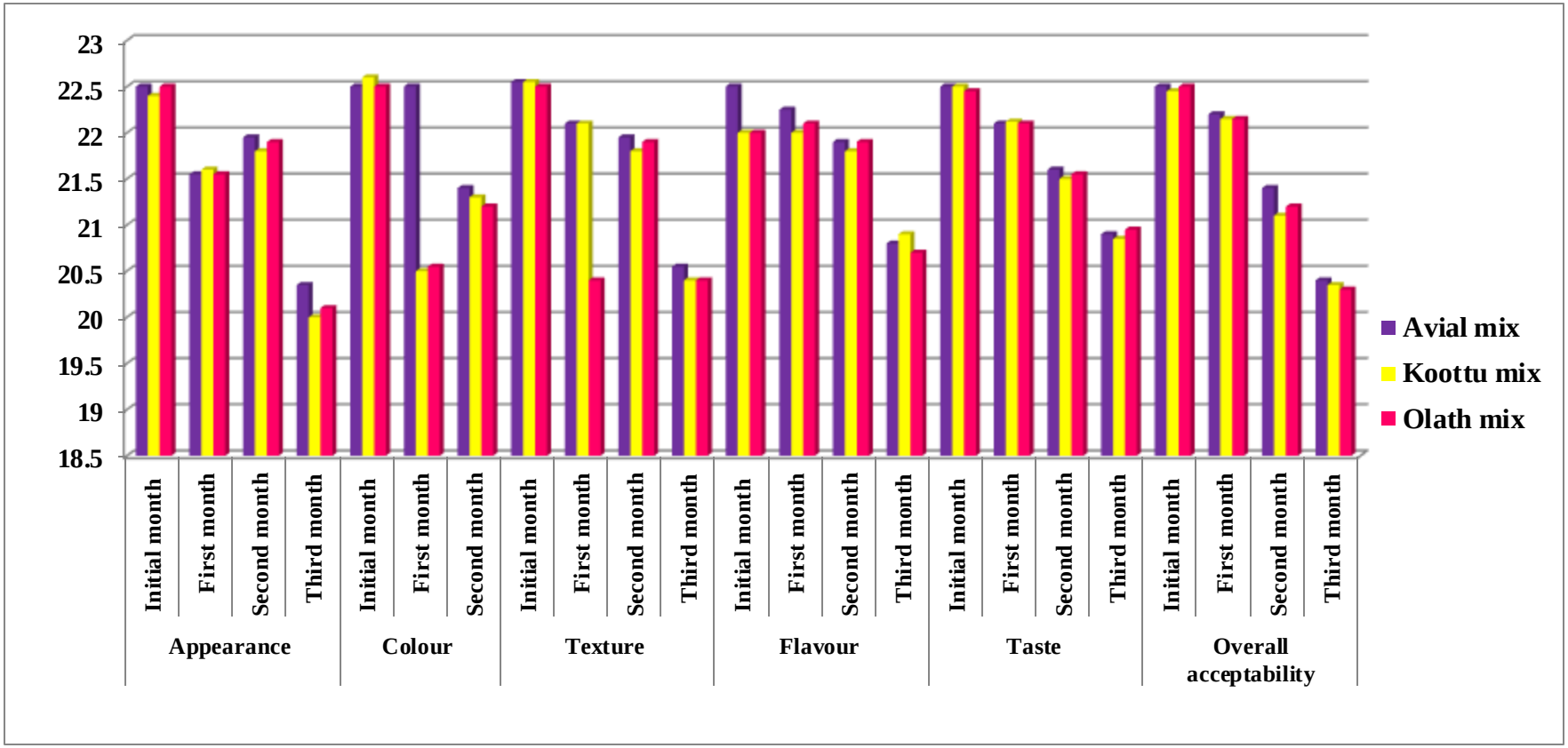


Fig. 24. Sensory evaluation of developed RTC mixes packed in laminated pouches

5.3.4.2. Moisture

Moisture is one of the important parameters which determine the shelf life quality of food product. Low moisture is highly important for the longer storage period (Shankar,1993). During the first month, the moisture content of the developed RTC mixes packed in PE and laminate pouches was assessed. Initially the moisture content of the developed RTC mixes packed on PE pouches ranged from 5.28-6.08 per cent whereas in laminate pouches ranged from 5.38-6.18 per cent. Higher moisture content was obtained for *Avial* mix packed in PE pouches (6.44) after the end of the third month. In the final analyses the moisture content of the developed RTC mixes packed in PE pouches ranged from (5.53-6.44) per cent and the laminate pouches moisture content ranged from 5.45- 6.25. Higher moisture content was noted for *Avial* packed in PE pouches and lower content was recorded for *Koottu* packed in laminate pouches (5.45 per cent). The increase in moisture content was negligible. Molla *et al*. (2008) observed that comparing polypropylene pouches, HDPE and metalex pouches, the lowest moisture percent (4.23%) was observed in samples packed in metalex foil. Midhila (2013) reported that the moisture content of the RTC produces from banana blossom was found to increase gradually during the storage period. But the increase in moisture did not influence the quality of the developed RTC product because the increase in moisture content was negligible. Syama (1997) reported that the moisture content of stored vermacelli was found to increase. Initial moisture content of sweet vermicelli was 10.28 percent and found to increase to 11.27 percent during storage period.

5.3.4.3. Microbial Profile

Microbial quality is one of the most critical quality parameters in dynamic systems such as food. There are different threats to food quality originating from microbial sources. Spoilage causing organisms causes off odour and off taste which leads to economic losses (Rao,1993). The spoilage by micro organisms are the primary cause of spoilage. Therefore reducing initial microbial population is a

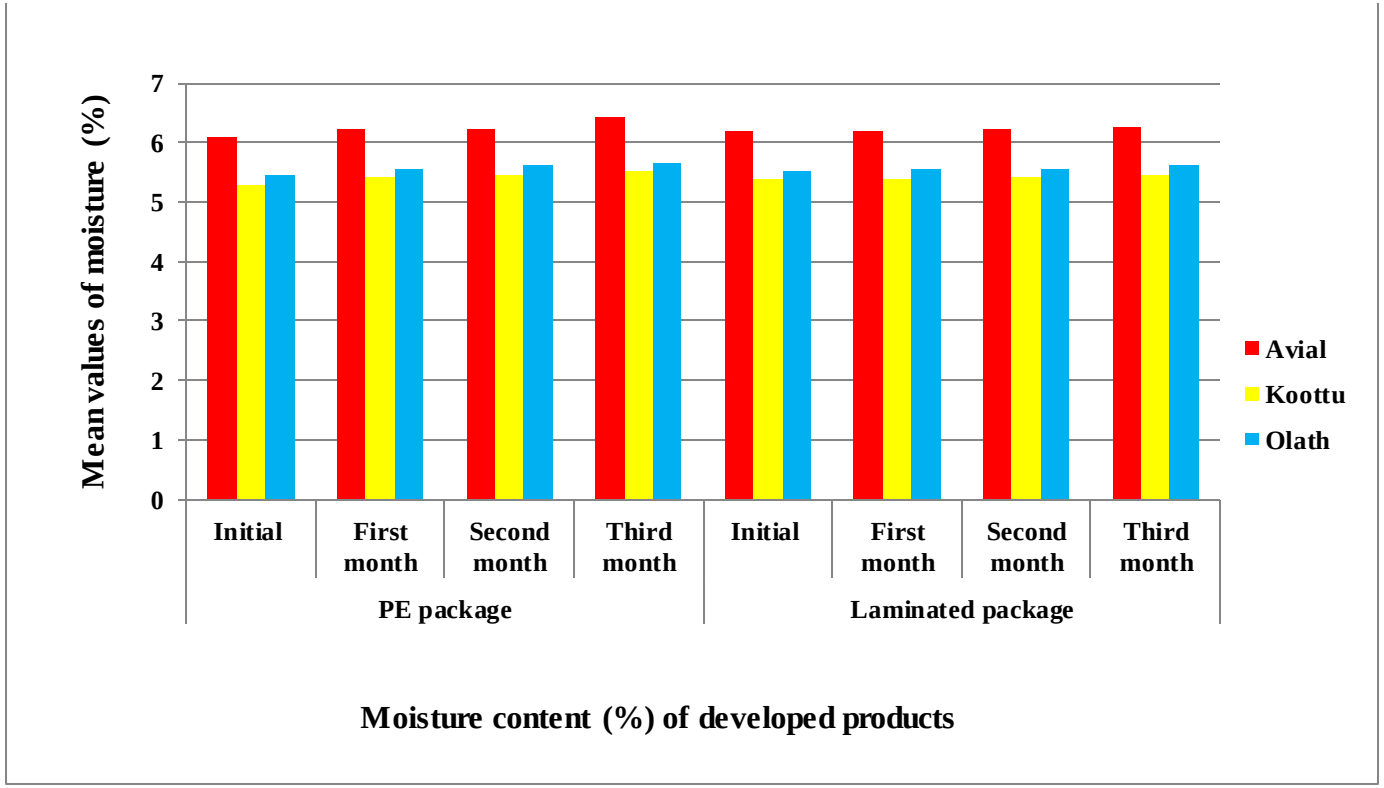


Fig. 25. Moisture content of the developed RTC products

strategy to extend the shelf life(Zagory,2003). Serial dilution followed by spread
plating was employed to detect the presence of micro organisms. In the present investigation negligible yeast growth was noted in *Koottu* mix packed in PE pouches. No microbial growth was seen in any other product packed on PE and laminate pouch. No yeast growth was noted in RTC mixes packed in laminated pouches. Nasheeda (2006) reported that the bacterial population of banana powder packed in poly propylene pouches ranged between 5.68-6.88 x 10^3cfu/g. Chellammal and Prema (1997) reported that sweet potato noodles stored in glass and plastic had no bacterial growth. John (2013) assessed the shelf life of RTC chapathi, they reported that chapathi packed in polypropylene (100 micron) pouches subjected to retort process was assessed to be free of microbes for more than 8 weeks. Caroline *et al*. (2013) conducted a shelf life study of dehydrated cassava based bar, they reported that aerobic mesophiles were found to be higher for 60 days and then reduced next 60 days. This was concluded due to reduction of O_2 in the pack.

5.3.5. Proximate Composition

Nutrients are invisible chemicals in the foods which are necessary for keeping the body healthy. Kalia and Sood (1996) defined nutritional quality as the attribute of a product that has significance in determining the degree of acceptability of the product to a user.

The carbohydrate content of the developed RTC mixes ranged between 33.16g/100g – 38.37g/100g. Carbohydrate content of tender jack fruit is 9.4g/100g (SCUC, 2006). Gupta *et al*. (2011) reported that 26.20g/100g of carbohydrate was present in the jack fruit seeds. Santos *et al*. (2011) reported that the carbohydrate content of the jackfruit cereal bar ranged from 42.50g/100g - 45.40g/100g. Lakshmana *et al*. (2013) reported that RTE tender jackfruit curry contained 12.03g/100g carbohydrate. Airani (2007) reported that 70.26g/100g carbohydrate is present in the jack seed flour.

Protein is one of the important nutrients required by the body to carry out a wide range of functions essential for the maintenance of life (Ensminger, 1994). The

protein content of the developed RTC mixes ranged from 12.93g/100g – 13.32g/100g. The young jack fruit contained 2.0-2.6g/100g protein (Azad, 2000). Santos *et al*. (2011) reported that 2.73g/100g protein was contained in the dehydrated jack fruit. Airani (2007) reported that the jack seed flour contain 9.03g/100g protein. Lakshmana *et al*. (2013) reported that 3.11g/100g protein was contained in the RTE tender jackfruit curry. Gupta *et al*. (2011) reported that jack fruit seeds contain 11.85g/100g of protein.

The fat content of the developed RTC mixes ranged from 0.52 – 0.71g/100g. Santos *et al*. (2011) reported that dehydrated jack fruit bulb contained 1.94g/100g fat and jack fruit cereal bar contained 6.22g/100g – 8.68g/100g fat. The fresh tender jack fruit and seeds contained 0.3g/100g and 0.4g/100g fat respectively (SCUC, 2006). Lakshmana *et al*. (2013) reported that RTE tender jack fruit curry contained 3.30g/100g fat. Jack seed flour contained 1.10g/100g fat (Airani, 2007). Singh *et al*. (1991) reported that jack seed flour contained 2.2g/100g lipids. Tulyathan *et al*. (2002) reported that lipid content of the flour from the seed with brown spermoderm and without brown spermoderm contained 1.01g/100g and 0.99g/100 respectively.

The energy content of the developed RTC mixes ranged from 189 Kcal/100g – 223Kcal/100g. The fresh tender jack fruit and seeds contained 50Kcal/100g and 139Kcal/100g energy respectively (Gunasena *et al*., 1996). Santos *et al*., (2011) reported that dehydrated jack fruit bulb contained 271.18 Kcal/100g and jack fruit cereal bar contained 413.21 Kcal/100 – 419.06 Kcal/100g of energy. Airani (2007) reported that the jack seed flour contained 376 Kcal/100g.

The interest in foods rich in dietary fiber increased in the recent decades and this has led to the development of a large market for fiber rich products and ingredients (Sudha *et al*., 2007). Total fiber content of the developed RTC mixes ranged from 6.54g/100g – 8.31g/100g. Santos *et al*. (2011) reported that dehydrated jack fruit bulb and jack fruit cereal bar contained 9.60g/100g and 4.10g/100g – 4.60/100g respectively. The fresh tender jack fruit bulb contained 4.40g/100g of fiber (SCUC, 2006). Tulyathan *et al*. (2002) reported that the fiber content of the jack

seed flour with and without spermoderm was 2.36g/100g and 1.67g/100g respectively. Singh *et al*. (1991) reported that jack seed flour contained 3.06g/100 fiber content. Lakshmanan *et al*. (2013) reported that RTE Tender jack fruit curry contained 2.30g/100g fiber.

The β carotene content of the developed RTC mixes ranged from 0.072mg/100g – 0.46mg/100g. Rahman *et al*. (2012) reported that osmotic dehydrated jack fruit prepared from 50°Brix sugar syrup contained 53.02µg/100g β carotene. Love and Paul (2011) reported that ripe jack fruit contained 540 IU β carotene. Kumar *et al*. (2012) reported that hot air oven dried jack fruit powder contained 150.45 IU β carotene.

Total mineral content of the developed RTC mixes ranged from 4.58g/100g – 5.61g/100g. The fresh tender jack fruit bulb were reported to contain 0.9g/100g of mineral content (Azad, 2000) . Gupta *et al*. (2011) reported that jack seed contained 0.15g/100g mineral content. Tulyathan *et al*. (2002) reported that ash content of the flour from the seed with brown spermoderm and without brown spermoderm contained 3.97g/100g and 3.92g/100 respectively. Lakshmanan *et al*. (2013) reported that RTE Tender jack fruit curry contained 1.68g/100g ash content. Chakraborty *et al*. (2013) reported that total mineral content of jack fruit seed based extruded break fast cereal was 3.01g/100g. It can be concluded that mineral content of the dried sample will be higher because of concentration of dry matter.

The calcium content of the developed RTC mixes ranged from 112.13mg/100g – 118.53mg/100g. Jack fruit contains high level of calcium (Burkill, 1997). Azad, (2000) reported that fresh jack fruit contained 30.00 - 73.20mg/100g calcium.

The iron content of the developed RTC mixes ranged from 121.18mg/100g – 121.93mg/100g. The fresh tender jack fruit contained 1.5mg/100g iron content (SCUC, 2006).

The potassium content of the developed RTC mixes ranged from 514.80mg/100g – 516.80mg/100g. The fresh tender jack fruit contained 206.00mg/100g potassium content (SCUC, 2006). Jack fruits are rich in components

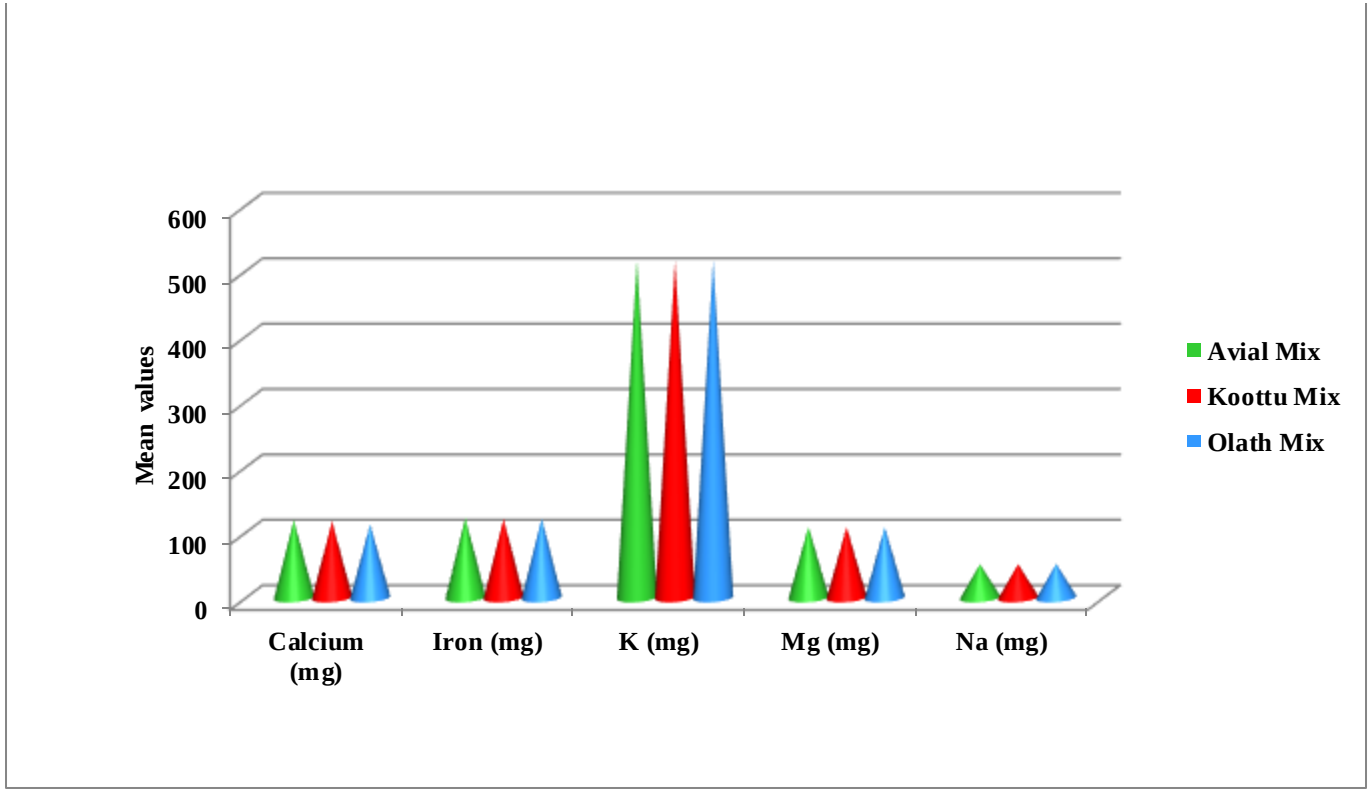


Fig. 26. Total mineral content of the RTC mixes

such as fibers, calcium, phosphorous, potassium and magnesium (Chandrika *et al*.,2005)

The magnesium content of the developed RTC mixes ranged from 108.35mg/100g – 108.48mg/100g. Azad (2000) observed that jack fruit seed contained 54mg/100g magnesium.

The sodium content of the developed RTC mixes ranged from 51.10 mg/100g – 51.80mg/100g. Love and Paul (2011) reported that sodium contained in ripe jack fruit contain 2 – 48mg/100g.

The manganese content of the developed RTC mixes ranged from 2.01 mg/100g – 3.91mg/100g.

The developed RTC mixes were evaluated for cost viability, physical characteristics, sensory characteristics, proximate composition and shelf life. A consumer acceptable product has thus been developed with respect to convenience, shelf life and nutritional quality.

Among the three RTC mixes developed 'avial' mix was preferred most by the consumers after cooking, this mix put forth a product comparable to freshly prepared 'avial'. The shelf life of 'avial' and 'olath' mixes were found to be excellent up to three months. Though nutrient loss are obligatory during processing, the nutritional profile was satisfactory for all the three mixes.

Summary

SUMMARY

The present investigation entitled "Development of jack fruit based Ready To Cook (RTC) instant mixes″ was carried out for developing convenient to use products from raw jack fruit (koozha type). The objective of the study was to develop value added product from raw jack fruit and to evaluate its quality parameters. The experiment was carried out in the Department of Home Science, College of Agriculture, Vellayani, Thiruvananthapuram during the period of 2012 – 2014. The major findings of the study are summarized below.

In the experiment, raw jack fruit of koozha type was collected, washed and the bulbs and seeds were separated. The separated bulbs and seeds were sliced into various widths. The dimension of 1.5cm, 0.5 cm and 1.00cm for *Avial*, *Koottus* and *Olath* respectively were selected by analysing the OVQ scores. In order to control the enzyme activity, to prevent browning and to get an acceptable product, sliced jack fruits slice was blanched for 3 min and pretreated with KMS (0.2 per cent) and salt (0.5 per cent) for 30 min for all the three mixes. These treatments were identified by analysing the scores of a sensory panel. The *Avial, Koottu* and *Olath* mixes were formulated and selected on the basis of sensory evaluation by 10 members panel using a five point scale. The identified *Avial* mix comprised of jack fruit bulbs and seeds, green chilly, garlic, jeera, turmeric powder and curry leaves. Similarly *Koottu* mix comprised of jack fruit bulbs and seeds, red chilly, turmeric powder, cumin and curry leaves. *Olath* mixes comprised of jack fruit bulbs and seeds, crushed red chilly, onion, garlic, turmeric powder and curry leaves.

In order to give valuable hints to the consumers for getting the best product, parameters like cooking methods, reconstitution time, cooking procedures, cooking time and addition of adjuncts were also standardized. Thirty minutes of reconstitution time was found to be best for all the three RTC mixes. After reconstitution, *Avial*, *Koottu* and *Olath* mixes were standardized for the cooking time. When *Avial* mix and *Koottu* mix needed 15 min cooking time *Olath* mix needed only 10 min for complete cooking. Among the four treatments cooking in strained hot water gave the best sensory qualities to the product.

Coconut is an essential adjunct in traditional Kerala cuisine. Because of its perishability coconut was not added into the mixes during processing. In order to improve the taste and flavour 30g and 35g of coconut was identified to be optimum to be added into *Avial* and *Koottu* mixes respectively. 3.5 ml and 3.0 ml of coconut oil were chosen as the optimum levels to be added in to *Avial* and *Olath* mixes respectively to enhance sensory qualities.

The physical characteristics like appearance, moisture, yield, physiological loss of weight, rehydration ratio and bulk density of the developed RTC mixes were assessed. The appearance was evaluated by sensory panel using a five point scale. Ready to cook *Avial* mix obtained the highest score 4.88 in this respect and lowest score was obtained for RTC *Koottu* mix. The moisture content was highest for *Avial* mix (6.18 per cent). The yield of the RTC mixes ranged from 35.90 – 37.32g/100. The physiological loss of weight of RTC mixes ranged from 62.68 – 64.10 g/100g. The rehydration ratio of RTC mixes ranged from 0.34 -0.42 and the bulk density of the developed RTC mixes ranged from 0.95 -0.97.

The proximate composition of the developed RTC mixes *viz., Avial, Koottu* and *Olath* showed that the carbohydrate content was higher for *Avial* mix (38.37g/100g) and lowest for *Koottu* mix (33.16g/100g). Similarly the protein content was found to be higher for *Avial* mix (13.32g/100g) and lower protein content was observed for *Koottu* mix (12.93g/100g). The highest fat content was noted for *Avial* mix (0.712g/100g) and lowest was observed for *Koottu* mix (0.52g/100g). The total fiber content was observed to be maximum for *Avial* mix (8.37g/100g) and minimum was noted for *Koottu* mix (6.54g/100g). β carotene was found to be highest for *Koottu* mix (0.46g/100g) and lowest β carotene levels were noticed for *Avial* mix (0.072g/100g).

The shelf stability of the developed product was studied by storing the product in PE and laminated pouches up to three months. The sensory qualities, changes in the moisture content and microbial profile were assessed. The organoleptic evaluation showed that among the two packaging materials laminate pouches retained the quality of the products better.

The moisture content was found to increase after each month. The moisture content was highest for *Avial* mix packed in PE and laminate pouches and lowest for *Koottu* mix packed in laminate and PE pouches during the storage period.

The microbial evaluation of the developed RTC mixes does not show any bacterial growth during three months of storage. Yeast growth was found to be observed in *Koottu* mix packed in PE pouches in negligible amounts.

Cost analysis of the developed product was analysed. Cost of the product indicated that *Avia*l mix was found to be the most expensive followed by *Olath* mix.

The consumer preference of the developed RTC mixes was assessed after the reconstitution of the product using Hedonic rating. *Avial* mix was preferred the most although all the mixes were found acceptable.

The study proves that RTC products from raw jackfruit will be acceptable, as the difficulty in handling the fruit is minimized by obtaining the product in a processed form. All the more so because the product is familiar to Keralites.

A mechanised approach in the preparation of jackfruit could make commercialization easier. Packaging methods using newer techniques like MAP could enhance the shelf life of the product and improvement of packing material could make the product more attractive.

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Appendix

APPENDIX – I

Score card for organoleptic qualities of RTC mixes

Particulars	Criteria	Scores	I	II	III	IV	V
Appearance	Excellent Very good Good Fair Poor	**5** **4** **3** **2** **1**					
Colour	Excellent Very good Good Fair Poor	**5** **4** **3** **2** **1**					
Texture	Excellent Very good Good Fair Poor	**5** **4** **3** **2** **1**					
Flavour	Excellent Very good Good Fair Poor	**5** **4** **3** **2** **1**					
Taste	Excellent Very good Good Fair Poor	**5** **4** **3** **2** **1**					
Overall acceptability	Excellent Very good Good Fair Poor	**5** **4** **3** **2** **1**					

APPENDIX – II

Hedonic rating scale for the preference of RTC product

Tested by

Age

Date: / / 2012

Rating	**Score**	**I**	**II**	**III**
Like very much	8			
Like moderately	7			
Neither like or dislike	5			
Dislike slightly	4			
Dislike	3			

Abstract

Development of Jack Fruit Based Ready -To -Cook (RTC) Instant Mixes

by

LIJI A.J

(2012 – 16 - 107)

ABSTRACT

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ABSTRACT

The study entitled " Development of jack fruit based Ready To Cook (RTC) instant mixes " was conducted in the Department of Home Science, College of Agriculture, Vellayani during the period of 2012-2014 with the objective of to develop value added products from raw jackfruit and to evaluate its quality parameters.

The Koozha type was selected because of its less popularity compared to *Varikka*. Three popular raw jack fruit based dishes of Kerala 'namely' *Avial', 'Koottu'* and '*Olath'* were identified for standardization.

The preliminary processing methods for each of the products were standardised with respect to size of the jack fruit slices, blanching and immersion in various pre-treatment media in different time durations. The adjuncts in the mixes in various proportions were formulated and dehydrated at 65°C till crisp. These formulations were cooked and evaluated for sensory quality. Cooking methods were optimized with respect to reconstitution time, cooking procedures, cooking time and additional ingredients to be added while cooking.

The standardised products were evaluated for their shelf life and these products were packed in PE and laminated pouches. They were stored in ambient conditions for three months. During the storage period yeast colonies were found in '*Koottu'* mixes packed in PE pouches.

The physical quality of the three mixes were evaluated with respect to appearance, moisture, yield, physiological loss of weight, rehydration ratio and bulk density. The proximate composition of the three products were studied. Calorie, fat and fibre content were found to be higher in *Avial* mix.

Consumer preference study indicated that avial mix was more acceptable amongst the subjects.

These products if popularised could overcome the cumbersome handling procedures of jackfruit and make it more popular among the urban classes.